Synopsis

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Thesis Title: **DESIGN OF FACTS CONTROLLER AND PSS USING INTELLIGENT TECHNIQUES FOR STABILITY ANALYSIS IN RESTRUCTURED MARKET**

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The electric utility industries have undergone unprecedented changes in its structure worldwide. New issues in power system operation and planning are inevitable due to the advent of an open market environment and restructuring of the industry into separate generation, transmission, and distribution entities [1] [2]. One of the major consequences of this new electric utility environment is the greater emphasis on stable, secure, controlled, momentary and high quality electric power in restructured power scenario. In restructure market consist generation companies (GENCOS), transmission companies (TRANCOS), distribution companies (GENCOs) and independent system operators (ISO). The ISO is independent and disassociated agent for market participation and perform the various ancillary services. The ISO uses ancillary services for [3] [4] maintaining the frequency, voltage profile,stability of the system and preventing the overloading as well as restoring the system after the black out.

The small signal stability analysis and transient stability analysis have become essential ingredient of for stable and secure operation of power system [5]. The stability of the power system has been affected by the disturbances like a sudden change in load, loss of generator or switching of a transmission line during the fault and wide spread use of the high gain

fast acting excitation system. The instability and low frequency oscillations limit the power transmission capability and the eventually breakdown of the entire power system under the certain operating conditions and configurations. The ancillary controllers play very important role in deregulated electric market to enhance the stability of the power system with their good controlling characteristics. The ancillary service such as power system stabilizer (PSS) [3] and Flexible Alternating Current Transmission system (FACTS) controller [4] [6] in deregulated electric market has been addressed. Significance and impact of small signal stability and transient stability issues in restructured electric market has been reported [3] [7].

The Power system stabilizer provides the supplementary control signal for the excitation system of the synchronous generator to damp the low frequency oscillations and to improve power system stability. The power system stabilizers have been designed very extensively using phase compensation techniques and parameters of PSS have been calculated based on linearized Philips–Heffron model of the power system for the small signal stability analysis [5] [8] [9]. The small signal stability and transient stability with concepts of synchronizing and damping torques has been explained in [10]. The conventional control techniques based PSS can provide optimal performance for the normal operating conditions and normal system parameters. However, a modern power system has become large, tight and highly dynamic, hence to difficult to solve low frequency oscillations problem through conventional and linear optimal control approaches. For the different loading conditions and configuration of power network, the parameters of PSS controllers are needed to be modified. To overcome these limitations, computational intelligent techniques such as Fuzzy Logic (FL), Artificial Neural Network (ANN), Genetics Algorithm (GA), Particle Swarm Optimization (PSO) etc. based PSS have been proposed in different literature.

The FACTS controller plays very important role in deregulated electric market to enhance the stability of the power system with their fast control characteristics and continuous compensating capability. FACTS devices can be effectively used for load flow control, loop power flow control, load dispatched, voltage regulation, enhancement of transient stability

and mitigation of system oscillation [11] [12]. One of the most important devices of series FACTS controller is thyristor controlled series capacitor (TCSC) [13] in order to enhance the stability and load ability of the transmission network.

In large power system, abnormal phenomena have been frequently observed such as tie-line power deviation, rotor speed deviation and outage of generation under various loading conditions. Automatic generation control (AGC) is an essential control loop in electric power system which maintain balances between generated power and demand power in each control area. For the conventional Load Frequency controller, the integral of area control error (ACE) is utilized as the control signal for conventional control strategy. An integral controller provides zero steady state deviation, but it produces poor dynamic performance. Therefore advanced control techniques are needed to handle abnormal situation in power system. The application of FACTS controllers [14] in multiarea AGC under deregulated electric market [15] has been reported by recent research paper.

Therefore achievement of desired performance of power system under contingencies, the intelligent techniques based adaptive PSS and FACTS damping controllers are required to be designed. The controllers accompany load frequency control (LFC) in multiple area generation (AGC) system in deregulated environment have been an attraction in ongoing research work.

The motivation behind the work presented in this thesis are:

1. To develop the linearized model of fifth order synchronous machine from non linear model and to derive the different constants follows block diagram of the synchronous machine connected to single machine infinite system.

2. To develop the mathematical model of the machine in state space form with conventional power system stabilizer (CPSS), proportional integral derivative PSS, and TCSC individually and simultaneously.

3. To design the PSS using different intelligent techniques such as Genetic Algorithm, Levenberg Marquardt neural network (LMNN), adaptive neuro fuzzy inference system

(ANFIS), genetics algorithm based artificial neural network hybrid algorithm (GA-ANN), Neural Netwrok based non linear auto regressive moving average (NARMA) -L2 controller.

4. To design the stability control loop of TCSC using GA, ANN and ANFIS techniques. To analyze the simultaneous and individual application of PSS and TCSC using programming and to carry out non linear simulations under different operating conditions and disturbances in power system .

5. To develop linear model and block diagram of the two area automatic generation control system with the first order and fifth order power system model under the restructured electric environment.

6. To build the model of two area power system with multiple PSS, individual tie-line TCSC and combining PSSs and TCSC.

7. To study the effectiveness of an ancillary controllers such as multiple PSSs and TCSC in restructured electric market.

8. To evaluate the performance of smart control techniques based ancillary controller using linear analysis and non linear simulation.

A brief description of the work reported in the thesis is given below:

In present Chapter 1 introduces the restructured electric market, stability issue and application of ancillary controllers in restructured market. It represents the relevant state-of-the-art survey and sets the motivation behind the research work carried out in this thesis.

Chapter 2 presents, detail modeling of the system components and linerization of non linear equations using Taylor's series method. The state space form of power system with conventional power system stabilizer and PID- power system stabilizer have been described. The linearized state space form of power system with individual TCSC and simultaneous CPSS and TCSC have been also derived.

Chapter 3 presents, Genetic Algorithm based control strategies for designing of CPSS, PID-PSS and TCSC damping controller. The individual PSSs and simultaneous designed TCSC and PSS have been applied to the dynamical power system. The small signal stability analysis and non-linear simulation for the transient stability analysis are carried out for details investigation of the power system stability issue.

Chapter 4 discusses Adaptive Neuro-Fuzzy Inference System and Levenberg-Marquardt Artificial Neural Network algorithm for development of the control strategy for thyristor control series capacitor based damping controller and power system stabilizer. The non-linear simulations of single machine infinite bus system have been carried out using individual and simultaneously application of PSS and TCSC. The comparisons between intelligent control strategies based damping controllers also have been carried out.

Chapter 5 discusses Non Linear Auto regressive Moving Average-L2 controller and hybrid Genetic Algorithm based Network Network for development of the control strategy for power system stabilizer. In order to achieve appreciable damping, developed ANFIS based Thyristor control series capacitor has been suggested in addition to power system stabilizer. The non-linear simulations of single machine infinite bus system have been carried out using individual and simultaneously application of PSS and TCSC.

Chapter 6 presents, performance and role of ancillary controllers such as PSS and TCSC in two area control system under restructured electric market. Low order power system model and higher order power system model have been considered for depth analysis of two area system with ancillary controllers. The small signal stability analysis and non-linear simulation for the transient stability analysis are carried out for investigation of the power system stability issue.

Chapter 7 concludes the main finding and significant contribution of the thesis and provides a few suggestion for further scope of research work in this area.

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