International Journal For Technological Research In Engineering
Volume 8, Issue 5, January-2021 *ISSN (Online): 2347 - 4718*

A REVIEW ON CABLE FAULT LOCATOR

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***Abstract*—This Review focuses on the Cable faults are damage to cables which affect a resistance in the cable. If allowed to persist, this can lead to a voltage breakdown. There are different types of cable faults, which must first be classified before they can be located. The insulation of the cable plays a significant role in this. While paper-impregnated cables are particularly susceptible to external chemical and thermal influences, in high-voltage PE or XLPE cables the polyethylene insulation of the conductor is affected, leading to partial breakdowns and cracks that "eat away" the insulation.**

***Keywords* – CFL (Cable Fault Location), TDR (Time Domain Reflectometry), Surge Pulse Reflection, Voltage Pulse Reflection. Acoustic Surge Detection (Thumping), Electromagnetic Surge Detection.**

I. INTRODUCTION

There are two distinct categories of cable fault location (CFL) methods.

A. *Localizing*

B. *Pin pointing*

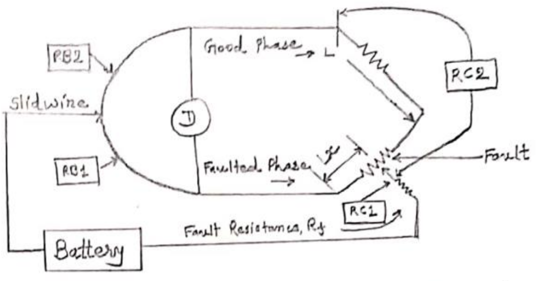
Localizing methods are generally used to identify either a faulted section of underground cable or the approximately location of a fault on an underground cable.
Pinpointing methods are generally used to identify the exact location of a fault on an underground cable especially on direct buried cable.

1. CLASSICAL MURRAY LOOP BRIDGE APPLICATION

In Murray Loop Method figure shows that adjacent resistance, RC1 and RC2 of a faulted cable in a loop with good cable, can be made to represent C1 and C2 in the wheatstone bridge, similarly, corresponding fraction of a slide wire RB1 and RB2 can be made to represent resistance B1 and B2, when adjusted so that the null detector D, will indicate balance, the position of the slide contact will represent their common point. At balance in the wheatstone bridge, the ratio C1/C2 is equal to ratio B1/B2. At balance in Murry Loop Bridge, RC1/RC2 is equal to Rb1/Rb2.
When it is assumed that the resistance of a uniform conductor is linearly proportional to its length, and the total length of the cable section under test is L, the distance to the fault, Lx is calculated as follows.

$$Lx = 2LRB1 / RB2$$

For this application we have total 02 nos. Kits (1) PES make cable fault locating kit & (2) BICCOTEST make high resistance cable fault kit.

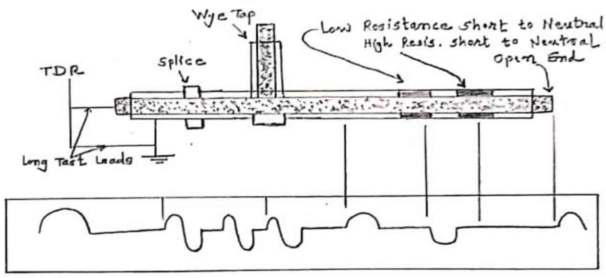


CLASSICAL MURRAY LOOP BRIDGE APPLICATION

2. ANALYSER / TDR / LOW VOLTAGE RADAR

Low voltage radar often referred to as TDR (Time Domain Reflectometry) Remember that although resistance bridge are especially valuable for localizing high resistance shunt fault they are useless on "opens" and multiple fault. TDR complement the capabilities of the bridge in that they are especially effective on opens and multiple faults. However TDRs have one major short coming that they cannot display high resistance shunt fault greater than 200 ohms and coaxial power cable.

In operation the TDR transmit high frequency pulses down the cable, display reflected pulses on a screen, and calculates the distance between two points of the cable. On a practical basis, the TDR can only be expected to provide approximate distances for TDR application on Power cable.



TDR APPLICATION ON POWER CABLE

3. ANALYSER / HIGH VOLTAGE RADAR

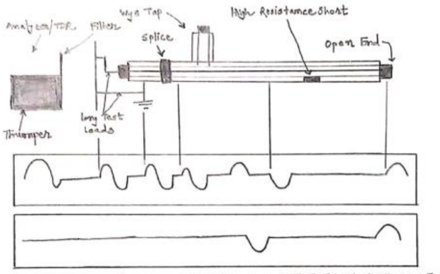
Because TDR is not independently capable to display high resistance shunt fault, its unassisted use on power cable as fault indicator is severely limited. When used in a "HIGH VOLTAGE RADAR" system with thumpers, filters or couplers, TDR is able to display both high and low resistance faults.

There are three basic high voltages Radar System.

a) Arc Reflection and Differential Arc Reflection

These method not only display faults, they also display landmarks such as splices, taps, transformers and even water ingress, so providing electrical map of the cable under test. Arc reflection makes it possible for the TDR to display "before" and "after" tracks the "before" trace is the low voltage radar trace that does not show the downward reflected pulses displayed for a parallel fault unless its resistance is lower than approximately 200 ohms. The "after" trace is the low voltage radar trace that includes the fault, even though the fault resistance may be higher than 200 ohms.

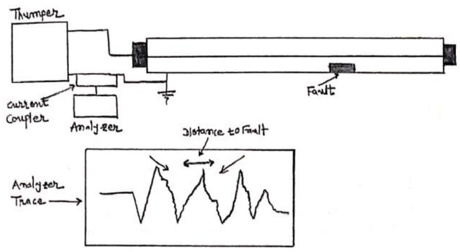
With Differential Arc Reflection a second screen is provide that display only the algebraic difference between the "before and after" traces for the portion of the display ahead of the fault.



ARC REFLECTION AND DIFFERENTIAL ARC REFLECTION METHODS OF HIGH VOLTAGE RADAR, CLASSICAL APPLICATION OF POWER CABLE

b) Surge Pulse Reflection

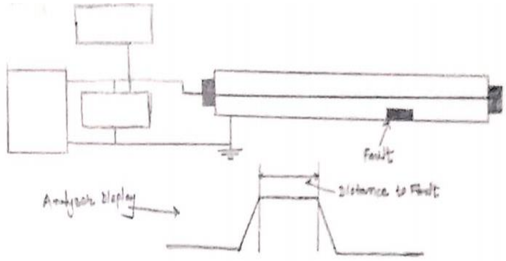
Surge pulse usually referred simply as Surge, will locate most of the same faults that can be located with arc Reflection, but usually with reduced accuracy and confidence. Other shortcoming of Surge are the greater difficulty experienced surge traces and the lack of landmarks in the traces. Fortunately, surge has redeeming value in that it will locate some fairly common faults that cannot be located with Arc Reflection.



SURGE PULSE REFLECTION METHOD OF HIGH VOLTAGE RADAR

c) Decay (Voltage Pulse Reflection)

Decay is used primarily to locate faults that require breakdown voltages greater than that which can be generated by thumpers. DC Dielectric test sets with approximately rated voltage surge couplers and an analyzer to break down the fault and capture the voltage transient.



DECAY METHOD OF HIGH VOLTAGE RADAR

II. MODERN PINPOINTING METHODS

Pin Pointing methods are generally used with surge generators (thumpers). Pin Pointing can be carried out by following methods.

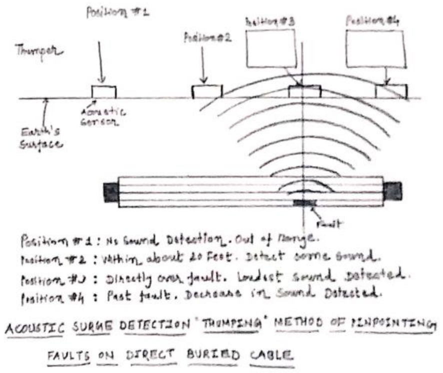
a. Acoustic Surge Detection (Thumping)
b. Electromagnetic Surge Detection
c. A.C. Voltage Gradient

All the three methods required a Thumper (Impulse Generator) in which high voltage capacitors are periodically charged and discharged to produce a high energy pulses. This pulse is used as a traceable signal for cable fault locating.

In the IMPULSE method of fault location, the test set repeatedly applies a high voltage impulse to the defective cable. This impulse travels is along the cable until it reaches the fault. At the fault the voltage causes a large current to pass through the return paths. The fault portion along the cable length can be traced by a detector which is applied along the cable path. All faults can be represented electrically by a gap shunted by resistance illustrated in figure below.

a. Acoustic Surge Detection (Thumping)

Acoustic or seismic – like detection relies upon the sound or shock wave that radiates from a fault with each succeed flashover, thus revealing it location at the point of peak intensity. The acoustic method is effective in the immediate vicinity of the fault but can be used only when there is a flashover and not when the fault resistance is very low because then there is no sound or shock wave. If the shockwave cannot be heard with the unaided ear, an acoustic detector must be used. This consists of a sensitive seismic pickup connected to an amplifier having earphones as well as a meter indicator. The pickup is a geophone, similar to those used to detect earthquakes. When placed on the surface near a fault it converts inaudible shockwaves to electrical impulses that can be heard in the earphones and seen on the meter. This detection method is used mostly on direct buried cable.

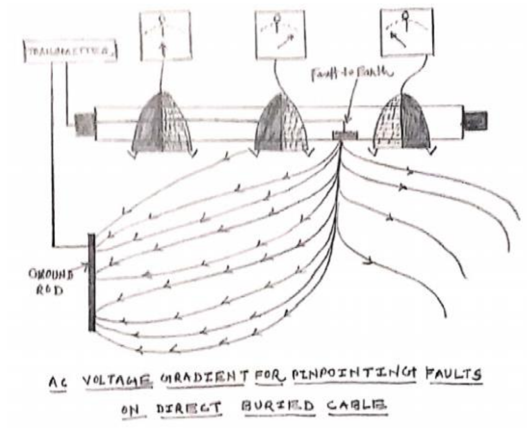


b. Electromagnetic Surge Detection

It uses the principle of inductive coupling to locate a fault by sensing the current which accompanies the travelling impulse. It is just as effective when the fault resistance is zero as when the resistance is very high. Electromagnetic detectors consist of an iron-cored pickup coil connected to an amplifier and centre zero meter indicators. The pickup coil responds to the travelling electromagnetic field radiated by the impulse current wave and the resulting deflections are the induced images of this current wave, by polarity as well as amplitude. An arrow on the pickup coil points to the transmitter so as to maintain consistent polarity readings. Electromagnetic detection can be used on ducted cable at access points and also on direct buried cable when it can be exposed at strategic points for testing.

c. A.C. Voltage Gradient

The voltage gradient method detects the drop that develops in the return path as each successive impulse discharges though the fault. It includes two variations known as the earth voltage gradient method, and the sheath voltage drop method. In either case a pair of probes connected to a detector having a meter indications are applied either directly to the earth or metallic sheath or shield. The amplitude of the signal indicates the proximity to the fault and with a centre-zero indicators, the ability to read a polarity reversal enables you to pinpoint the fault.



III. THE SYSTEMATIC APPROACH TO FAULT LOCATING

All fault location methods can be classified either a tracer or terminal methods. A terminal methods permits fault location from one end of the cable, the tracing method involves patrolling the route of the faulted cable.

IV. FAULT LOCATION METHODS AND ITS APPLICATIONS

A. Terminal Methods and Its Applications

Terminal Methods	Applications
Radar also known as pulse echo or TDR (Time Domain Reflectometry)	Shorts, grounds, opens and other discontinuities.
Murray Loop Bridge	Shorts and Grounds
Capacitance Bridge	Opens

B. Tracing Methods and Its Applications

Tracing Methods	Applications
AC, Continuous or pulsed	Shorts, grounds, opens
DC, Continuous or pulsed	Shorts, grounds, opens
Impulse	Shorts, grounds, opens

V. ADVANTAGES OF CABLE FAULT LOCATOR

1. Low voltage drop.
2. Low Maintenance and low chances of fault occurring.
3. Very suitable for urban areas where overhead transmission lines are not easy to install.

VI. DISADVANTAGES OF CABLE FAULT LOCATOR

1. It is very expensive.
2. It is quite difficult to search the exact fault locations.
3. It has insulation problem at higher voltage compared to overhead transmission system.

VII. CONCLUSION

Terminal methods provide a measurement of the distance to a fault from a terminal; they are fast but suffer from limitations of accuracy and applications. Tracing methods transmits a signal that can be physically traced along the length of a cable for its effect at a fault, thus revealing the location, usually with the aid of auxiliary detecting instruments. Tracing methods are slower but are very accurate and have fewer limitations in applications.

ACKNOWLEDGMENT

I would like to convey my whole hearted gratitude to Mr. R. B. KALARIA, Senior Electrical Engineer of GNFC Limited, Gujarat because after reading his chapter based on Cable

Fault Locator, I got an inspiration to write this research paper. I would like to thank my mother, my father, my loving wife and my naughty son for their endless love, kindness and support me at every stage of my life.

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