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IDENTIFICATION OF POWER SYSTEM DISTURBANCES USING WAVELET TRANSFORM

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ABSTRACT

Electrical power system consists of three main structures which are generation, transmission and distribution system. If any disturbances occur in the system, it will affect the normal operating condition of the system. When a short circuit fault occurs in the system, the high fault current is produced and it will affect the overall reliability, power quality, protective devices in the system. In renewable integrated system, the fault will affect the overall interconnected system. Therefore fault identification plays a major role in power system.The objective is to identify the fault occurs in the system using wavelet .The fault identification requires fast and accurate analysis. The tripping action depends mainly on the voltage and current waveforms during the fault. Wavelet transform(WT) is a mathematical tool used for the analysis of the current waveform during faulty condition. The symmetrical and unsymmetrical faults are created and the fault current in the system is given to the wavelet transform. Energy values are extracted from wavelet transform and it used to identify the fault. The proposed methodology is verified by using MATLAB/simulink model.

Keywords: symmetrical fault, unsymmetrical fault, wavelet transform(wt).

1 INTRODUCTION

The main function of the electrical transmission and distribution systems is to transport electrical energy from the generation unit to the customer. 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. Transmission line protection has always been a topic of major concern in the field of Electrical engineering, as it is a vital power system and is constantly exposed to the environmental conditions. Indeed, the faults due to overhead transmission lines are about 50% as compared to the different types of faults that occur in a power system Fault Detection is important from the view point of improving system availability and reliability. Locating transmission line faults quickly and accurately is very important for economy, safety and reliability of power system. The methods for fault location such as measuring the changes of impedance or voltage and current of line before and after a fault occurred seriously rely on fault type, grounding resistance, load conditions and system running way. Therefore faults on electrical power system transmission lines are supposed to be first detected and then be classified correctly and should be cleared in least fast as possible time. The fault detection techniques depends mainly on studying the pattern of the voltage and current waveforms associated with the fault. Among these are

Kelman filtering based algorithms, Fourier analysis based algorithms and FIR filtering based protection. Recently a new technique is presented for wave analysis which is wavelet analysis. Wavelet analysis allows the decomposition of a signal into different levels of resolution. The basic function (mother wavelet) is dilated at low frequencies and compressed at high frequencies, so that large windows are used to obtain the low frequency components of the signal while small windows are used to obtain reflect discontinuities. Some applications of the wavelet analysis are used for modeling the power system transients, power quality and power system relaying.

1.1 Importance of Fault Analysis

- Rapid information about the type and the location of fault can assist the task of repair and maintenance, thereby minimizing the economic effects of power interruption.
- An analysis of system disturbances provides the wealth of valuable information regarding power system phenomena and the behaviour of protection system.
- Helps to improve reliability of the system.

1.2 Types of Fault

Fault is classified into two types

- Symmetric fault
- Asymmetric fault

1.2.1 Symmetric Fault

A symmetric or balanced fault affects each of the three phases equally. In transmission line faults, roughly 5% are symmetric. This is in contrast to an asymmetrical fault, where the three phases are not affected equally. These faults rarely occur in practice as compared with unsymmetrical faults. Two kinds of symmetrical faults include line to line to line (L-L-L) and line to line to line to ground (L-L-L-G). A rough occurrence of symmetrical faults is in the range of 2 to 5% of the total system faults. However, if these faults occur, they cause a very severe damage to the equipments even though the system remains in balanced condition.

1.2.2 Asymmetric Fault

An asymmetric or unbalanced fault does not affect each of the three phases equally. Common types of asymmetric faults, and their causes:

I. LINE-TO-LINE - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator. In transmission line faults, roughly 5% - 10% are asymmetric line-to-line faults.

II. LINE-TO-GROUND - a short circuit between one line and ground, very often caused by physical contact, for example due to lightning or other storm damage. In transmission line faults, roughly 65% - 70% are asymmetric line-to-ground faults.

III. DOUBLE LINE-TO-GROUND - two lines come into contact with the ground (and each other), also commonly due to storm damage. In transmission line faults, roughly 15% - 20% are asymmetric double line-to-ground.

2 FAULT LOCATION TECHNIQUES

Traditional line fault detection used to heavily rely on visual inspections of the faulted line parts resulting in long and tedious foot or aerial patrols. These methods were expensive and prone to more errors. Thus, the shift to automatic fault locators was not only desired, but also natural. Fault location techniques can be generally classified into the following main categories:

- based on fundamental-frequency currents and voltages, mainly on impedance measurement
- based on travelling wave phenomenon
- knowledge-based approaches
- based on high-frequency components of currents and voltages generated by faults.

The most widely used FLAs can be split into two main groups: impedance based and travelling wave based. Impedance-based algorithms make use of the line parameters (such as resistance, inductance and conductance per unit length, and the line length) as well as voltage and current data from one or more line terminals to calculate the distance to the fault from a reference point or line terminal. Travelling-wave based algorithms utilize the theory that waves travel along a line from a fault at the speed of light to calculate the distance to a fault from a reference point and timing wave reaching the line terminal.

2.1 Impedance Based Algorithm

Impedance based FLAs calculate fault distance using the per unit length impedance of the line, voltage and current data, and circuit analysis techniques, such as Kirchhoff's voltage and current laws. Single-terminal and two-terminal algorithms are the two main groups of impedance based FLAs. Single-terminal FLA (STFLA) often cited as the first and earliest class of FLA use voltage and current data from one end of the transmission line only. They determine the fault distance by calculating the impedance of the transmission line as seen from one line terminal and then using the line parameters to convert that value into a distance measurement. Two-terminal algorithm provides more accurate results compared to single-end algorithm because this two-terminal algorithm is not affected by fault resistance and reactance. Phasor voltage and current data can be collected from two-ends of a transmission line either by synchronized or unsynchronized. Synchronized data can be collected using GPS, PMU. For the unsynchronized data, users have to first compute the synchronization error and fault location is calculated. Since the synchronized method has to use the communication device, it is more expensive than the unsynchronized method.Requirements: Voltage and current information at primary substation level, grid topology, line and load data.Disadvantages: Lower accuracy with multiple fault location estimations. Affected by high DG penetration

2.2 Travelling Wave Based Fault Location Algorithm

The traveling wave fault location method is known as the most accurate method currently in use. Fault location on transmission lines using traveling wave was first proposed by Rohrig in 1931. In this method, when faults occur on transmission lines, an electrical pulse originating from the fault propagates along the transmission line on both sides away from the fault point. The time of pulse return indicates the distance to the fault point. This method is suitable for a long and homogenous line. The disadvantage of the traveling wave method is that propagation can be significantly affected by system parameters and network configuration. It is also difficult to locate faults near the bus or faults that occurred near zero voltage inception angle . Under this method, we have single-ended fault location algorithm and double-ended fault location algorithm. In single-ended algorithm, traveling time of the first wave away from the fault point to terminal and the arrival of same wave after reflecting back from fault point is always proportional to fault distance. In single-ended algorithm, fault location is proportional to the first two consecutive transient arrival time. From measurements of the first two consecutive transient arrival times, fault location can be calculated. In double ended algorithm, fault location is proportional to the arrival time of waves at each end away from the faults. Because of that limitation, wavelet transform has developed. In wavelet transform, dilation of a single wavelet is done for analysis. It uses short windows at high frequencies and long windows at low frequencies. It can represent signal both in time and frequency domain, which helps to figure out sharp transitions and fault location. The ability of wavelet transform to locate both time and frequency makes it possible to simultaneously determine sharp transitions of signals and location of their occurrence. Disadvantages: Costly installations of high frequency measurement devices and possibly equipment for pulse generation

2.3 Knowledge Based Fault Location Algorithm

Uncertainty of line parameter affecting variables, such as length of cables and unknown fault resistance, coupled with the complex structure of distribution management systems tends to make fault location through impedance and travelling wave techniques inaccurate. As a result of this, knowledge-based technique for locating faults has receiving attention from researchers in the last few years. In general, the technique requires information such as substation and distribution switch status, line measurements, atmospheric conditions, and information provided by fault detection devices installed along the distribution feeders. This information is analyzed using artificial intelligence methods to locate a fault. Requirements: Voltage and current data at secondary substation level, grid topology, line and load data.Disadvantages: Sensitive to modelling errors, requires repeated training and extensive data for training

2.4 High Frequency Component Based Fault Location Algorithm

High-frequency transient signals generated in the range of Hz to kHz due to fault conditions can be applied to achieve high accuracy in fault location as shown in the work established in reference papers. This method of fault location detection, based on the high frequency voltage and current components, has been shown to be immune to power frequency phenomena such as power swings and current transformer saturations. This method mainly uses the fault generated high-frequency signals, negating the problem of identifying multiple reflections of the travelling wave from bus-bars and the fault point, as is seen in the travelling wave based FLAs Problems associated with fault-inception angle are addressed as the high-frequency signals associated with the fault arc do not vary with the point on the wave at which the fault occurs.

3 WAVELET TRANSFORM

Wavelet transform (WT) is a mathematical technique used for many application of signal processing. Wavelet is much more powerful than conventional method in processing the stochastic signal because of analyzing the waveform in time scale region. In wavelet transform the band of analysis can be adjusted so that low frequency and high frequency components can be windowing by different scale factors. It allows time localization of different frequency components of a given signal. Windowed Fourier transform also partially achieves this same goal, but with a limitation of using a fixed width windowing function. In the case of the wavelet transform, the analyzing functions, which are called wavelets, will adjust their time-widths to their frequency in such a way that, higher frequency wavelets will be very narrow and lower frequency ones will be broader.

3.1 Wt Application In Power System

Wavelets were first applied to power system in 1994 by Robertson (Robertson et al., 1994) and Ribeiro (Ribeiro, 1994). From this year, the number of publications in this area has increased. The most popular wavelet analysis applications in power systems are as following:

- Power quality
- Partial discharges
- Forecasting in power systems
- Power system measurement
- Power system protection

4 SIMULATION RESULTS

The single line diagram of simulated system is given below

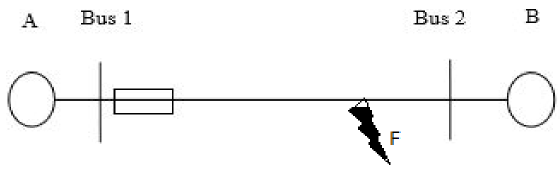

Fig.1 Fault System

Fig 1 shows the two sources A and B with buses 1 and 2.Simulink model of two bus and nine bus system is simulated in MATLAB/Simulink model. The fault is created and the fault current from the system is given to wavelet transform. Then the energy values are extracted from the wavelet transform and it used to identify the fault. The fault current waveform is given below and the energy values are tabulated.

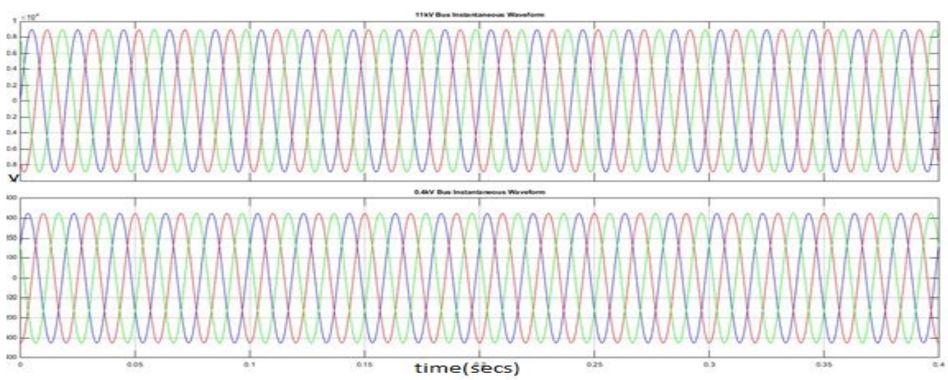

Fig 2 without fault

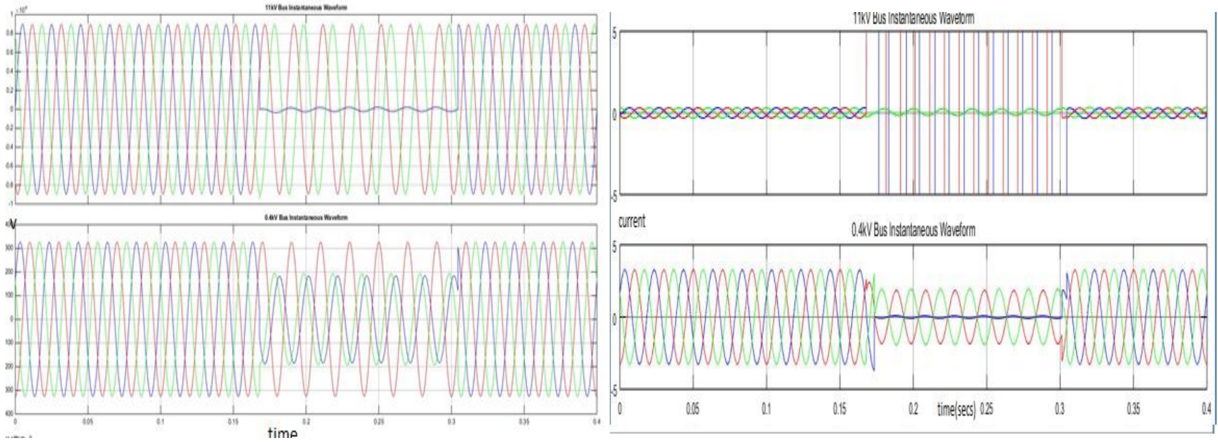

Fig 3 LG fault of voltage and current waveform

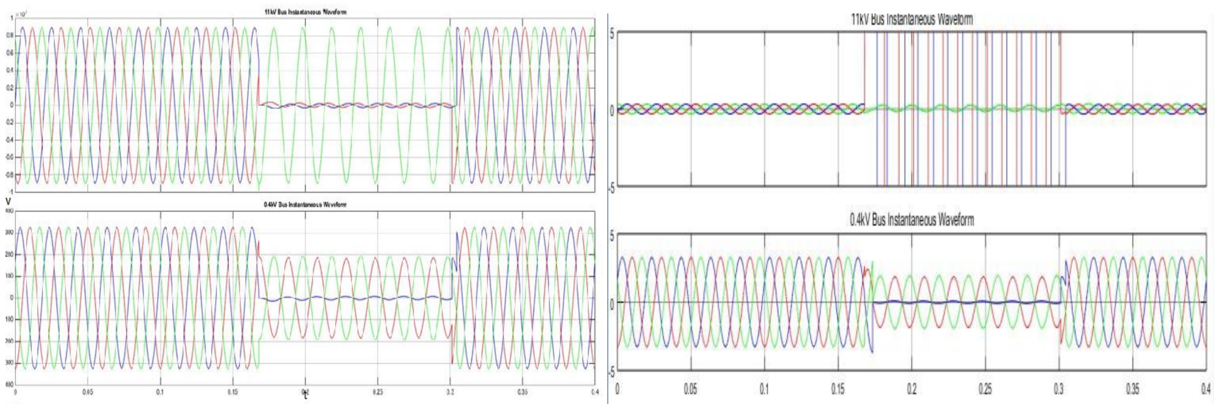

Fig 4 Voltage and Current Waveform Of LLG Fault

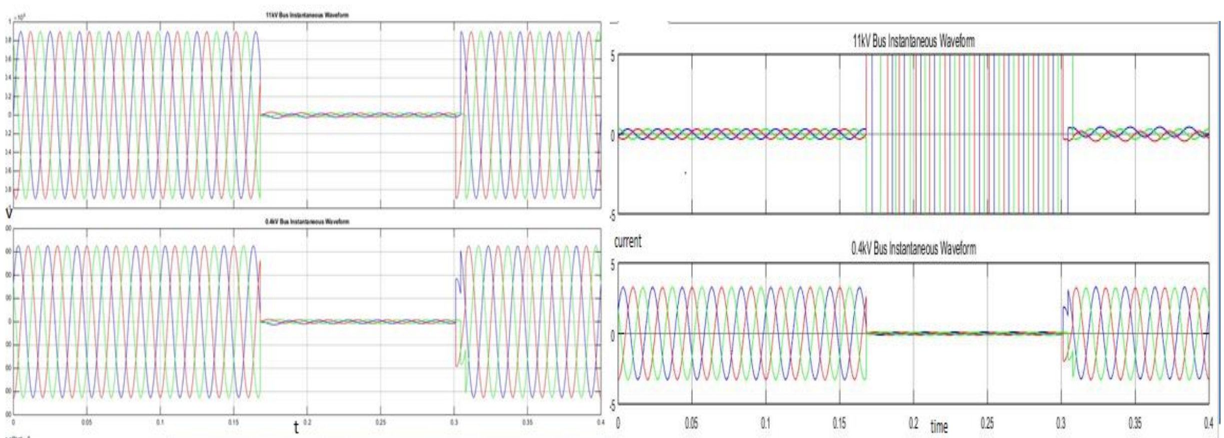

Fig 5 Voltage and Current Waveform Of LLL fault

The energy values for eight faults are tabulated in 1.in line to ground fault, energy a is less then other two phases.in double line to ground fault any one energy is less than other two energy.in three phase fault ,all energy values will be approximately equal and low.

Table 1 Energy Values

FAULT TYPE	ENERGY A	ENERGY B	ENERGY C
AG	2.324e^6	3.835e^5	4.024e^5
BG	4.142e^5	2.112e^6	3.956e^5
CG	3.856e^5	4.022e^5	1.951e^6
ABG	2.489e^6	2.174e^6	4.050e^5
BCG	4.039e^9	2.23e^6	1.967e^6
CAG	2.636e^6	4.087e^5	2.069e^6
ABC	2.601e^6	2.302e^6	2.089e^6

Table 2 Energy Value For Nine Bus System

Fault type	ENERGYA	ENERGYB	ENERGYC
AG	43847	26321	25496
BG	25509	42891	26681
CG	26447	25258	52290
AB	41507	33218	23546
BC	26499	47438	42717
CA	44709	26118	49696
ABG	44604	39135	26215
BCG	25945	46115	51441
CAG	44667	25550	54539
ABC	45725	40595	53894

5 CONCLUSION

Wavelet Transform has many applications in the field of Power system protection. One of those applications related to the detection of transmission line faults is presented here. WT has the ability to decompose current and voltage signals into both time and frequency domain which can be used for accurate fault classification. In this work, various type of faults are created. The abrupt change of current component of fault current for power system can be detected and the energies obtained. Therefore the proposed algorithm is feasible for transmission line protection. In further work, the computational intelligence technique which has the best performance will be used for a more complicated power system and using the logic method, fault fast detection is performed. For societal impacts,detection of faults will improve the power quality,system reliability and continous supply to the consumers.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.

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