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Methods of Fault Location in Cable System

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Abstract: **Finding and designing new methods for determining type and exact location of faults in power system has been a major subject for power system protection. One of the main capabilities that can improve the efficiency of new protection relays in power systems is exact fault location. In this paper various approaches used for determining fault location in cable systems and the factors that affects the fault location are discussed.**

Keywords: **Fault Location, Neural Networks, Cable System, Fault location based on ANNS, Factors affecting fault location**

1. INTRODUCTION

The main function of the electrical transmission and distribution systems is to transport electrical energy from the generation unit to the customers. 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 system, it is hard to seek out the fault location. The demand for reliable service has led to the development of technique of locating faults. During the course of recent years, the development of the fault diagnosis has been progressed with the applications of signal processing techniques and results in transient based techniques. It has been found that the wavelet transform is capable of investigating the transient signals generated in power system. In recent years, there have been many activities in using fault generated travelling wave methods for fault location and protection. The travelling wave current-based fault location scheme in which the distance to fault is determined by the time differences measured at the sending end betweenanincident wave and the corresponding wave reflected from the fault have been developed for permanent faults in underground low voltage distribution networks. However, due to the limitation of the bandwidth of the conventional CT (up to a few GHz) and VT (up to 50 kHz), the accuracy of fault location provided by such a scheme is not satisfactory for a power cable [1]. Also there have been many activities in using power frequency (low frequency) for fault location and protection. However, in such techniques which are based on power frequency signals, some useful information associated with high frequencies in transient condition is missed. In association with wavelet transform the artificial intelligence can also be used in locating faults on power cable by means of neural networks [2]. Although this method is complex yet speed for fault location is increased.

2. IDENTIFICATION OF FAULT LOCATION METHODS

The approach used by utilities for fault location depends on the types of installations. Underground distribution circuit routes are less defined than underground transmission circuits and affect the application of fault location methods. The details required to locate the fault vary with the types of installations. Several techniques were determined from literature searches, fault location equipment-manufacturers. Each of these are summarized in the following sections, where the general procedure and some theory for the approach to each method is described. Generalized descriptions of the two categories of fault location methods are provided in the following two paragraphs.

2.1 Terminal Methods:

Terminal fault location methods are techniques which are performed from one or both ends ofthecable circuit. In general, these methods are most useful in pre-locating the cable fault.

2.2 Tracer Methods:

Cable fault location with tracer techniques requires "walking the route" to locate an audible or electromagnetic signal. These methods are most useful for pinpointing the fault location after the approximate location has been determined.

3. FAULT LOCATION METHODS

3.1 Bridge Techniques:

Bridge techniques require a resistive bridge to determine the location of the fault. In the past, bridges were useful for locating cable faults although the accuracy of common null detectors (galvanometer or other means) was poor. With the advent of digital multi-meters and other devices that may be accurate to 4-5 digits, several utilities are revisiting the use of bridges for cable fault location. A generic bridge is shown in Figure 1.

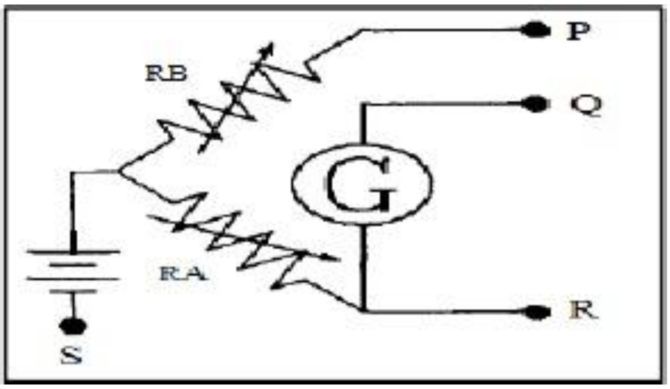

Figure. 1

Typical electrical bridge with terminals P, Q, R, and S in the bridge, RA and RB are variable resistors that are adjusted until the galvanometer, Indicates a null. Under this condition, the bridge is balanced. Several fault location methods employ the use of abridge. Each of the bridge methods found during research for the EPRI fault location expert system is described in the remainder of this section.

1. Hillbom Loop

2. Murray Loop,

3Murray Loop Two-End

4. Murray-Fisher Loop

5. Open &Closed Loop

6. Varley hop

7. Werren Overlap

$$X = \frac{R_A}{R_A+R_B+L_{UF}} L_F \ldots\ldots(1)$$

Where, X is distance to fault, L_{UF} and L_F is length of un-faulted cable and faulted cable.

3.2 Other Techniques:

1. Capacitance Ratio

2. Charging Current

3. DC Charging Current

4. Halfway Approach

5. Insulation Resistance Ratio

6. Pulse Discharge Detection

7Rudarhw Voltage

8. Radar with High Voltage Pulse

9. Standing Wave Differential

10. Voltage Drop Ratio

In these methods, 1, 2, 5 are valid for open conductor faults on shielded cables. Since the faults open, itis possible to measure the capacitance, C of the cable section from one terminal to the fault and ratio this value to the capacitance, C of an un-faulted cable. The measurement is made from both ends. Method 3 is valid for shorted and high-impedance (shunt) faults on shielded primary distribution cables. This method provides a means to isolate a faulted feeder by using a d.c. source and volt-meter. The voltmeter is connected in series between the d.c. source and the cable conductor. With the D.C. source applied to a healthy cable, the volt-meter will initially show a potential between the source and the cable, but will gradually go to zero as the cable is charged. A faulted cable will never sustain a charge (continuously discharging through the fault), so the volt-meter will show a continuous voltage, thereby indicating faulted cable. While Method 4 is valid for all fault types. For extremely difficult faults, it may be necessary to sectionalize the cable and then test the individual sections until the fault is located. This is done by disconnecting the cables at pad-mounted transformers, riser poles or other convenient points. In extreme cases (long circuits with limited access to terminals), it may be necessary to cut the cable and perform a test. This may damage the cable and prolong service restoration efforts. Methods 5, 6, 7 employ the use of an impulse generator or capacitor discharge device (thumper) to cause a breakdown at the cable fault. A signal is sent down the cable which produces reflections at the fault location. Where conventional radar does not sufficiently indicate the location of a cable fault, a capacitive discharge device may enhance the radar trace. 9 and 10 are valid for all types of faults on shielded cables.

4. FAULT LOCATION BASED ON ANNS

ANNs have emerged as a powerful pattern recognition technique and act on data by detecting some form of underlying organisation not explicitly given or even known by human experts and it possesses certain features which are not attainable by the conventional methods. In this respect, this paper describes a new method for fault location based on the ANNs technique. The successful development of ANNs approaches depends on the successful learning of the correct relationship or mapping between the input and output patterns by the ANNs [2]. In order to achieve this, practical issues surrounding the design, training and testing of an ANN such as the best network size, generalization versus memorisation, feature extraction, convergence of training process and scaling of signals have been addressed and examined. In order to find the best topology for accurate fault location, an extensive series of studies have revealed that it is not satisfactory to merely employ a single ANN and attempt to train it with a large amount of data. A much better approach is to separate the problem into two parts: firstly to employ and train an ANN to classify the faults; secondly, to use separately ANNs (one for each type of fault and faulted phases) to accurately locate the actual fault position. Fig. (2) Shows the fault location scheme based on ANNs.

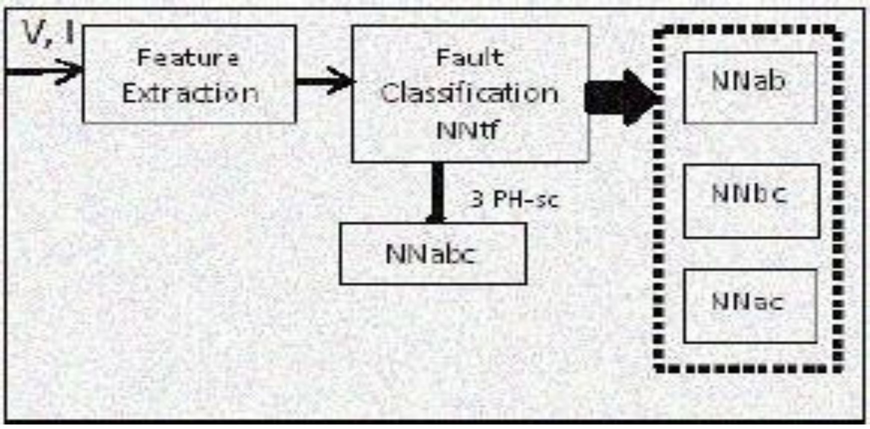

Figure 2

Schematic diagram of fault location by ANN There are many types of ANNs but the most commonly used are the multi-layer feed-forward networks, as, a three-layer network (input, one hidden and output layers). Because of this, a fully connected three-layer feed-forward ANNs with Levenberg-Marquardt (LM) learning algorithm can be used in the complete fault classification and fault location networks.

5. FACTORS AFFECTING ON FAULT LOCATION

5.1Effect of fault parameters:

The inception angle significantly affects the fault transient voltage and current signals and itis vitally important to verify the effect of this parameter on the performance of the proposed technique. This feature is important since in practice, faults can occur at any point on wave i.e. the fault inception angle cannot be defined in advance [2].

5.2 Effect of remote source:

It is well known that a remote in feed can adversely affect the accuracy of conventional fault locators. These small changes can be directly attributed to the fact that with a remote source, the current changes in the healthy phase in terms of magnitude and distortion.

5.3Effect of load taps:

It is apparent that load taps significantly affect the fault transient waveforms. Therefore, it is vitally important to verify the effect of the load taps on the performance of the proposed techniques. This is a significant advantage since being different load taps at different location of DS is inevitable.

5.4 Effect of cable length:

The cable length can vary considerably in the DS, it is vitally important to ascertain as to what extent the fault location accuracy is affected as a result of a change in the cable length.

5.5 Effect of External Faults:

In any fault location technique, although a high accuracy for internal faults is of primary concern, nonetheless, it should also be stable under external faults.

6. CONCLUSION

In this paper, different methods of fault location in underground cable systems are discussed. For bridge technique accuracy level is poor, while accuracy level of wavelet transform is quite high compared to bridge technique but, it is still lower than artificial neural networks. By combining wavelet transform and neural networks the fault location accuracy increases and is found higher than other methods.

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