INTRODUCTION

Abstract: Fault location in radial distribution Systems can be divided into two important steps. The first is to identify the fault branch and the second one is to determine the location of the fault in the faulty branch. It is rare less papers in the field of faulty branch identification. In this paper a new method based on previous works is presented for identifying the faulted branch in a distribution system. The proposed method takes advantage of the special properties of wavelet transform to differentiate between faults occurring along different laterals of the same main feeder, with equal distance away from the main substation. The advantages of the method compared with the previous ones are: a) JMarti line model simulation improvement, b) using a specified range for $s$ factor instead of a fixed number for a branch of network depend on its topology c) generalizing the method for untransposed lines and deriving modal matrix for them. The algorithm of this method has been tested for a test radial distribution network. Simulation results obtained by using ATP/EMTP for the sample distribution system are included for demonstration of the proposed method.

Faults in distribution systems effect power system reliability, security and quality. Accurate fault location minimize the time needs to restore power and will reduce the costs. The application of traditional fault location techniques that use fundamental voltages and currents at line terminals for distribution lines with tapped load is difficult. In recent years they have been used in conjunction with the concept of traveling wave and wavelet transform [8].

In distribution systems, fault location technique based on the information provided by DFR is not so common. Usually the fault location is estimated based on the information provided by the customer and is verified by the experienced dispatcher who sends the crew to the suspected location. If the initial estimation is incorrect, the dispatcher will have to make another guess and redirect the crew to the newly suspected location. This procedure may be repeated several times before successful location of the fault, for systems with several laterals emanating from the same feeder.

Several new techniques have been proposed in the recent years to address this problem. In [1] a fault location technique for radial transmission lines with multiple loads taps data available only at the source side of the line is presented. A technique based on the high frequency measurement is proposed in [2]. Reference [3] proposed a fault location technique for rural distribution systems based on the apparent impedance method approach. Another technique based on the concept of super imposed components of the voltages and currents rather than total quantities are presented in [4]. Nevertheless, the case of a feeder having multilateral, with measurement normally available only at the substation where multiple possibilities of fault location exist for a given recording has not been fully resolved. The essential problem of such a case is that a number of possible locations by the same electrical distance from the substation can be found for a specified recorded signal at the substation end. Some attempts to address the problem of multiple solutions have been made using knowledge based approaches [5]. They are based on not only the information provided by the measurements but also that information presented in [7] integrated the information available from a substation DFR with the known feeder configuration as well as the protective coordination scheme used for the feeder. This data may not be accurate or even not available at all at the substations.

PROPOSED METHOD

According to the traveling wave theory, fault transients will have different signature at the substation terminals depending in network junctions which they pass through from them as travel toward the substation. These signatures can only show up at the high frequency study of voltage signals. Fig 1 shows that the fault path between the substation and the actual fault location contains different number of network junctions depending on which lateral is actually faulted. For instance, for a fault at NQ or at EG, there will be 2 or 3 junctions respectively between fault and the Node C (substation bus). Here “Junction” is used to refer to a network node with more than 2 incident branches. A load may also appear as a branch, even though most loads being inductive, will be have like open circuits at high frequencies. Although the traveling wave signals due to faults at EG and NQ may have the same frequency spectrum, their amplitude will be different due to the different attenuation factors resulting from different number of junctions in their paths connecting to the substation [8]. In order to determine fault branch in a radial distribution network, the three-phase voltage of substation supplying bus must be recorded in the sampling rate of at least 100 KHz.
The procedure of fault location can be described as follows: first, the phase voltages are transformed into the modal domain, then the modal signals are decomposed into the wavelet coefficients (WTC), in the next step, the energy of the signal which is in the bound of 12.5-25 KHz is described. The amount of this energy is compared with the database and finally, the path and the distance to the fault are estimated using the information provided by the WTC [8, 9].

Calculation routine:

The most important step in this algorithm is the calculation of modal matrix. In untransposed line, this matrix is extracted by “line constant” module of EMTP for desired frequency range. This matrix is used to transform the Phase signal to modal signal.[9]

\[ \text{Smodal} = T \times \text{Sphase} \]  

In Simple case, when the line is fully transposed above formulation is simplified to Clark transformation. \((2)\)

Mode 2 of Voltage signal which is used for wavelet transformation after decomposition to 4 detail levels by db4 will be used for branch identification. The s factor for this mode is as below:

\[ S = \left[ \text{WTC}_i^T \times \text{WTC}_i \right] \]  

Where WTC is the wavelet transformation coefficients of the mode 2 in desired scale, \(i\) is the scale number.

This factor is now ready to compare with the database, which is provided for each faulty branch of the network. The amount of S factor is in the specific range between two nodes S factor, it will show the branch of fault in the network. It must be noted that in constraint with the usual method for modeling J-Marti which a typical model it as a reference model and is repeated in all the simulation, for extracting the S factor in forming database each branch must be modeled by a unique J-Marti alone.

(Because the virtual nodes of each J-Marti typical model should not add the nodes of the network)

Simulation result

This algorithm is tested for the network shown in Fig 1. This network is part of a real distribution network. The lines are untransposed by which the EMTP line constant module is used for extracting J-Marti model.

Sampling rate is 100 KHZ and desired scale the frequency boundary is 12.5-25KHz. A database is formed for this network.

At the next step the fault is modeled in six nodes as NQ, EK, EG and QS, KM, GI in each time. In the Fig 2.

The S factor for the database and for each of six cases as mentioned above is shown in Fig 3. It is clear that this algorithm can locate the fault by good estimation.
A fault location technique based on high frequency signals is developed. The method identifies the faulted lateral. The identification method is described in detail with examples. The method is based on the wavelet decomposition of the transient signals. After the initial identification stage, using the post fault steady state phasors along with the simplified model of the system, the exact fault location can be calculated. The identification of the faulted lateral is based on the voltage signal decomposition in a frequency spectrum from 12.5 to 25 KHz, therefore voltage transducer with a bandwidth of 50 KHz are needed.

In this paper a powerful method for fault location in distribution network was proposed. Besides of the good estimation of this method for determining the path and distance of faulted point, this method is insensitive to the initial phase angle of Voltage, and the network loading. The result is shown in Fig 4.

**REFERENCE**


