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Fault Location in Underground Distribution Networks

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ABSTRACT: Underground cables have been widely implemented due to reliability and environmental concerns of a distribution system. An accurate identification of a faulty segment is required to reduce the interruption time during fault. Speedy and precise fault location plays an important role in accelerating system restoration, reducing outage time thereby reducing great financial loss and significantly improving system reliability. This paper proposes a fault identification method in distribution system. The system consists of a fault locator for underground cable circuits for calculating more accurately the location of a cable fault. It includes a transmitter and receiver unit. The transmitter unit consists of step up transformer with delay timer for injecting a series of high voltage pulse streams into the faulted cable shortly after the cable fault has been established. The effect of noise caused by arcing voltage is received by a receiver which helps in accurate location of cable fault.

KEYWORDS: Transformer 315V/120 kV, Digital Timer, Load Balancing Unit, Receiver Section, Monitor Section

I. INTRODUCTION

In modern electrical power systems, the transmission and distribution networks are growing continuously and their reliability is getting more important than ever. The complexity of the whole network comprises various components that can interrupt and fail the power supply for the end user. An accurate fault location for transmission lines is of vital importance in restoring power services and reducing outage time as much as possible.

Concerns about the reliability of overhead lines, increases in their maintenance and operating costs, and issues of public safety and quality-of-life are leading more and more utilities and municipalities to the realization that converting overhead distribution lines to underground is the best way to provide high-quality service to their customers. Underground cables have been widely applied to reduce the sensitivity of distribution networks to the environmental influences. Because they are not influenced by weather conditions, less liable to damage by storms or lightning, no susceptible to trees, less expensive for shorter distance, environment friendly and low maintenance. For utility companies, undergrounding provides potential benefits through reduced operations and maintenance costs, reduced tree trimming costs, less storm damage and reduced loss of day-to-day electricity sales when customers lose power after storms. The underground cable system is very important for distribution especially in metropolitan cities, airports and defence service. However, the disadvantages of underground cables should also be mentioned, including 8 to 15 times more expensive than equivalent overhead lines, less power transfer capability, more liable to permanent damage following a flash-over, and difficult to locate the fault.

Fault location on communication and power cables is a very specialized area of electrical technology. The rising demand for electrical energy increases the importance and priorities of uninterrupted service to customer. Thus, faults in power distribution networks have to be quickly detected, located and repaired. Generally, when fault occurs on transmission lines, detecting the fault is necessary for power system in order to clear fault before it increases the damage to the power system. Because of large damage and inference of power cable accident, power authorities want to have exact fault detection method to recover power lines as soon as possible. The performance of efficient fault

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location is very much dependent on good logistics and knowledge. Fast and reliable fault location is dependent on these factors if prelocation of a fault is to be done with high accuracy.

II. TYPES OF FAULT IN UNDERGROUND CABLES

The most common types of fault that occur in underground cables are:

1. Open Circuit Fault.

2. Short Circuit Fault.

3. Earth Fault.

1. **Open Circuit Fault:** When there is a break in the conductor of a cable, it is called open circuit fault. The open-circuit fault can be checked by a megger. For this purpose, the three conductors of the 3-core cable at the far end are shorted and earthed. Then resistance between each conductor and earth is measured by a megger. The megger will indicate zero resistance in the circuit of the conductor that is not broken. However, if the conductor is broken, the megger will indicate infinite resistance in its circuit.
2. **Short Circuit Fault:** When two conductors of a multi-core cable come in electrical contact with each other due to insulation failure, it is called a short-circuit fault. Again, we can seek the help of a megger to check this fault. For this purpose, the two terminals of the megger are connected to any two conductors. If the megger gives zero reading, it indicates short circuit fault between these conductors. The same step is repeated for other conductors taking two at a time.
3. **Earth Fault:** When the conductor of a cable comes in contact with earth, it is called earth fault or ground fault. To identify this fault, one terminal of the megger is connected to the conductor and the other terminal connected to earth. If the megger indicates zero reading, it means the conductor is earthed. The same procedure is repeated for other conductors of the cable.

III. RELATED WORKS

The common methods of locating faults in underground cables are follows:

1. 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 time and 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.

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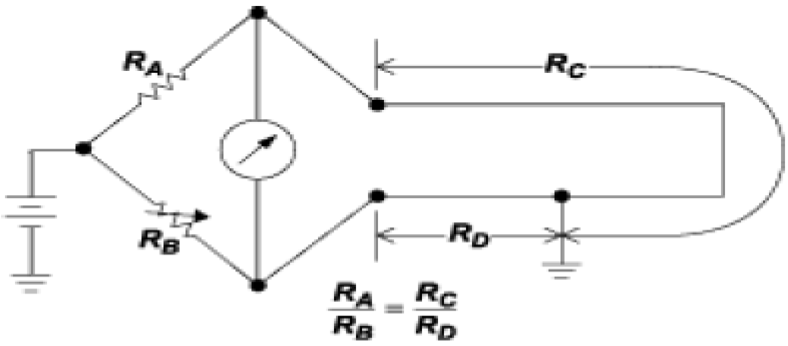

Fig .1.Murray Loop Test

In above figure, RC is proportional to (l+ (l-x)) and RD is proportional to l. Therefore

RA/RB=r=RC/RD = (2l-x)/x (1)

And hence

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 UG cable resistance and cable conductors have uniform resistance per unit length.

4. 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.

The drawbacks of the above methods can be overcome to certain extent by this method of applying high voltage pulses.

IV. BLOCK DIAGRAM

This paper implement the fault location in underground distribution networks. Here a series of high voltage pulse streams are injected into the faulty cable shortly after the cable fault has been established. The effect of noise caused by arcing voltage is used for the determination of accurate location of cable fault.

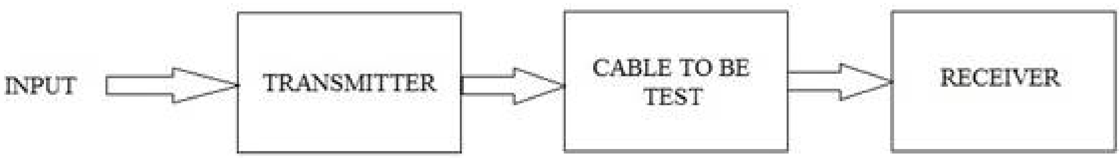

Fig.2: Basic block diagram

The basic block diagram is shown in the figure. Basically it includes a transmitter and receiver unit.

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V. EXPLANATION

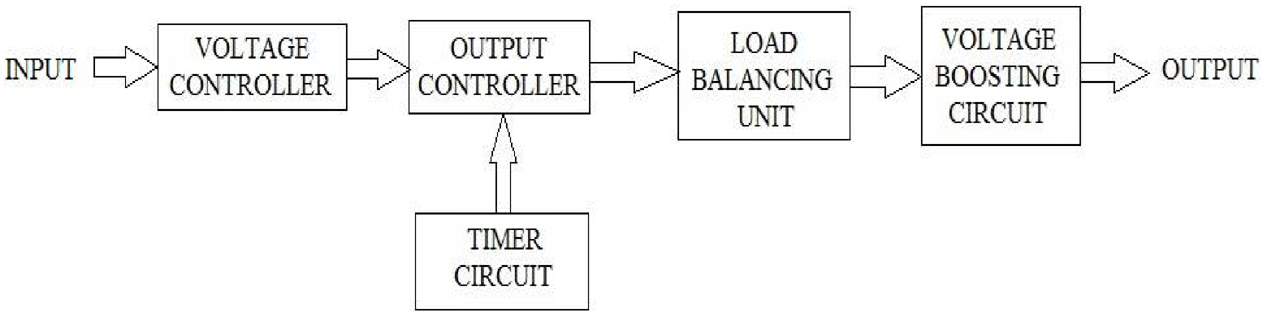

Fig.3: Transmitter Unit

The transmitter is basically a pulse generating unit. It consists of

1. Input Supply: The circuit uses standard three phase, 50Hz power supply and is given to the voltage controller.
2. Voltage Controller: It is a three phase autotransformer used to vary the input voltage. The voltage selection depends upon the type faulty cable and the type of fault.
3. Output Controller: The output controller is contactor or electrically controlled switch used for switching the electrical power network. It is similar to a relay except with high current rating.
4. Timer Circuit: It is a Digicon Series Multi-Function Digital Timer. It consists of 3 digit LCD display with wide timing range from 0.1 sec to 999 h and wide operating voltage of 24 to 240 VAC/DC.
5. Load Balancing Unit: It is a Scott connected transformer for transforming 3 Phase to 2 Phase supply. There are two main reasons for transforming three phase to two phase. To give a supply to an existing two phase system from a three phase supply and to supply two phase furnace transformers from a three phase source.
6. Voltage Boosting Circuit: It is a step up transformer with rating 315V/120kV.

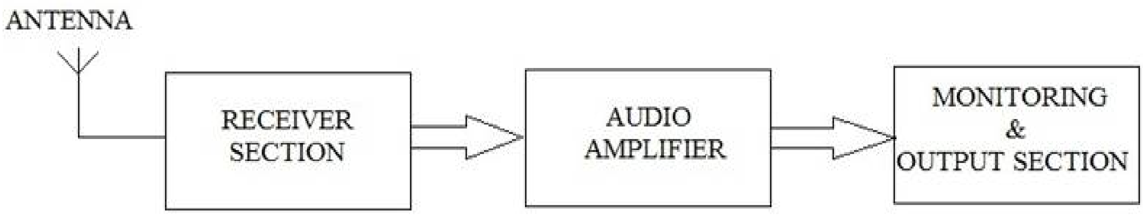

Fig.4: Receiver Unit

1. Receiver Section: It consists of an antenna which receive the noise frequency of the arc produced across the faulty position of the cable.
2. Audio Amplifier: It amplifies the signal received by the antenna.
3. Monitoring & Output Section: The display part consists of 16x4 pins LCD display interfaced to the Arduino board which shows the signal strength as percentage, in case of any fault and also display the time, date and year.

VI. WORKING

This paper implement the fault location in underground distribution networks. It includes a transmitter and receiver unit. In order to determine the location of fault in a cable, first of all isolate the faulty cable from both the feeder end

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and consumer end. Using a megger, check which type of fault being occur in the cable. This will help to understand the type fault and also we can select appropriate value of input supply.

After isolating the cable, the core and shield of the underground cable is connected to the output terminals of the transmitter unit. Transmitter unit consists of step up transformer with output controller and delay timer for injecting a series of high voltage pulse streams into the faulted cable shortly after the cable fault has been established. Now the receiver unit is traced along the length of the cable. The fault in the UG cable produces arcing which is accomplished by high frequency noise. The effect of noise caused by arcing voltage is received by a receiver. The strength of the detected signal is display on the LCD display. Thus provide an accurate location of the cable fault.

VII .CONCLUSION

Detection and location of faults are very important in the power system as they are the basic of protection of the power system. If detection and location of faults are not accurate, the protective devices cannot trip properly and required operation cannot be done, which may leads to damage of the large equipment. This paper reviews some of the cable fault locating methods that are mostly used in practical field and focuses on accurate fault detection in underground cables and thereby eliminates the power failures in the distribution system.

In the proposed system, the receiver unit will be carried by human along the path of the underground cable layout. Considering the human effort and safety involved, it is recommended that the receiver unit can be in cooperated with a robot. The robot will trace the faulty section automatically. The robot can be connected to the main control unit via network.

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