

TRANSIENT STABILITY ENHANCEMENT OF POWER SYSTEM USING INTELLIGENT TECHNIQUE

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ABSTRACT

In this paper, Automation of a power system fault detection using multi resolution analysis (MRA) wavelet transform is proposed and the various coefficients obtained from wavelet transform are given as an input to the probabilistic neural network (PNN). This PNN will classify and find the nature of fault occurring. Later, the decisions obtained from the output of PNN can be used to tune the power system stabilizer. The two-area 4-machine system with a double circuit transmission lines between the two areas is modified to include a fictitious bus for the study. The integral square error functions are used as a fitness function during the minimization operation. Results show that the proposed control of the Power System Stabilizer is more robust in damping the oscillations as compared to the fixed conventional PSS. The paper is simulated using the wavelet, neural network toolboxes and using power system blocksets.

Keywords: Power System Stabilizer, Probabilistic Neural Network, Wavelet Transform

INTRODUCTION

Power systems have become more complicated under competitive and deregulated environments. As a result, more advanced security control is required to smooth power operations and planning. It is known that power system security control is one of the main current concerns. As a framework of security control, fault detection is one of the important tasks. Specifically, it requires that power system operators at control centers appropriately handle information on faults and detect faults effectively. In other words, more sophisticated fault detection techniques are necessary to maintain secure power systems [1]. In this study, a new method is proposed for fault detection and classification. Automation of a power system fault detection using multi resolution analysis (MRA) wavelet transform is proposed and the various coefficients obtained from wavelet transform are given as an input to the probabilistic neural network (PNN). This PNN will classify and find the nature of fault occurring. Later, the decisions obtained from the output of PNN can be used to tune the power system stabilizer.

POWER SYSTEM STABILITY

The ability of power system to remain in stable for different types of faults is stability. Shunt type of faults involve power conductor or conductors-to-ground or short circuit between conductors. When circuits are controlled by fuses or any device which does not open all three

phases, one or two phases of the circuit may be opened while the other phases or phase is located. These are called series type of faults. These faults may also occur with one or two broken conductors. Shunt faults are characterized by increase in current and fall in voltage and frequency whereas series faults are characterized by increase in voltage and frequency and fall in current in the faulted phases.

Role of Power System Stabilizer

Function of a power system stabilizer (PSS) is to add damping to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signals[2]. To provide damping, the stabilizer must produce a component of electrical torque in phase with the rotor speed deviations.

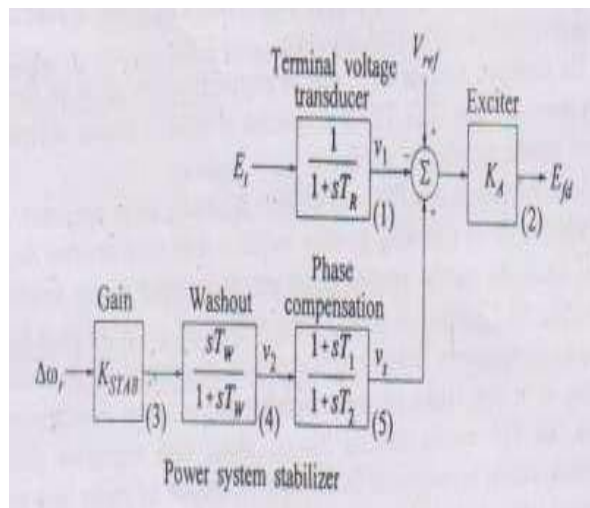


Figure1: Block diagram excitation system

The above figure shows block diagram of the excitation system, including the AVR and PSS. Since we are all concerned with small-signal performances, stabilizer output limits and exciter output limits are not shown in figure.

The phase compensation block provides the appropriate phase-lead characteristic to compensate for the phase lag between the exciter input and the generator electrical (air-gap) torque. The figure shows the single first-order block. In practice, the two or more first-order blocks may be used to achieve the desired phase compensation. In some cases, second-order blocks with complex roots have been used. Normally, the frequency range of interest is 0.1 to 2.0 Hz and the phase-lead network should provide compensation over this entire frequency range. The phase characteristic to be compensated changes with system conditions. Therefore, the compromise is made and a characteristic applicable for different conditions is selected. The signal washout block serves a high-pass filter, with the time constant T_w high enough to allow signals associated with oscillations in W_r to pass unchanged. It allows the PSS to respond only to changes in speed. The main consideration is that it be long enough to pass stabilizing signals at the frequencies of interest unchanged. The stabilizing gain K_{STAB} determines the amount of damping introduced by

PSS. A power system stabilizer which is installed in the Automatic Voltage Regulator of the Generator, can improve the power system stability. Therefore the PSS has excellent cost performance rather than constructions of power system arrangements. A PSS is classified according to input Δp , $\Delta \omega$, Δf input type and can respond to various customer needs. High performance excitation systems are essential for maintaining steady state and transient stability of modern synchronous generators, apart from providing fast control of the terminal voltage. It is well established that fast acting exciters with high gain AVR can contribute to oscillatory instability in power systems. This type of instability is characterized by low frequency (0.2 to 2.0 HZ) oscillations which can persist (or even grow in magnitude) for no apparent reason. A cost efficient and satisfactory solution to the problem of oscillatory instability is to provide damping for generator rotor oscillations. This is conveniently done by providing Power System Stabilizer(PSS) which are supplementary Controllers in the excitation systems. The signal V_s is the output of the PSS which has Input signal derived from rotor velocity, frequency, electrical power or a combination of these variables. The objective of designing PSS is to provide additional damping torque without affecting the synchronizing torque at critical oscillation frequencies. Though the generator output power is decided by the turbine mechanical torque, a generator output power also can be changed by changing excitation value transiently as shown below fig. A PSS detects the changing of generator output power, controls the excitation value, and reduces the power swing rapidly. In this paper, delta speed type pss is chosen as the system considered is having an inter area mode type of power oscillations.

WAVELET TRANSFORM

Wavelet transform (WT) a mathematical technique, has a special feature of variable time-frequency localization, which is different from the windowed Fourier transform[3]. Wavelet algorithms Process data at different scales so that they may provide multiple resolutions in frequency and time, these mainly being used in this study to detect and classify faults. This property of multi resolution is particularly useful for analyzing fault transients, which contain localized high frequency components superposed power frequency signals. The basic concept in wavelet analysis is to select a proper wavelet, called mother wavelet (analyzing wavelet or admissible), and then perform an analysis using its translated and dilated versions. In this report, the Daubechies five wavelet transform is used to analyse the speed deviation measured on each of the generator in the test system. Faults were created at a distance of 10kms from both the buses. Different types of faults were simulated using Electromagnetic Transient Analysis in Mi power package. Different types of faults were created and the transients were recorded for analysis. Simulation is carried out for Phase-A, symmetric faults. Data sets for each type of fault were obtained by varying the fault inception angles. The voltage at the generator is measured.

The wavelet transform is introduced as a method for analyzing electromagnetic transients associated with power system faults and switching[4]. This method, like the Fourier transform, provides information related to the frequency composition of a waveform, but it is more

appropriate than the familiar Fourier methods for the non periodic, wide-band signals associated with electromagnetic transients. It appears that the frequency domain data produced by the wavelet transform may be useful for analyzing the sources of transients through manual or automated feature detection schemes. The basic principles of wavelet analysis are set forth, and examples showing the application of the wavelet transform to actual power system transients are presented. Wavelet transforms comprise an infinite set. The different wavelet families make different trade-offs between how compactly the basis functions are localized in space and how smooth they are. Some of the wavelet bases have fractal structure. The Daubechies wavelet family is one example.

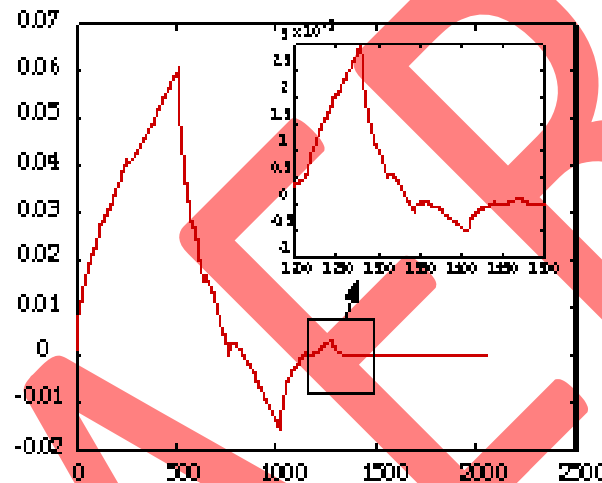


Figure2: The fractal self- similarity of the Daubechies mother wavelet.

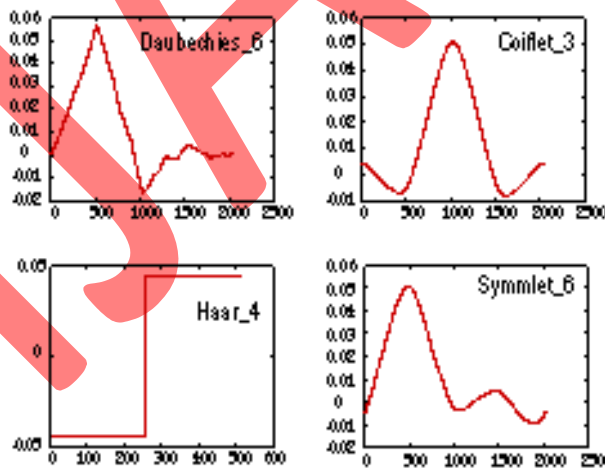


Figure3: Several different families of wave lets

ARTIFICIAL NEURAL NETWORK

The training data set of an ANN should contain the necessary information to generalize the problem. Combinations of different fault conditions were considered and training patterns were

generated by simulating different kinds of faults on the power system. Fault type, fault location, fault resistance and fault inception time were changed to obtain training patterns covering a wide range of different power system conditions. The simulated training data set was used to train the ANN-based selector module [5].

Network Inputs

Measured currents at the relay location are subject to change when a fault occurs on a transmission line. Fault detection/classification principle may be based upon detecting these changes. The principle of variation of current signals before and after the fault incidence is used and a fast and reliable ANN-based fault detector/classifier module is designed to detect the fault and classify the fault. Current waveform signals are sampled at a rate of 20 samples per cycle. Samples of each of the phase currents are compared with the samples of the same phase current taken half cycle and one cycle before. These superimposed signals are made based on the combination of the current samples using equations 1-3. In these equations Sup A, Sup B and Sup C correspond to phases A, B and C superimposed signals, respectively. The resultant three superimposed signals are considered as the first three inputs to the designed neural network module.

$$\text{SupA} = i_A(n) + 2.i_A(n - N) + i_A(n - 2N) \text{-----} (1)$$

$$\text{SupB} = i_B(n) + 2.i_B(n - N) + i_B(n - 2N) \text{-----} (2)$$

$$\text{SupC} = i_C(n) + 2.i_C(n - N) + i_C(n - 2N) \text{-----} (3)$$

In equations 1-3 n is the sample number and N is the number of samples per cycle. There is a chance that one cycle after occurrence of a fault, the second cycle fault signals become similar to the first cycle signals and therefore, superimposed signals might decrease considerably. To have stable outputs for a few cycles after occurrence of a fault, one cycle of data from each of the phase currents prior to the fault incidence is stored in the memory. One cycle after the occurrence of a fault, fault current samples are compared to the prior to fault current samples based on the same principle used in equations 1-3. Extensive studies were performed and it was found that to be able to design a reliable fault selector scheme which could perform correctly for a wide range of power system parameters and fault conditions, it is better to add zero and negative sequence components of the three phase currents as the neural network inputs. These two signals are considered as the 4th and 5th inputs of the designed network, respectively. Using the above input information as the neural network inputs, it was found that the fault detector algorithm is also able to detect fault type changes and behave correctly even for evolving sequential faults.

Proposed PNN Structure

Once trained, the networks performance was tested using a validation data set. The suitable network which showed satisfactory results was finally selected. The selected network structure is shown in Fig. 4. The network has 5 normalized inputs and 4 outputs. The number of neurons for the hidden layer is chosen to be 10 neurons. Based on the fault type which occurs on the system, output neurons should be 0 or 1. Outputs which are greater than 0.7 are considered to be active, while outputs less than 0.3 are considered to be inactive[6].

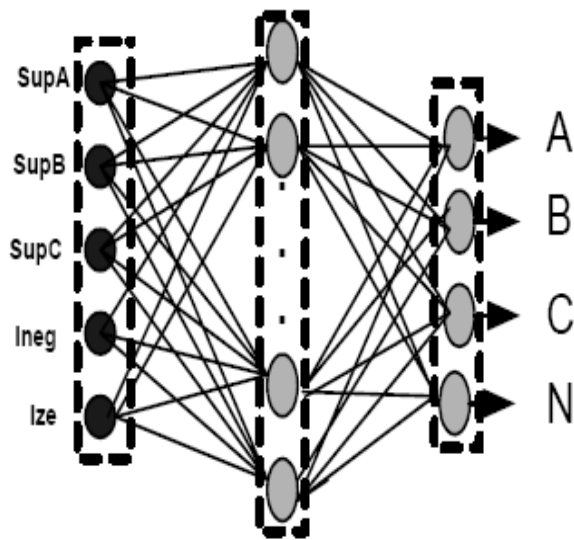


Figure 4: PNN Structure

Table1: Neural network desired outputs for different types of faults.

| Fault Type | A | B | C | N |
|------------|---|---|---|---|
| AG | 1 | 0 | 0 | 1 |
| BG | 0 | 1 | 0 | 1 |
| CG | 0 | 0 | 1 | 1 |
| AB | 1 | 1 | 0 | 0 |
| BC | 0 | 1 | 1 | 0 |
| CA | 1 | 0 | 1 | 1 |
| ABG | 1 | 1 | 0 | 1 |
| ACG | 1 | 0 | 1 | 1 |
| BCG | 0 | 1 | 1 | 1 |
| ABC | 1 | 1 | 1 | 0 |

RESULTS

The D coefficients obtained from wave let transform changing its amplitude at appropriate instants (where deviation exists) of frequency and voltage waveforms are shown.

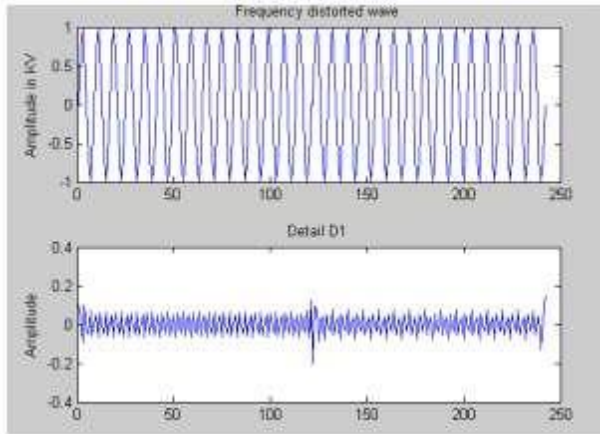


Figure5: D-Coefficients obtained for frequency distortion

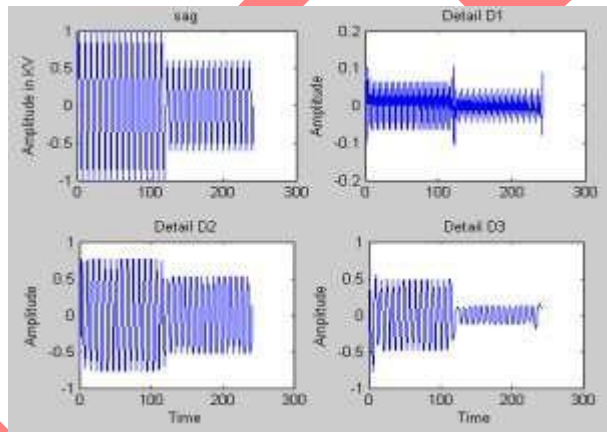


Figure6: D Coefficients obtained for voltage sag:

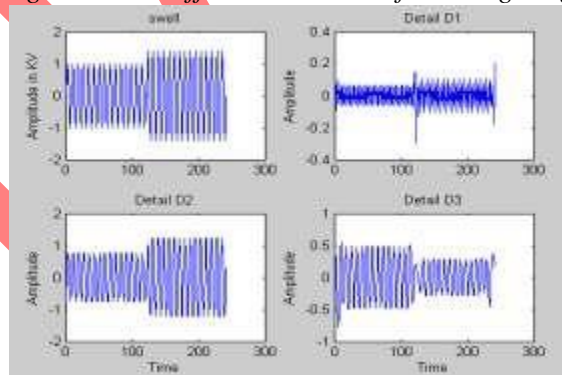


Figure7: D Coefficients for voltage swell

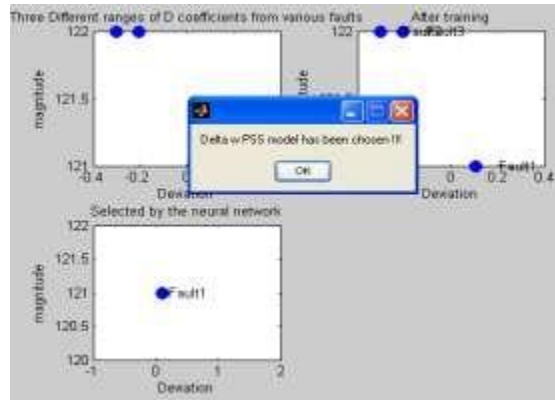


Figure8: PSS Model chosen for various D coefficients:

Frequency analysis of Power system stabilizer

The magnitude and phase plot of the proposed Power system stabilizer are shown.

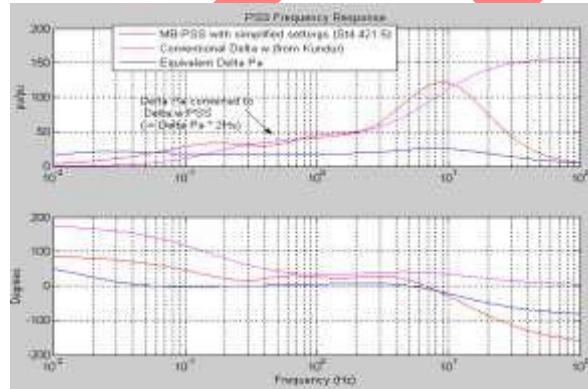


Figure9: Magnitudeplot

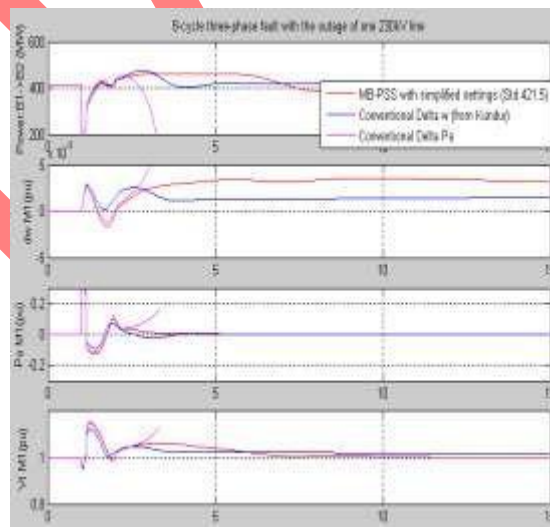
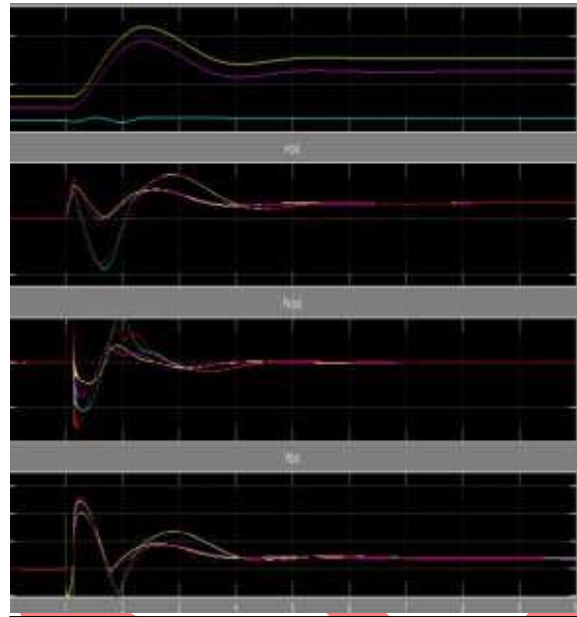


Figure10: Phaseplot

Various waveforms for line outage

The change in speed, accelerating power, terminal voltage and power exchange between the two ends of the power network are shown.



CONCLUSIONS

A new method in fault detection and classification of transmission line using intelligent technique is proposed in this paper. The use of Multi resolution Analysis (MRA) Wavelet Transform proved to be very efficient in extracting relevant features from the signal. The MRA decompositions components were analyzed for their energy contents and characteristics and are then used as a feature for different classes and locations of the fault to be classified. Neural network are very popular as classifiers and have proved efficient. Here we use the outputs of the PNN network to choose the one of the PSS model. Here based on the dynamic conditions of the exciting system and the steam turbine governor we choose the appropriate PSS model. Here we want to show that how wavelet transforms and PNN networks for power system stabilization. Thus the application of wavelet transform to determine the type of fault and its automation incorporating PNN could achieve an accuracy of 100% for all type offaults.

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