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MONITORING AND DETECTING TRANSMISSION LINE FAULTS BY USING DWT

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Abstract:

This paper presents discrete wavelet analysis technique for identifying the transmission line faults. Normally the transients are non stationary waves. Wavelets are best choice to analyses the transient signals. Protection of transmission line is very important because it is a vital component between the generating stations and end users. Sudden changes in lines can cause very dangerous impact on power system. Many researches are even going on to enhance the techniques to solve these problems. Here discrete wavelet transform is used for extract the hidden factors from the fault signal by performing decomposition at each level. The proposed system simulated in MATLAB the result promises detect and classify symmetrical and unsymmetrical faults possible on transmission line of the power system.

Key Words: Fault Detection, Discrete Wavelet Transform, Transmission Line & Dabechies Wavelet Function

1. Introduction:

Transmission lines, among the other electrical power system components, suffer from unexpected failures due to various random causes. These failures interrupt the reliability of the operation of the power system. When un predicted faults occur protective systems are required to prevent the propagation of these faults and safeguard the system against the abnormal operation resulting from them. According to [1] the transient signals are collected by DFR and it send to A/D converter then it analyze by discrete Fourier transform.

It is well known from Fourier theory that a signal can be expressed as the sum of a, possibly infinite, series of sine's and cosines. This sum is also referred to as a Fourier expansion. The big disadvantage of a Fourier expansion however is that it has only frequency resolution and no time resolution. This means that although we might be able to determine all the frequencies present in a signal, we do not know when they are present. To overcome this problem in the past decades several solutions have been developed which are more or less able to represent a signal in the time and frequency domain at the same time. The wavelet transform or wavelet analysis is probably the most recent solution to overcome the shortcomings of the Fourier transform.

General discrete wavelet equation is given below

$$x(t) = \sum_{k} a_j(k)\ (t-k) + \sum_{k}\sum_{j} d_j(k)\ \varphi(2-jt-k) \qquad (1)$$

Where,

c_j - Approximate coefficient

d_j - Detail coefficient

(t) - Scaling function

$\varphi(t)$ - Wavelet function

According to fault transients, there are number of algorithms have been developed for detection of faults and its classification. In this proposed algorithm, how transient features are extracted from original fault signal is an important issue. Wavelet Transform (WT) is selected as the strongest tool to analyze the fault because of its perfect time frequency localization ability (2-6). Effective feature extraction using wavelet has been proposed in (4). Suitability of WT for non-stationary signal analysis is dealt in (7). Local analysis of relaying signal with the help of WT expressed in (8, 9). WT is applied in (10) to capture the high frequency components of travelling waves for detection of faults and faulty phase selection. Discrete Wavelet Transform (DWT) is used to design the fault classification tool for series compensated transmission lines in (11). DWT is used as online tool for relaying applications (12).

2. Discrete Wavelet Transform:

Discrete Wavelet Transform is found to be useful in analyzing transient phenomenon such as that associated with faults on the transmission lines. Multi-Resolution Analysis (MRA) is one of the tools of Discrete Wavelet Transform (DWT), which decomposes original, typically non-stationary signal into low frequency signals called approximations and high frequency signals called details, with different levels or scales of resolution. It uses a prototype function called mother wavelet for this. At each level, approximation signal is obtained by convolving signal with low pass filter followed by dyadic decimation, whereas detail signal is obtained by convolving signal with high pass filter followed by dyadic decimation.

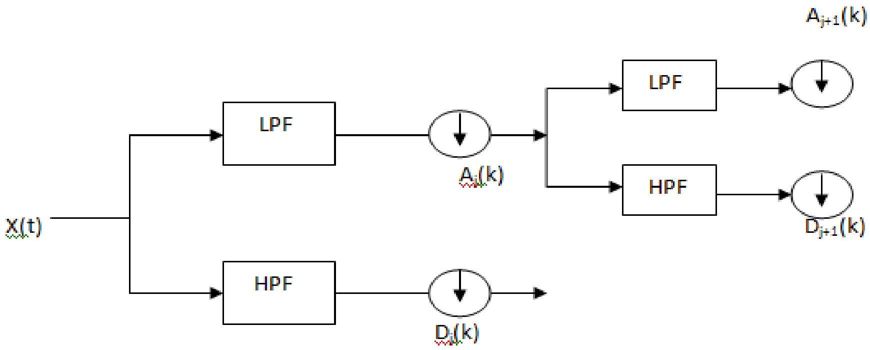

Figure 1: Decomposition Tree

3. Proposed System Logic:

In this proposed scheme we use discrete wavelet transform to extract the hiding factors. The three-phase current signals are fed through a discrete wavelet decomposition filter to decompose transients into a series of wavelet components, each of which corresponds to a time domain signal that covers a specific octave frequency band containing more detailed information. Such wavelet components appear to be useful for detecting, localizing, and classifying the sources of transients. Wavelet transform is largely due to this technique, which can be efficiently implemented by using only two filters, one high pass (HP) and one low pass (LP) at level (k). The results are down-sampled by a factor two and the same two filters are applied to the output of the low pass filter from the previous stage. The high pass filter is derived from the wavelet function (mother wavelet) and measures the details in a certain input. The low pass filter on the other hand delivers a smoothed version of the input signal and is derived from a scaling function, associated to the mother wavelet. The choice of mother wavelet is very important in detecting and localizing different types of fault transients. The daubechies (dB) is the commonly used mother wavelet suitable for protection applications. In this paper db6 wavelet is used which decomposes the signal effectively.

4. Fault Detection and Classification:

A fault detector must detect the fault inception and to issue an output signal indicating this condition. During normal operating conditions the currents and voltages of the power system are sinusoidal signals. Load variation with time may produce slow amplitude changes in current signals and, in a lesser extent, in voltage signals. The inception of the fault introduces abrupt changes of amplitude and phase in current and voltage signals. Fault signals can be contaminated with different transient components such as exponentially-decaying dc-offset (mainly in current signals) and high-frequency damped oscillations (mainly in voltage signals), among other components. These changes of amplitude and phase, and the appearance of transient components, can be used to detect the inception of a fault. Phase currents I_α, I_β, I_γ are obtained when a disturbance is detected. Then these currents are subjected to decomposition using discrete wavelet decomposition filter to extract high frequency details from the current signals. The coupling effect of the mutually coupled three- phase transmission line must be nullified effectively before the information is provided for discriminating the type of faults. A simple transformation called karrenbaur transformation is used to achieve this. The karrenbaur transformation is achieved with summers/subtracters alone without any need for multipliers. The transformation matrix is given as:

$$\begin{bmatrix} \alpha \\ \beta \\ 0 \\ \gamma \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

Where, α, β, γ *is a in line modals*

Classification of faults carried by following equation

$$I_0 = \frac{I_a + I_b + I_c}{3}$$

$$I_\alpha = \frac{I_a - I_b}{3}, \quad I_\beta = \frac{I_a - I_c}{3}, \quad I_\gamma = \frac{I_b - I_c}{3}$$

After the detection and classification fault location were calculated by using following formula.

$$Fault\ location = \frac{FL_{rt} * L_t}{FL_{st} + FL_{rt}}$$

Where,

FLrt-Fault Location Signal from Remote Terminal
FL_{st}-Fault Location Signal from Source Terminal
L_t-transmission line length

5. Results and Discussion:

The proposed logic was first developed in the MATLAB/SIMULINK environment. The wavelet decomposition to the fault current signals is applied using the wavelets available in the wave menu toolbox in the matlab. Various types of faults, like line to ground LG (AG, BG, CG), double line to ground LLG (ABG, BCG, ACG), line to line LL (AB, BC, CA), and three-phase faults LLL (ABC), were created, and the test waveforms for the proposed method were obtained. These waveforms were imported to MATLAB environment and given as input to the algorithm developed to detect and classify the faults along with its location.

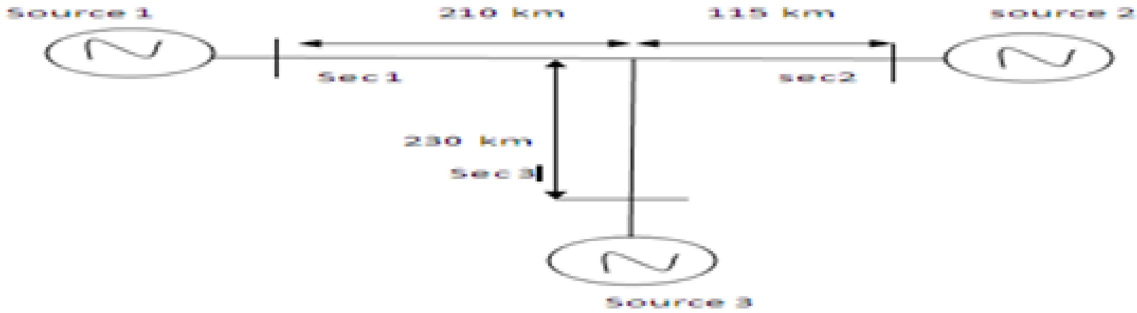

Figure 2: Test System

LPF(A_j)-Approximation coefficient	HPF(D_j)-Detail coefficient
a_0 =0.0010773011	d_0=0.1115407434
a_1 = 0.0047772575	d_1 = 0.4946238904
a_2 = 0.0005538422	d_2 = -0.7511339080
a_3 = -0.0315820393	d_3 = 0.3152503517
a_4 = 0.0275228655	d_4 = 0.2262646940
a_5 = 0.0975016056	d_5 = -0.1297668676
a_6 = -0.1297668676	d_6 = -0.0975016056
a_7 = -0.2262646940	d_7 = 0.0275228655
a_8 = 0.3152503517	d_8 = 0.0315820393
a_9 = 0.7511339080	d_9 = 0.0005538422
a_{10} = 0.4946238904	d_{10} = -0.0047772575
a_{11} = 0.1115407434	d_{11} = -0.0010773011

Table 1: DB6 Co Efficient

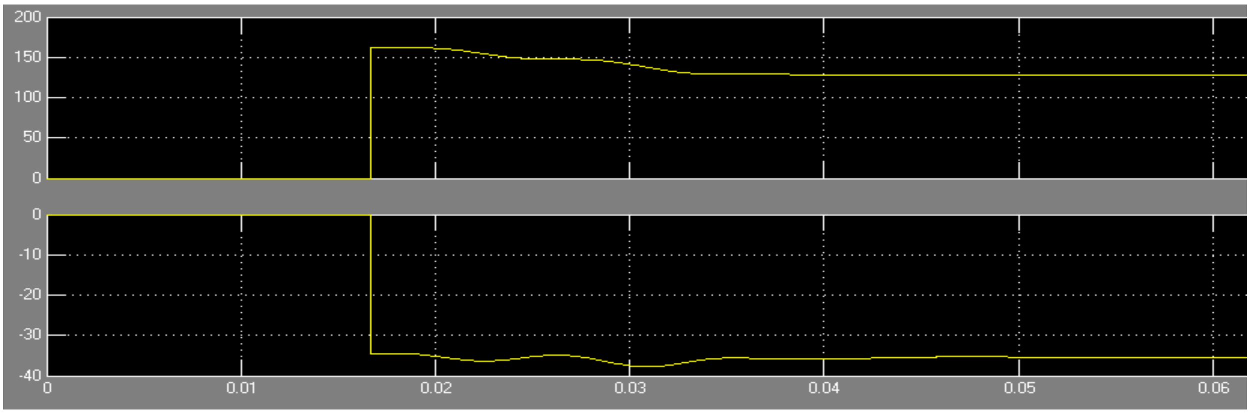

Figure 3: L-G Fault

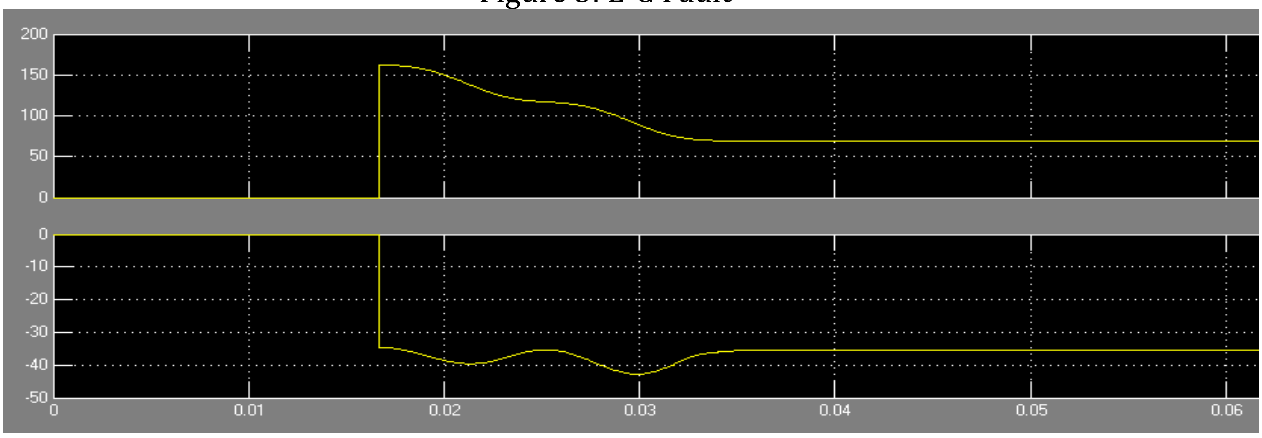

Figure 4: LLG fault

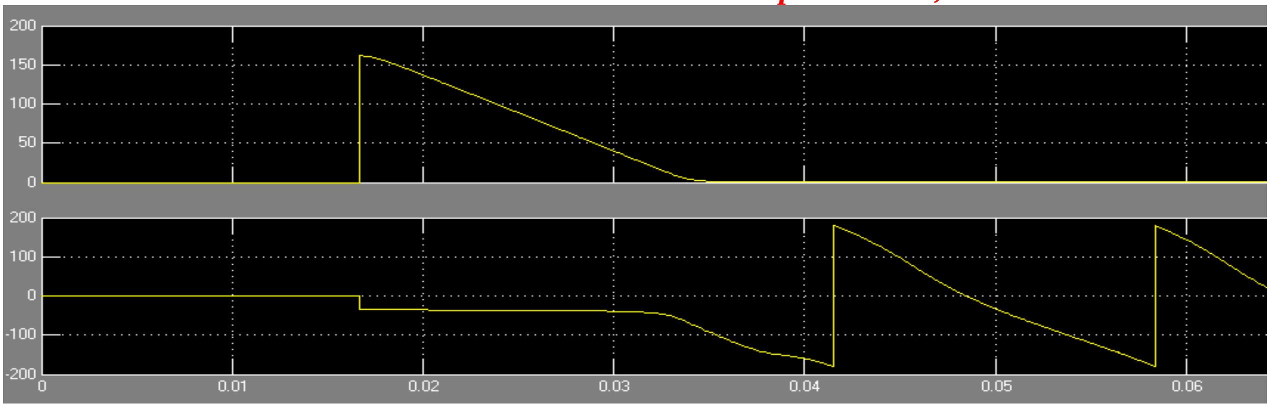

Figure 5: LLL fault

6. Conclusion:

A novel technique for fault detection, classification and location in transmission lines is proposed. WT used to extract information from three phase current signals and to process the high frequency details to derive information about the fault. The salient features of this proposed logic are single "dB6" high pass wavelet filter is enough for each phase, need for multipliers avoided using karrenbaur transformation, simple transient energy calculation required for fault detection, classification and location is done. For ground fault adaptive threshold calculation is employed. The logic is fully deterministic, easy to understand, and also the classifier operation is fast and reliable. Simulation results are verified under various fault cases using MATLAB/Simulink.

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