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Fault identification in electrical power distribution system using combined discrete wavelet transform and fuzzy logic

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Abstract

In this proposed work a fuzzy logic based algorithm using discrete wavelet transform is developed for identifying the various faults in the electrical distribution system for an unbalanced distribution electrical power system. This technique is capable to identify the ten different types of faults with negligible effect of variation in fault inception angle, loading and other parameters of the power distribution system. The proposed method is tested on IEEE 13 bus electrical distribution system and on an Indian scenario of distribution system. The current of respective three phases is used as input signal for fault identification and the results obtained from the proposed method are more than satisfactory.

Keywords: Fault identification; Fuzzy logic; Discrete wavelet transform; Fault inception angle

1. Introduction

Nowadays, distribution systems carry a large amount of power as compared to earlier era because of increase in per capital consumption of electricity. Any, change is not predicted in the present trend in near future and it will sustain for decades at least in India and in other developing countries. So, any disturbance in the power supply may lead to discontinuation of power supply and degradation in the power quality. Distribution system is the most vital component in terms of its effect on reliability, quality of service, cost of electricity and aesthetic impact on society. In any industrialized country, the distribution system delivers electricity literally everywhere taking power from different generating station to the end users. Two foremost things which are required for quick restoration of the faulty part are fault location and type of fault. Similarly, in digital distance protection system the appropriate operation of protective device and accurate classification of the fault are necessary (Grainger and Stevenson, 1994).

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By seeing the above mentioned benefits of fault type identification a lot of research work is carried out (Aggrawal et al., 1999; Lin et al., 2001; Ferrero et al., 1995; Wang and Keerthipala, 1998; Girgis and Johns, 1989; Protopapas et al., 1991; Togami et al., 1995; Chen et al., 2000; Adu, 2002). Previously, a large amount of research work has been done in the electrical transmission system as they carry large amount of power and any disturbance on the transmission system will affect the whole power system. Nowadays, distribution system is also carrying a large amount of power due to increase in urbanization and industrialization in developing country like India. Moreover the use of underground cable also increases the complexity in fault identification. So, distribution system fault type identification is becoming much more important.

Although, a large number of techniques are available for fault identification and classification. Some of them are based upon continuous monitoring of (1) Voltage, (2) Current, (3) Impedance, *etc.* All these techniques have their own advantages and disadvantages (Alanzi et al., 2014).

Some intelligent techniques, (generally known as knowledge based techniques) of the fault classification in transmission line are based upon Neural Network (Aggrawal et al., 1999; Lin et al., 2001); Fuzzy Logic and Fuzzy Neural Network (Ferrero et al., 1995; Wang and Keerthipala, 1998); and knowledge system based approach (Girgis and Johns, 1989; Protopapas et al., 1991). All these techniques suffer from a major drawback that a proper training is required for neural network and these are not susceptible to high impedance faults. Most of the research work has been done for identifying the various types of fault *i.e.* whether the fault is line to ground, double line to ground, double line fault or three phase fault. Recently, the phase angle classification and fuzzy logic based schemes (Das, 2006) have been published in the research papers. A major drawback of the angle based method is that its accuracy is only about 60%. Other techniques such as the under-impedance and torque technique utilize the positive and zero sequence impedances of the electrical transmission line. But the zero sequence impedance of the transmission line cannot be determined precisely and are therefore, suitable for distance relays where the reach of the relays is defined. A fault recorder, however, is able to monitor all transmission lines emanating from a station and possibly most of the adjoining lines. Furthermore, the under-impedance and torque algorithms are sensitive to close-in faults with strong sources behind them. It is possible that for such fault conditions more than one measuring unit would estimate either the positive sequence fault impedance or the effective operating torque is close to the desired value. These techniques, therefore, cannot be reliably depended upon to determine the faulted phases under all fault conditions.

An angle based fault classification approach (Das, 2006) possesses a better benefit as the difference of load current and the fault current. Moreover the use of fuzzy logic provides greater flexibility for fault classification, but removing the decaying fault current component from the load current is very difficult and generally fuzzy membership function overlapping provides poor results. Multi Resolution Wavelet Transform algorithm (Gayatri et al., 2007) is very fast and accurate in classification of fault, but the main drawback is that it only identifies the type of fault *i.e.* LG, LL, LLG and three phase fault.

The proposed scheme of fault classification is more accurate as it can easily classify the ten different types of fault *i.e.* three types of line to ground fault, three types of double line to ground fault, three line to line fault and a three phase symmetrical fault. The main benefit of proposed scheme is that only three phase line current measurement is needed and no other parameter or information *e.g.* circuit breaker (CB) position and isolator is required. The developed method is tested on IEEE 13 bus distribution system and on Indian power distribution utility. All the signal analysis, distribution system model simulation and fuzzy logic system are designed in MATLAB®/SIMULINK environment.

2. Fault identification strategy

Fault identification strategy is achieved by implementing the discrete wavelet transform. The discrete wavelet transform is used to calculate the change in energy of a particular energy level of measured current signals. The energies calculated from discrete wavelet transform are then uses as inputs into the fuzzy logic system.

2.1. Discrete wavelet transform

The wavelet transform is a tested tool for analyzing and studying the signals effectively (Rizwan et al., 2013). The wavelet transform resolves the measured distorted signal into different time–frequency domains (Jamil et al., 2014). Wavelet transform uses the expansion and contraction of basis functions to detect various frequency components in the measured signal. Wavelet transform decomposes the signal into different band of frequencies. The basis function