Dynamic Stability Enhancement of Power System Using Fuzzy Logic Based Power System Stabilizer

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Abstract- Power systems are subjected to low frequency disturbances that might cause loss of synchronism and an eventual breakdown of entire system. The oscil- lations, which are typically in the frequency range of 0.2to3.0Hz,might be excited by the disturbances in the system or, in some cases, might even build up spontaneously. These oscillations limit the power transmission capability of a network and, sometimes, even cause a loss of synchronism and an eventual breakdown of the entire system. For this purpose, Power sys-tem stabilizers (PSS) are used to generate supplementary control signals for the excitation system in order to damp these low frequency power system oscillations.

The use of power system stabilizers has become very common in operation of large electric power systems. The conventional PSS which uses lead-lag compensation, where gain settings designed for specific operating conditions, is giving poor performance under different loading conditions. The constantly changing nature of power system makes the design of CPSS a difficult task. Therefore, it is very difficult to design a stabilizer that could present good performance in all operating points of electric power systems. To overcome the drawback of conventional power system stabilizer (CPSS), many tech- niques such as fuzzy logic, genetic algorithm, neural network etc. have been proposed in the literature.

In an attempt to cover a wide range of operating conditions, Fuzzy logic based technique has been suggested as a possible solution to overcome the above problem, there by using this technique complex system mathematical model can be avoided, while giving good performance under different operating condition. Fuzzy Logic has the features of simple concept, easy implementation, and computationally efficient. The fuzzy logic based power system stabilizer model is evaluation single machine infinite bus power system, and then the performance of Conventional power system stabilizer (CPSS) and Fuzzy logic based Power system stabilizer (FLPSS) are com- pared. Results presented in the thesis demonstrate that the fuzzy logic based power system stabilizer design gives better performance than the Conventional Power system stabilizer.

I. INTRODUCTION

Power System Stability

Power system stability is the tendency of a power system to develop restoring for cesequ alto or greater than the disturbing forces to maintain the state of equilibrium. Since power systems rely on synchronous machines for generation of electrical power, a necessary condition for satisfactory system operation is that all synchronous machines remain in synchronism. This as- pect of stability is influenced by the dynamics of generator rotor angles and power-angle relationships.

The power system is a dynamic system. The electrical power systems today are no longer operated as isolated systems but as interconnected sys-tems which may include thousands of electric elements and be spread over vast geographical areas. There are many advantages of inter connected power systems

Provide large blocks of power and increase reliability of the system.

Reduce the number of machines which are required both for operational peak load and required as spinning reserve to take care of a sudden change of load.

Provide economical source of power to consumers.

On the other hand there are disadvantages of using interconnected power systems. The interconnecting ties between neighboring power systems are relatively weak when compared to the connections with in the system. It easily leads to low frequency inter oscillation. Many of the early instances of oscillation instability occur at low frequencies when interconnections are made. Power system stability can be classified into three categories.

Steady-state stability:

Transient stability:

Transient stability is the ability of the power system to maintain syn-chronism when subjected to a sudden and large disturbance within a small time such as a fault on transmission facilities, loss of generation or loss of a large load .

The system response to such disturbances involves large excursions of generator rotor angles, power flows, bus voltages etc.

It is a fast phenomenon usually occurring within 1 second for a generator close to the cause of disturbance such as 3-phase to ground fault, line to ground fault etc.

Dynamic Stability:

A system is said to be dynamically stable if the oscillations do not acquire more than certain amplitude and die out quickly. Dynamic stability is a concept used in the study of transient conditions in power systems. Any electrical disturbances in a power system will cause electromechanical transient processes. Besides the electrical transient phenomena produced, the power balance of the generating units is always disturbed, and thereby mechanical oscillations of machine rotors follow the disturbance

Types of Oscillations

The disturbances occurring in power system include electro mechanical oscillations of electrical generators. These oscillations are also called power swings and these must be effectively damped to maintain the system stability. Electromechanical oscillations can be classified in four main categories.

1. Local oscillations:- Between a unit and rest of generating station and between the later and rest of power system. Their frequency typically ranges from 0.2 Hz to 2.5 Hz.
2. Interplant oscillations:- Between two electrically close generating plants. Frequency canvary from 1Hzto2Hz.
3. Inter area oscillations: - Between two major groups of generating plants. Frequencies are typically in the range of 0.2 Hz to 0.8 Hz, generally called low frequency oscillations.
4. Global oscillations:-Characterized by a common in phase oscillations of all generators as found on an isolated system. The frequency of such globalmodeistypicallyunder0.2Hz.

Low Frequency Oscillations

Low frequency oscillations (LFOs) are generator rotor angle oscillations hav- ing a frequency between 0.1 Hz to 3.0 Hz and are defined by how they are created or where they are located in the power system. The use of high gain exciters, poorly turned generation excitation, HVDC converters may create LFOs with negative damping; this is a small-signal stability problem. The mitigation of these oscillations is commonly performed with"supplementary stabilizing signals" and the network ksuse dt ogenerate the sesignal shave come to be known as "power system stabilizer" networks.LFOs include local plant modes, control modes, torsional modes induced by the interaction between the mechanical and electrical modes of a turbine-generator system, and inter- area modes, which maybe caused by either high gain exciters or heavy power transfers across weak tie lines.

Low frequency oscillations can be created by small disturbances in the system, such as changes in the load, and are normally analyzed through the small-signal stability (linear response) of the power system. These small disturbances lead to a steady increase or decrease in generator rotor angle caused by the lack of synchronizing torque, or to rotor oscillations of in- creasing amplitude due to a lack of sufficient damping torque. The most typical instability is the lack of a sufficient damping torque on the rotor's low frequency oscillations.

II. LITERATURE SURVEY

DeMello[15] has explored the phenomenon of stability of synchronous machines un- der small perturbations by examining the case of single machine connected to an infinite bus through external reactance. The design of PSS for single machine connected to an infinite bus has been described [19] using fast out- put sampling feedback. A step-up transformer is used to set up a modified Heffron-Philips(ModHP) model. The PSS design based on this model utilizes signals available within the generating station

D.A Swann have presented in their 3titled 'Applying power system stabilizer - I, II, III' the history of power system stabilizer and its role in a power system. Practical means have been developed using Eigen value[16] analysis techniques to guide the selection process. An extended quasi-steady-state model

G.H. Hwang [26] have described a design of fuzzy power system stabilizer (FPSS) using an adaptive evolutionary algorithm (AEA). AEA consists of Genetic Algorithm(GA) for a global search capability and evolution strategy (ES)

Fuzzy Logic Controller

Lin[32] proposed a fuzzy logic power system stabilizer which could shorten the tuning process of fuzzy rules and membership functions. The proposed PSS has two stages, first stage develops a proportional derivative type PSS, in the second stage it is transformed into FLPSS. Roosta, A.R, [44] have described three proposed types of fuzzy control algorithms and tested in the case of single machine connected to the network for various types of disturbance. S.A. Taher has proposed a novel robust fuzzy logic power system stabilizer (RFLPSS). Here to provide robustness, additional signal namely speed is used as inputs to RFLPSS enabling appropriate gain adjustments [48]. M.L.Kothari,T.Kumar[29] have presented a new approach for designing a fuzzy logic power system stabilizer such that it improves both transient and dynamic stabilities. Here they have considered FLPSS based on 3, 5 and 7 MFs of Gaussian shape. T.Hussein[25] has described an indirect variable- structure adaptive fuzzy controller as a power system stabilizer (IDVSFPSS) to damp inter-area modes of oscillation following disturbances in power systems. S.K. Yee and J.V. Milanovic [54] have proposed a decentralized fuzzy logic controller using a systematic analytical method based on a performance index.F.Rashidi[42] has described a fuzzy sliding mode controller in which a simple fuzzy inference mechanism is used to estimate the upper bound of uncertainties. Kamalasadan, S and Swann, G [28] have proposed a fuzzy model reference adaptive controller uses a fuzzy reference model generator (FRMG) in parallel with the model reference adaptive controller(MRAC).

III. SCOPE OF THE PRESENT STUDY

- To study the nature of power system stability, excitation system, automatic voltage regulator for synchronous generator and power system stabilizer.
- To develop a fuzzy logic based power system stabilizer which will make the system quickly stable when fault occurred in the transmission line.
- By using simulation to validate fuzzy logic based power system stabilizer and its performance is compared with conventional power system stabilizer and without power system stabilizer.

IV. PROBLEM STATEMENT

Some of the earliest power system stability problems included spontaneous power system oscillations at low frequencies. These low frequency oscillations (LFOs) are related to the small signal stability of a power system and are detrimental to the goals of maximum power transfer and power system security. Once the solution of using damper windings on the generator rotors and turbines to control these oscillations was found to be satisfactory, the stability problem was thereby disregarded for some time. However, as power systems began to be operated closer to their stability limits, the weakness of asynchronizing torque among the generators was recognized as a major cause of system instability. Automatic voltage regulators (AVRs) helped

5.From the present studies following conclusions were drawn-

The effectiveness of power system stabilizer in damping power system stabilizer is reviewed. Then the fuzzy logic based power system stabilizer is introduced by taking speed deviation and acceleration of synchronous generator as the input signals to the fuzzy controller and voltage as the output signal. FLPSS shows the better control performance than power system stabilizer in terms of settling time and damping effect. Therefore, it can be concluded that the performance of FLPSS is better than conventional PSS. However, the choice of membership functions has an important bearing on the damping of oscillations. From the sim- ulation studies it shows that the oscillations are more pronounced in case of trapezoidal membership functions. The response with gaussian membership functions is comparable to triangular membership functions. However, the performance of FLPSS with triangular membership functions is superior compared to other membership functions.

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