Comparison of Different Design Methods for power System Stabilizer Design - A Review

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Abstract— In the past two decades, the utilization of supplementary excitation control signals for improving the dynamic stability of power systems has received much attention. In recent years, several approaches based on intelligent control and optimization techniques have been applied to PSS design problem. This paper introduces a review on the techniques applied on the conventional PSS design only. Power System Stabilizer (PSS) is the most cost effective approach of increase the system positive damping, improve the steady-state stability margin, and suppress the low-frequency oscillation of the power system. A PSS has to perform well under operating point variations. This paper introduces a review on the techniques applied on the conventional PSS design only. The techniques could be mainly classified into linear and nonlinear.

Keywords: Power system Stabilizer, low frequency oscillation, Damping, stability

I. INTRODUCTION

The power system is a dynamic system and it is constantly being subjected to disturbances. It is important that these disturbances do not drive the system to unstable condition.

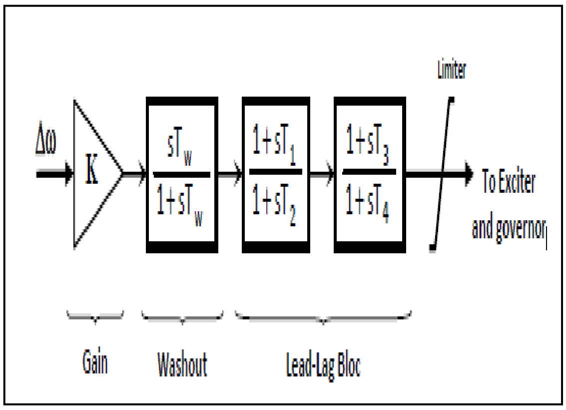
Beginning in the late 1950's and early 1960's, most of the new generating units added to electric utility systems were equipped with continuously-acting voltage regulators. As these units became a larger percentage of the generating capacity, it became apparent that the voltage regulator action had a detrimental impact upon the transient stability or the steady-state stability of the power system. This is due to the oscillations of small magnitude and low frequency which are typically in the range of 0.7 to 2 Hz for local mode and 0.1 to 0.8 Hz for inter-plant or inter-area mode. Without timely and properly handling and control, these oscillations can sustain, continue to grow, spread throughout the system and eventually cause the system disconnection and collapse. [1 2] AVR alone is not adequate to reject the oscillations. Thus, the above discussion give rise to importance of PSS that is employed to reject the oscillations from the power grid and to prevent the rotor speed or angle from oscillations.

II. IBASICS OF PSS

The basic function of power system stabilizers is to add damping to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signals. To provide damping, the stabilizer must produce a component of electrical torque in phase with rotor speed deviation.

Both AVR and PSS are feedback controllers, it is important to emphasize that they need to be designed jointly in order to optimize the power feedback control system and to accomplish the goal of damping out the rotor angle oscillation and goal of voltage regulation simultaneously.

The basic block diagram of PSS is shown below. [3]



The input to the conventional PSS is speed deviation. The PSS gain Kpss is an important factor as the damping provided by the PSS increase in proportion to an increase in the gain up to a certain critical gain value, after which the damping begins to decrease. The basic structure of the CPSS is as follows.

(1) A phase compensation block
(2) A signal washout block
(3) A gain block

Phase compensation block provides the appropriate phase lead characteristics to compensate for the phase lag between exciter input and generator electrical torque.

The signal washout block serves as high pass filter .It allows PSS to respond only to changes in speed.

The stabilizer gain Kstab determine the amount of damping introduce by PSS.

The limiting block at the output of PSS is connected to prevent the over excitation.[4]

III. .CONTROL TECHNIQUES

In general, a conventional power system stabilizer design methods could be categorized into linear and nonlinear methods of design.

A. Linear Methods of Design

Several linear methods were proposed to design the power system stabilizers which are:

(1) Pole placement method
(2) pole shifting method
(3) Linear quadratic regulator formulation
(4) Linear matrix inequalities

1) Pole placement method

These reasons induced Othman and his co-workers design non-switching controllers for systems with multiple operating conditions. A set of gains were separately designed. Then, a special root locus technique was used to adjust the gains and only dominant modes were used in the controller design. The new stabilizer performs better than the traditional one especially if a machine outage occurs. [5]

2) pole shifting method

A pole-shifting technique, which is different from the pole-assignment method and the minimum variance algorithm adopted were developed for the tuning of the stabilizer's parameters. By continuously estimating system input-output relationship from the measured inputs and outputs, the gain settings of the self-tuning PID stabilizer were adjusted in real-time. [6]

3) Linear quadratic regulator formulation

Power utility operators are eager to obtain all generators and turbine control input signals within their own power station to get better accuracy in the identified signals. . This stabilizer used information at the secondary bus of the step-up transformer as input signals to the internal generator bus by defining the secondary bus as the reference bus instead of an infinite bus. However, PSS designed using Linear Quadratic Regulator (LQR) formulations required complete measurements which were neither practical nor economical for most cases. [7]

4) Linear matrix inequalities

Scavoni applied to power systems a design method for robust controllers based on the solution of LMI. The centralized controllers require much low gain to achieve the same amount of damping enhancement, have less disturbance rejection capabilities and require fast communication links to implement. [8]

B. Nonlinear Methods of Design

To improve the damping torque applied by the PSS, researchers have used different nonlinear techniques including the following:

(1) Fuzzy logic control techniques
(2) Neural network
(3) partial swarm optimization
(4) Genetic algorithm
(5) Hybrid AI controller

1) Fuzzy logic control techniques

Fuzzy logic controllers are model-free controllers. They do not require an exact mathematical model of the controlled system. These is rule based controllers. The structure of this logic resembles that of a knowledge based controller; it uses principle of fuzzy set theory in its data interpretation and data logic. It has excellent response with small oscillations. The controller is robust and works effectively under all types of disturbance. It has very short computation time. [9]

2) Neural network

Neural Network is used to approximate the complex non-linear dynamics of power system. Magnitude constraint of the activators is modelled as saturated non-linearity and is used in Lyapnov’s stability analysis. The overshoot is nearly same as conventional PSS but settling time is drastically reduced. [10 11]

3) partial swarm optimization

Particle swarm optimization (PSO) technique was applied to design a robust power system stabilizer (PSS). The design problem of the proposed controller was formulated as an optimization problem and PSO was employed to search for optimal controller parameters. By minimizing the time-domain based objective function, in which the deviation in the oscillatory rotor speed of the generator was involved; stability performance of the system was improved. [12]

4) Genetic algorithm

Genetic algorithm is independent of complexity of performance parameters and to place the finite bounds on the optimized parameters. As a result it is used to tune multiple controllers in different operating conditions or to enhance the power system stability via PSS and SVC based stabilizer when used independently and through different applications. [13]

5) Hybrid AI controller

Two or more artificial intelligent techniques are used to produce a hybrid intelligent system. Through cooperative interactions such techniques are applied in series or inintegration to gain successful results. If the training data and algorithm are selected properly then good performance can be observed. The actual design method may be chosen based on real time application and dynamic performance characteristics. If the training data and algorithm are selected properly then good performance can be observed.

IV. CONCLUSION

In this paper, I have present a review of different techniques used by researchers in designing the conventional PSS and also the study the concept of PSS and its importance. These techniques could be classified as linear and non linear. Thus, we can make a conclusion that design of PSS with nonlinear AI techniques like FLC, ANN, GA gives more accurate results compare to other methods.

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