Application of Wavelet Transform in Power System

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***Abstract*----This paper gives a review of the use of wavelet transform in power system. For a modern power system, selective high speed clearance of faults on excessive voltage transmission line is essential and this review indicates the efficient and promising implementations for fault detection, classification and fault location in electricity transmission line protection. Also review the methods for power quality analysis using wavelet transform technique. The work done in this place prefer use of various mother wavelet for transmission line in different conditions of protection to facilitate safer, secure and reliable power systems. The focal point of this paper is at the most current strategies based on wavelet transform utilized in transmission line protection and power quality disturbance analysis.**

***Keywords---Wavelet transform, Transmission line protection*.**

I. INTRODUCTION

Transmission lines are among the power system components with the highest fault incidence rate, since they are exposed to the environment. Line faults due to lightning, storms, vegetation fall, fog and salt spray on dirty insulators are beyond the control of man. The balanced faults in a transmission line are three phase shunt and three phases to ground circuits while Single line-to-ground, line-to-line and double line-to-ground faults are unbalanced in nature.

In an electric power system, a fault is any abnormal flow of electric current. Example, the fault in which current flow bypasses the normal load we called it as a short circuit. Open-circuit fault occurs if the circuit is interrupted by some failure. In three phase (3Ø) systems, a fault occurs between one or more phases and a ground, or also may arise only between phases. In "Ground Fault", the current follows the earth path.

In power systems, the protective devices will detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure. In a polyphase system, a fault may influence all phases equally which is a "symmetrical fault". When only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyze due to the simplifying assumption of equal current magnitude in all phases has being no longer applicable. Analysis of such type of fault is more often simplified by using methods such as symmetrical components. A symmetric or balanced fault affects each of the three phases equally. In the transmission line faults, roughly 5% are symmetric. Which upon comparison with asymmetric fault, three phases are not affected equally. In practical, mostly unbalance faults occur in power systems. An asymmetric or unbalanced fault does not affect each of the three phases equally.

In this paper, various techniques for protection of transmission line based on wavelet transform are discussed mainly focuses on the various methods to achieve fault detection, classification and isolation in transmission line. Those techniques include Wavelet transform. In a modern power system, high speed fault clearance is very critical and to achieve this objective different techniques have been developed.

II. WAVELET TRANSFORM

Wavelet transforms have become one of the most important and powerful tool of signal representation. Nowadays, it has been used in image processing, data compression, and signal processing.

Wavelet analysis is a relatively new signal processing tool and is applied recently by many researchers in power systems due to its strong capability of time and frequency domain analysis [11], [12]. The two areas with most applications are power quality analysis and power system protection [13]–[16].

The definition of continuous wavelet transform (CWT) for a given signal x(t) with respect to a mother wavelet ψ(t) is

$$\text{CWT}(a, b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} x(t)\ \psi\left(\frac{t-b}{a}\right) dt \quad (1)$$

where is the scale factor and is the translation factor.
For CWT, t, a, and b are all continuous. Unlike the Fourier transform, the wavelet transform requires the selection of a mother wavelet for different applications
The application of wavelet transform in engineering areas usually requires a discrete wavelet transform (DWT), which implies the discrete form of t, a, and b in (1). The representation of DWT can be written as

$$\text{DWT}(m, n) = \frac{1}{\sqrt[m]{a0}} \sum_k x(k)\ \psi\left(\frac{k-nb}{}\right) \quad (2)$$

$$DWT(m,n) = \frac{1}{\sqrt{a_0}^{m}} \sum_k x(k) \psi\left(\frac{k - nb_0 a_0^m}{a_0^m}\right)$$

where the original and parameters in (1) are changed to be the functions of integers n, m. k is an integer variable and it refers to a sample number in an input signal.

A very useful implementation of DWT, called multiresolution analysis, is demonstrated in Fig. 2. The original sampled signal x(n) is passed through a highpass filter h(n) and a lowpass filter l(n). Then the outputs from both filters are decimated by 2 to obtain the detail coefficients and the approximation coefficients at level 1 (D1 and A1). The approximation coefficients are then sent to the second stage to repeat the procedure. Finally, the signal is decomposed at the expected level. In the case shown in Fig. 1, if the original sampling frequency is F, the signal information captured by D1 is between F/4 and F/2 of the frequency band.D2 captures the information between F/8 and F/4, D3 captures the

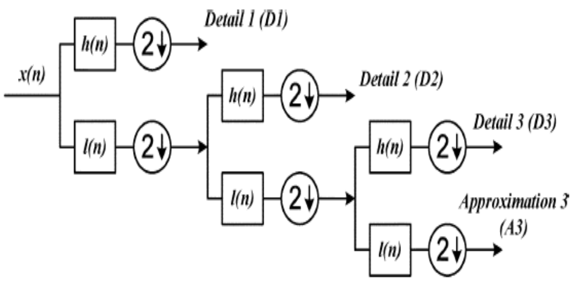


Fig 1.Wavelet multiresolution analysis

information between F/16 and F/8, and A3 retains the rest of the information of original signal between 0 and F/16 . By such means, we can easily extract useful information from the original signal into different frequency bands and at the same time the information is matched to the related time period.

III. TRANSMISSION LINE PROTECTION USING WAVELET TRANSFORM

In this section review different techniques based on wavelet transform for protection of transmission line.

High speed, computationally economical theme for protections of transmission lines utilize the relay logic consists of 3 parts: directional protection, fault classification and fault location. moving ridge remodel is employed for extracting data from the fault transients and solely the primary level high frequency details of the voltages and currents area unit used. Planned protection logic compares the directional signals from each terminals to discriminate between faults within and outdoors the zone of interest. Fault classification is achieved mistreatment native terminal current data [1].

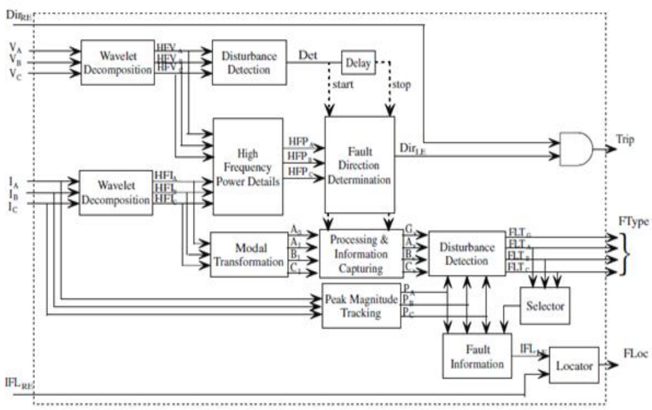


Fig 2. Block diagram of proposed scheme [1]

The logic is settled and might work faithfully within the presence of fault resistance, load variation and CT saturation. A high degree of process potency is achieved because of the utilization of single level wave decomposition. Directional protection needs solely minimum communication from the remote finish and provides high-speed operation (sub-cycle operative time). Fault classification logic uses solely native terminal current info. Fault location logic uses solely peak current info from anybody of the faulted phases of each terminal. The performance of the relay isn't stricken by the variation in load settings and power flows, so creating it inherently adaptive. It will work faithfully within the presence of CT saturation, fault resistances and ranging supply resistivity. The relay operation is selective, reliable and secure.

One of the system model is based upon a mix of the electrical resistance calculation and the Continuous wavelet Transformation (CWT) methodology to notice the disturbance beside distance of Fault prevalence [2].

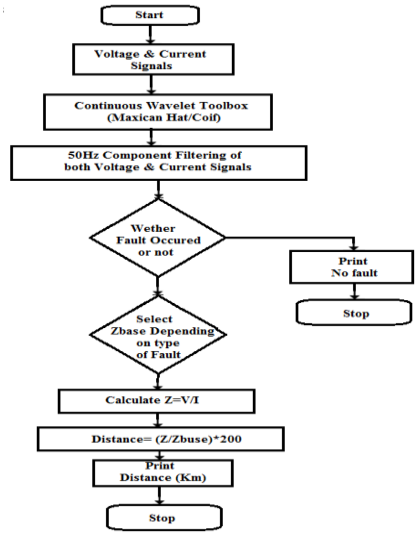


Fig 3.Overall flowchart of proposed method [2]

This scheme measures the impedance of the line up to the fault point from relay location. As the measured quantity is proportional to the distance along the line, the measuring relay is called a distance relay. Modern distance relays provide high-speed fault clearance. They are used where over current relays become low, and there is difficulty in grading time for complicated networks. For 132kv and above systems, the recent trend is to use carrier current protection. The relaying units used in carrier current protection are distance relays and are operated under the control of carrier signals. In case of failure of carrier signal, distance relay act as back up protection.

Distance relays are double actuating quantity relays with one coil energized by voltage and the other coil energized by current. The torque produced is such that when V/I reduce below a set value, the relay operates. During a fault on a transmission line the fault current increases and the voltage at the fault point decreases. V and I are measured at the location of CT'S and VT'S. The voltage at VT location depends on the distance between the VT and the fault. If fault is nearer, measured voltage is lesser. If fault is farther, measured voltage is more. Hence by assuming constant fault resistance, each value of V/I measured form relay location corresponds to distance between the relaying point and the fault along the line. Hence such protection is called Impedance protection or

Distance protection. The distance protection is high speed protection and is simple to apply. These relays are called as phase measuring units and are energized by line to line voltages and difference in line currents, so that they measure the positive sequence impedance.

This CWT formula is distinguishing the fault from the moment at that faulted sample knowledge enters the window and conniving the fault distance at intervals 0.5 cycle when the fault origin.

For all the faults under consideration with moving window algorithm, the error in the fault location is varied from - 10% to 13%. As the fault resistance in the fault increases the %error increases and the increase in %error is rapid at high fault resistances.

The impedance of the circuit during fault condition and healthy condition to calculate the distance where the fault has occurred, the %error in the distance measurement increases with the increase in fault resistance. If the fault resistance increases then resistance of the circuit under fault condition will be increased which may dominate the effect of reactance in that case and thus there may be some increase in % error.

In system [3], discrete wavelet transform of voltage signals at the two ends of the transmission lines are analyzed. Transient energies of detail info for two consecutive data windows at fault are used for analysis. Four layer feed forward back propagation neural networks are designed to classify and find the fault at different single line to ground fault conditions.

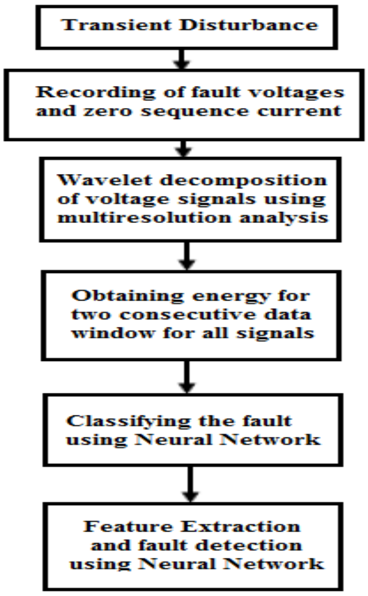


Fig 4. Procedure for fault analysis [3]

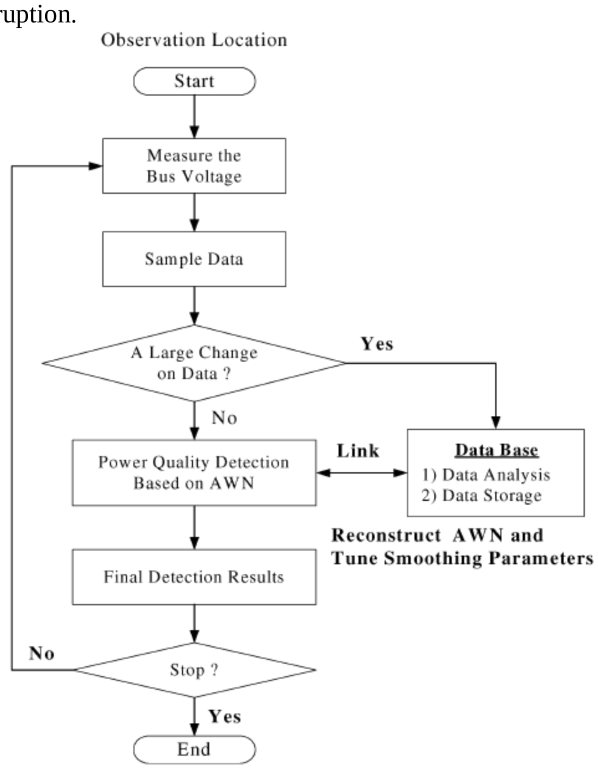
The line voltage signals from both the ends of are used for fault analysis on the transmission line. The signals are sampled at a frequency of 320 KHz, which gives 6400 samples per cycle. Daubechies „db5" wavelet is employed since it has been demonstrated to perform well. Using multi resolution wavelet analysis of all the six voltage signals their detail D1 and D5 components are extracted. The fifth level detail D5 contains harmonics ranging from 5 kHz-10 kHz and the first level detail D1 contains harmonics ranging from 80 kHz-160 kHz.

Energy of two consecutive windows of all six voltage signals 5th level detail along with energy of zero sequence currents at the two terminals for the same data window was taken as input. Initial three outputs show the status of three lines; output is high (1) if a fault exists and low (0) if there is no fault. The fourth output is to distinguish earth fault and line fault; a high (1) indicates the earth fault and low (0) indicates the line fault.

After successful classification, details of fault signals are used to locate the fault. The classification of faults was exact and the location of the faults was identified with above 95% accuracy.

IV. POWER QUALITY ANALYSIS USING WAVELET TRANSFORM

The system proposed [18] of power-quality detection for power system disturbances using adaptive wavelet networks (AWNs). An AWN is a two-sub network architecture, consisting of the wavelet layer and adaptive probabilistic network. Morley wavelets are used to extract the features from various disturbances, and an adaptive probabilistic network analyzes the meaningful features and performs discrimination tasks. AWN models are suitable for application in a dynamic environment, with add-in and delete-off features using automatic target adjustment and parameter tuning. The proposed AWN has been tested for the power-quality problems, including those caused by harmonics, voltage sag, voltage swell, and voltage interruption.



The detection of the disturbance and its duration are attained by a proper application, on the sampled signal, of the Continuous Wavelet Transform (CWT) [19]. Disturbance amplitude is estimated by decomposing, in an optimized way, the signal in frequency sub bands by means of the Discrete Time Wavelet Transform (DTWT). The proposed method is characterized by high rejection to noise, introduced by both measurement chain and system under test, and it is designed for an agile disturbance classification. Moreover, it is also conceived for future implementation both in a real-time measurement equipment and in an off-line analysis tool.

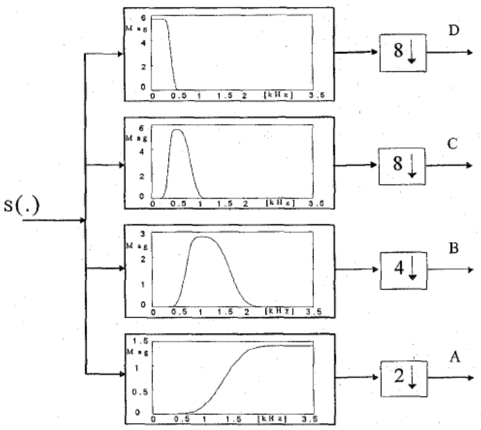


Fig. Equivalent filter bank related to a decomposition in four subbands by means of the DTWT.

V. CONCLUSION

This paper is an effort to review the most recent techniques which are used for protection of transmission line using Wavelet transform. Wavelet transform with Neural network for classification of transmission line fault and isolation is considered to be a fast, robust and accurate technique. But, Fuzzy logic systems are subjective and heuristic and are simpler than the wavelet transform or the neural network based techniques. But, most of the available tools for fault detection and classification are not efficient and are not investigated for real time implementation. So, for this there is a need for new algorithms that have high efficiency and suitable for real time usage and wavelet transform serves for this purpose. All these techniques have their own features and researches are still going on to obtain lesser operating time of relay at high speed.

VI. FUTURE SCOPE

Wavelet based transmission line protection will be extended in future for Parallel Transmission Line protection and multiterminal transmission line protection. This review also useful in including innovative features in microprocessor based distance relays.

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