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STUDY OF 3-ph UNDERGROUND CABLE FAULT LOCATOR USING ACOUSTIC METHOD

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Abstract *--This project evaluated underground cable failure and researched innovative techniques for diagnosing failing underground power distribution cables. In this paper, a technique for detecting faults in underground distribution system is presented.A HV surge tester is used to generate spark at fault position which produces noise and vibrations in fault site. This noise is picked up with the help of sensitive ground microphone which is further amplified in surge wave receiver set and exact fault point is locatedby detecting the fault having maximum noise and vibrations. The result is found that the proposed technique provides satisfactory result and will be very useful in the development of power systems protection scheme.*

Keywords: *Underground cable, HV surge tester (Thumper), Surge wave Receiver, Ground microphone.*

I INTRODUCTION

The main function of the distribution system is to transfer electrical energy from generation unit to consumer.The electrical energy is transport by Overhead transmission lines and underground distribution cables.Underground cables are widely used for transporting this electrical energy.Generally, when fault occurs on transmission lines, detecting fault is necessary for power system in order to clear fault before it increases the damage to the power system. Although the underground cable system provides higher reliability than the overhead line systembut difficult to locate the fault.

Faultsfall under two categories:permanent fault where the electricity supply remains off until the fault is located, and transient faults where there is intermittent loss of power.Pin pointing the exact locations of either type of cable fault is currently hit and miss,as many L.V(Low Voltage)cable system have a complex system of multiple T-joints which confuse existing cable fault detection technology, resulting in lengthy downtime and numerous costly highway excavations . Cost of the power utility include a regulatory cost for each hour the electricity supply is lost, excavation cost and labour cost as well as deterioration in the brand image of the company.The demand for reliable service has led to the development of techniques of locating faults. During the course of recent years, the development of the fault diagnosis has been progressed with the application of signal processing techniques and results in transients based techniques.

This paper is aimed to present a technique based on Arc Reflection Method combined with a high capacitance surge generatorand state of the art pin pointing devices for underground cable fault locating will find faults in less time and with less risk of damaging good cable than classical technique.

II SYSTEM BLOCK DIAGRAM

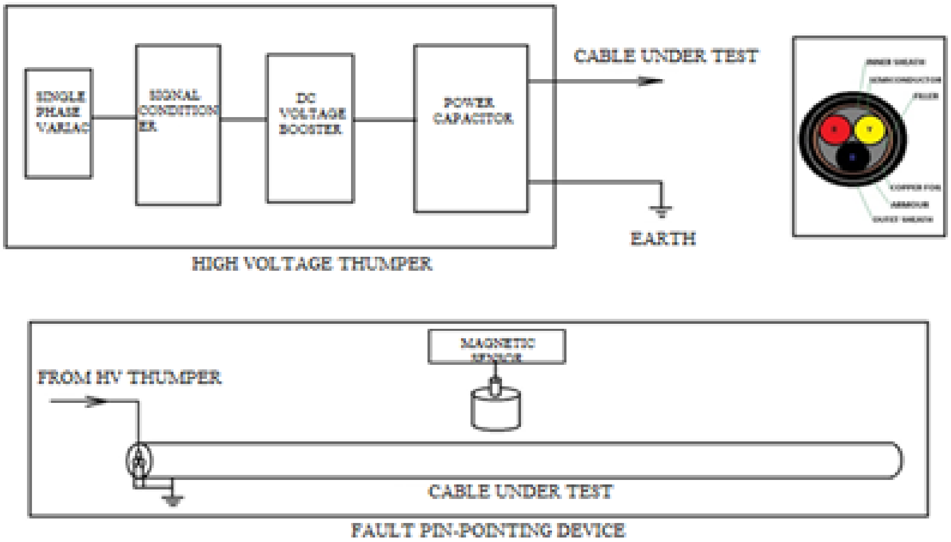

Fig. 1System Block Diagram

A) High Voltage Thumper

The device is basically high voltage pulse generator consisting of a dc power supply, high voltage capacitor.The power supply is used to charge the capacitor into the cable under test.If the voltage is enough to break the fault,the energy stored into the capacitor is suddenly discharged into the cable producing sound and vibrations which is also called "thump" [1].

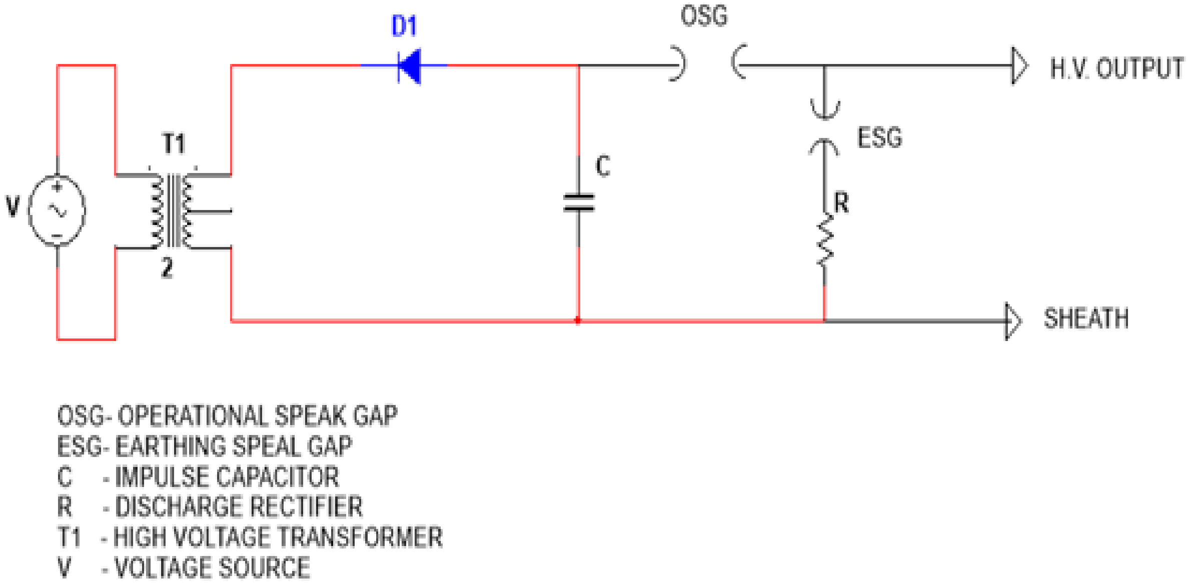

Fig. 2 Basic construction of Modern HV surge Tester

High resistance flashing and intermittent nature faults in underground cables are located successfully by shock discharge method. Stored energy from an implse capacitor is discharge into the faulty cable through a spark gap (fig. 2). The released energy is defined in Ws(Joules) is calculated as

$$J=\frac{2V \times C}{2}$$

High voltage thumper is mainly consists of a Single phase variac, Signal conditioner, Dc voltage Booster, Power capacitor.Single phase variacis an auto transformer with only one winding. In an autotransformer, portion of the same winding act as both the primary and secondary side of the transformer[2]. Signal Conditioner is a electronic device which manipulating an analog signal in such a way that it meets the requirement of the next stage for further processing. Here signal conditioner is used as a rectifier circuit which converts ac signal into the dc signal (+5v or +12v) (fig. 2).Dc voltage Booster (step up convertor) is a Dc to Dc power convertor with an output voltage greater than its input voltage[3]. Power of the boost convertor can come from any suitable dc sources, such as batteries, solar panels, rectifiers and Dc generators process that changes one DC voltage to a different DC voltage is called DC to DC conversion (fig. 1). A boots convertor is a DC to DC convertor with an output voltage greater than the source voltage.A boost convertor is sometime called a Step-up convertor. Since it “Stepup” the source voltage. Since power (P=VI)must be conserved, the output current is lower than a source current[4].A capacitor is passive two terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely,but all contain at least two electrical conductors(plates) separated by a dielectric(i.e. insulator)[5]. The conductor can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. When there is a potential difference across the conductors, an electric field develops across the dielectrics, causing positive charge +Q to collect on one plate and negative charge –Q to collect on the other plate. All these equipment combining called as thumper and the process is called as thumping [1].

B) Fault Pin-Pointing Device

The surge wave receiver serves for pin point location of faults in power cables as per the acoustic method. For this purpose, electrical flash over (arc) is generated at the fault by means of surge wave tester. The energy dissipated into the fault by surge wave tester produces big sound at the fault point on the cable. This sound is termed ‘thumping’. The thumping sound gets attenuated during travel to the surface of the ground. A sensitive ground microphone connected to a high gain amplifier is given on the headphone as well as on the bar graph display for visual evaluation of the signal received (fig. 3). The energy dissipated into the cable fault generates electromagnetic field around the cable. The field produces flux linkages into a coil placed in the ground microphone is placed above the cable. The signal is further amplified and given on LCD bar graph display. This helpsthe operator to walk on the lay of the cable. Under mute operation, the acoustic window is opened for short period at the arrival of the electromagnetic wave (fig. 3). This enables the operator to reach the fault point quickly without hearing the unwanted noise [1].

The surge wave receiver has two independent receiving channels namely acoustic and magnetic. These channels have independent LCD bar indicators. Ground Vibrations/minute acoustic signals are picked up by sensor of MIC. These signals are amplified and given on the headphone as well as LCD bar graph indicator namely acoustic. Simultaneously electromagnetic waves are picked up by sensor at signal level is displaced on LCD bar indicator namely magnetic [1].

C) Cable

Usually standard copper (cu) or aluminium (Al) conductors are used. Copper is denser and heavier, but more conductive than aluminium. Electrically equivalent aluminium conductors have a cross- sectional area approximately 1.6 times larger than copper, but are half the weights which may save on material cost. Surface coating of copper conductors is common to prevent the insulation from attacking or adhering to the copper conductors and prevents deterioration of copper at high temperatures. Tin coatings are used in the past to protect against corrosion from rubber insulation, which contained traces of the sulphur used in the vulcanising process. For mechanical protection of the conductor armour is used. Steel wire armour or braid is typically used.

When electric current pass through the cable it produces the magnetic field (the higher the voltage the bigger the field and hence sound at the fault position will be greater). The magnetic field will induce an electric current in steel armour (eddy currents) (fig. 3), which can cause overheating in Ac systems. The non-magnetic aluminium armour prevents this from happening. From underground cables, a nylon jacket can be applied for termite protection, although sometimes a phosphor bronze tape is used.

III TEST METHOD/FAULT PROCESS

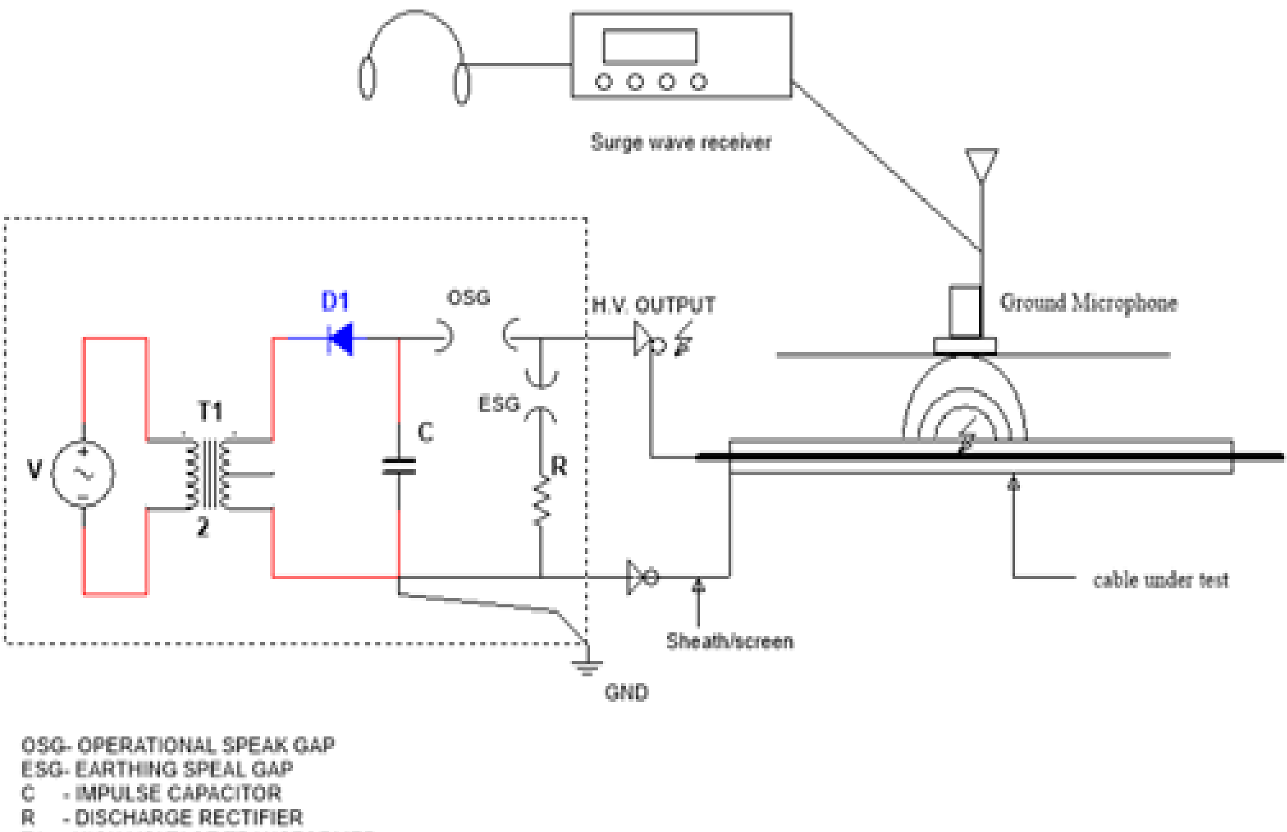

Fig. 3Test Method

To understand how faults are located, it is necessary to discuss the properties of the breakdown process. All faults can be represented electrically by a gap shunted by a resistance[6]. Although the electrical circuit is simple, variations in the conditions of the two paths can over an extremely wide range, the resistance ranging from a dead short to many megohms, and the gap breakdown voltage varying from zero to many thousands of volts. While modelling the faults itself is important, so is modelling the faulted cable. When a cable fails, Portion of the cable are destroyed (fig. 3). Depending on the cable type and the available fault current in the circuit, the damage at the fault site can vary anywhere from a small pinhole to damage that destroys both the centre conductor and neutrals. Traditional classification of faults as high or low resistance only describes the fault partially. Successful application of fault locating techniques requires complete definitions that describe the state of the conductors of the cable as well as the impedance of the faults. The different faults are High- resistance fault, Low-resistance fault, Shunt faults, and Series faults [7].

The core of the surge wave tester is the capacitor bank consisting of four non polarised impulse capacitors, having extremely low self inductance that offers minimum self loss. The capacitor bank is charged through rectifier circuit and HV transformer coils encapsulated in resin molds. The variac in the primary side of HV transformer enables to start the surge testing from zero and gradually increase the output energy to full extent on the selected range to obtain flash-over across the fault. The spark gap consist of an operational spark gap and protective or discharge spark gap (fig. 2). Both these spark gaps remain in open condition when the HV circuit is energised. Operational spark gap closes at the time of impulse release.The impulse sequence of the operational spark gap can be pre-selected by means of a timer switch having 3, 6, and 10 seconds intervals(Depending on the model used) The timer switch has a single impulse position also, in which the operational spark gap operated by a push switch. At the time of switching off/mains failure during operation, both spark gap close, thereby the cable under test as well as the impulse capacitor bank discharge instantly. This brings the instrument and the cable under test to safe working condition [1].

After the approximate position of the fault has been found using a radar method, some means of pinpointing the fault must be used. A common practice has been to apply repeated high-voltage surges to the cable and listens for the "thump". To date, this is by far most successful method used to pin point the precise location of the fault. However, indiscriminate use of surge generator can place sound insulation at risk. It is prudent to minimise the stress to the cable because there is suspicion that excessive impulsing of aged cable shortens its life [8]. The safest way to pin point a fault is to keep the surge voltage as low as possible and to apply only as long is needed. The problem associated with this approach is that sound decreases when the voltage is lowered. Increasing the capacitance in the surge generator can compensate this but the point of diminishing returns is quickly approach when the increase in size and cost does not justify the added benefits (fig. 3).To simplify the task of fault pinpointing, the industry has developed acoustic listening devices that amplify the sound of the thump. Using devices like these can simplify fault locating greatly, especially in difficult cases where the cable is buried deep. The simplest acoustic detectors are geophones followed by an amplifier. These devices work well if the operator is experienced in their operation. The general approach is to listen carefully in the vicinity of the fault, move the detector, listen again and make a judgment, based on the sound, whether the geophone was placed closer to or farther from the fault. This requires a trial-and-error approach that translates into an increased number of thumps being applied to the cable. Furthermore, when an inexperienced operator uses these devices, the time to locate the fault increases even more.

IV CONCLUSION

In this paper a system for locating permanents faults in underground distribution network is presented. It can be used on 1-ph, 2-ph, 3-ph voltage distribution network. The resulting high current arc makes a noise loud enough for hear above ground.The result is found that the proposed technique provides satisfactory result and will be very useful in the development of power systems protection scheme.

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