A Wide Area Damping Controller of Power System

Prajapati Ravi Kumar*[1], Dr. Sanjay Jain[2]
*[1] *M.Tech Student, Electrical Engineering Department, RKDF University, Bhopal, M.P.*
prajapati.ravi@yahoo.com[1]
[2]*HOD, Electrical Engineering Department, RKDF University, Bhopal, M.P.*
jain.san12@gmail.com[2]

ABSTRACT

The major work in this dissertation is to design a wide area damping controller based on different signal selection methods. The selection of most suitable stabilizing feedback signal to the wide-area controller is the key objective of the controller design. In this dissertation two different methods of signal selection for wide area damping controller of power system have been exercised with emphasis on damping of critical inter area mode. The methods of signal selection discussed include approach based on residue and geometric measure of joint controllability/observability. The controller design and structure have been kept simple. The controller used in this dissertation is as simple as a two channel lead-lag compensator based Power System Stabilizer. The methods of signal selection were illustrated on Kundur's two area four machine system. The effectiveness in damping of the critical inter area mode was assessed by both small disturbance and large disturbance stability analysis.

. **Keywords:** *Two area four machine system, Power System Stability*

1 INTRODUCTION

The development of electric power system and continues interconnection of regional electric grids, the stability problem becomes more complex in nature, especially low frequency oscillation which play an important role to influence the stability and efficient operation of inter connected grids. The low frequency oscillations in the power system network especially the inter-area oscillations (0.1 to 1 Hz) is the key factor that influence the stable operation of interconnected grids and limits the transmission capacity of large-scale power system. Inter-area oscillations mainly represents the power oscillations among different generators located in different area of power systems. In the local control strategies adopted, local control signals for the controller can't achieve the effective damping control for these inter-area oscillations.

.

The current installed capacity of electricity generation in India is 304.761 GW as of the end July 2016, [Wikipedia, 2016]. Nowadays, the continuous inter-connection of regional electric grid is the developing trend of modern power system all over the world, such as interconnection of national grids of India, Europe network, the Japan power grids, the national grids of Chinaand North American power grids. The main reason for interconnection of electric grids is that it can efficiently utilize various power resources distributed in different areas and achieve the optimal allocation of energy resources. This also optimize the economic dispatch of power and get relatively cheaper power, which implies that decrease of system installed capacity and the investment. Moreover, in case of fault or disturbance in operating condition, it can provide additional supporting power of each area of interconnected grids which can increase the reliability of generation, transmission and distribution system

The inter area oscillations inherent to the large inter connected grid becomes more dangerous to the system's security and the quality of the supply during transient situation. Hence it can be said that the low frequency oscillations put limitations on operation of the power system and network's control security.The increased interconnected network of power system carries out heavy inter change of electrical energy which invokes such poorly damped low frequency oscillation that the system stability becomes major concern. Figure 1.1 indicates the post-disturbance oscillations of the power system are neither increasing nor decreasing which shows that the damping ratio is zero. In such situations, the power system may become unstable.

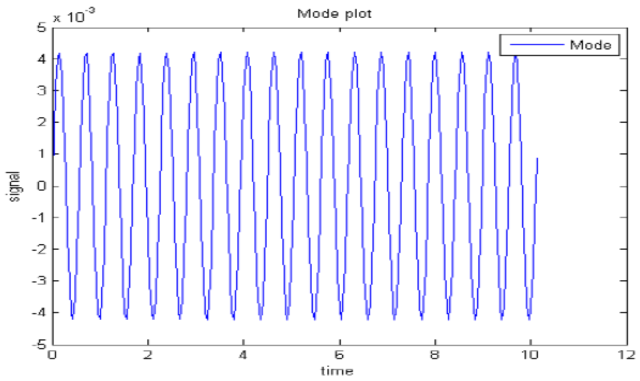
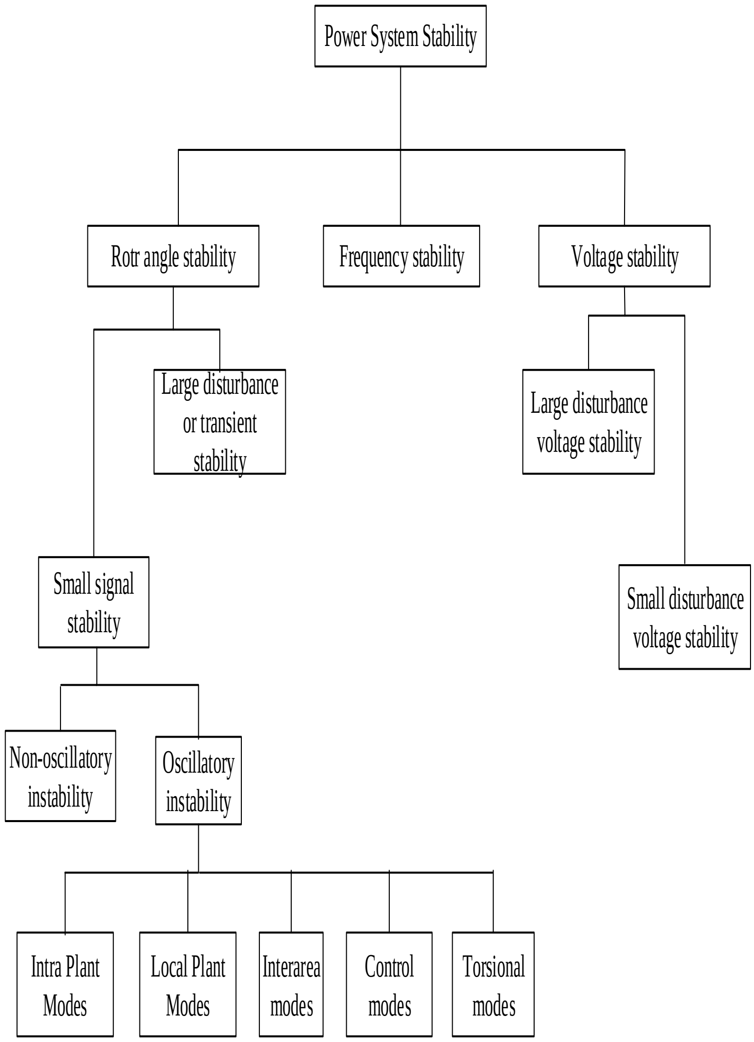


Figure 0-1 Undamped oscillations with frequency of 1.78 Hz (30th July 2012) mode (Damping: 0%): Post-Disturbance

2 Power System Stability

Power system stability may be broadly defined as property of power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain acceptable state of equilibrium after being subjected to a disturbance

In the evaluation of stability the concern is the behaviour of power system when subjected to a transient disturbance. This disturbance may be small or large. Small disturbances in the form of load changes take place continuously. The system must be able to operate satisfactorily under these conditions and successfully supply the maximum amount of load. Large disturbance occur due to severe change in nature such as short circuit on a transmission line, loss of a large generator or load, or loss of a tie- line between two sub systems.



2.1 Rotor Angle Stability

Rotor angle stability is the ability of interconnected synchronous machines of a power system to remain in synchronism. The rotor angle stability depends on the ability of each synchronous machines of a power system to maintain/restore equilibrium between electromagnetic torque (generator output) and mechanical torque (generator input). If any of the synchronous machines fails to maintain synchronism with the rest of generators, then this will gives the result of instability.

2.2 Voltage Stability

Voltage stability is the ability of a power system to maintain steady acceptable voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance. A system enters a state of voltage instability when a disturbance, increase in load demand, or change in system condition causes a progressive and uncontrollable drop in voltage. The main factor causing instability is the inability of the power system to meet the demand for reactive power.

For the purposes of analysis, it is useful to classify voltage stability into the following two subclasses:

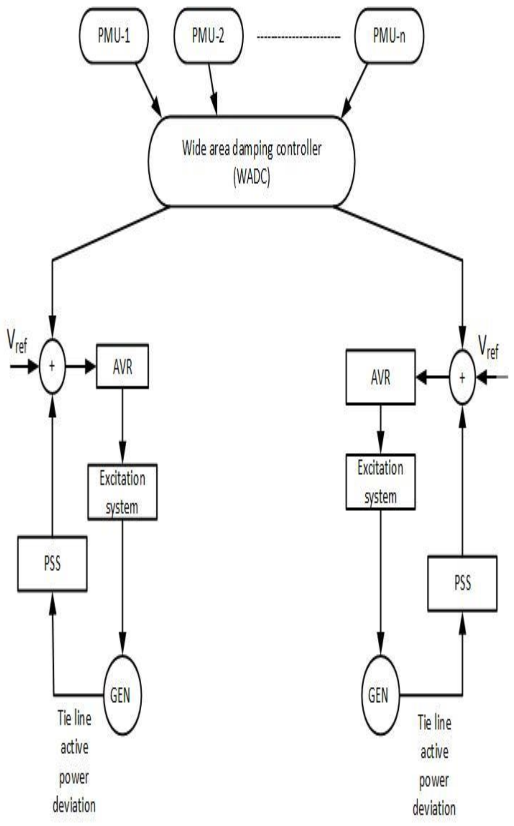
- Small-disturbance voltage stability is concerned with a system's ability to control voltages following small perturbation such as incremental changes in system load. This form of stability is determined by the characteristics of load, continuous controls, and discrete controls at a given instant of time.
- Large-disturbance stability is concerned with a system' ability to control voltages following large disturbances such as system faults, loss of generation, or circuit contingencies. This ability is determined by the system-load characteristics and discrete controls and protections.

Though the time frame of interest for voltage stability problems may vary froma few seconds to tens of minutes, voltage stability may be either ashort-term or a long-term phenomenon.

3 Damping Controller Design Structure

In a power system local oscillation modes are well damped out due to installation of local PSSs, but inter area modes are lightly damped out because of less observability of some significant inter area mode. A centralized controller structure is shown in figure.3.5. In the wide area damping control system selected stabilizing signals are measured by PMUs and send through dedicated communication links to the controller. This signal is modulated and sent them to selected generator exciters.

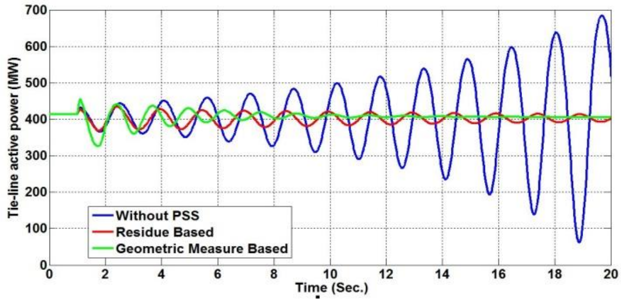
- for the display by selecting Options



3 RESULTS AND DISCUSSION

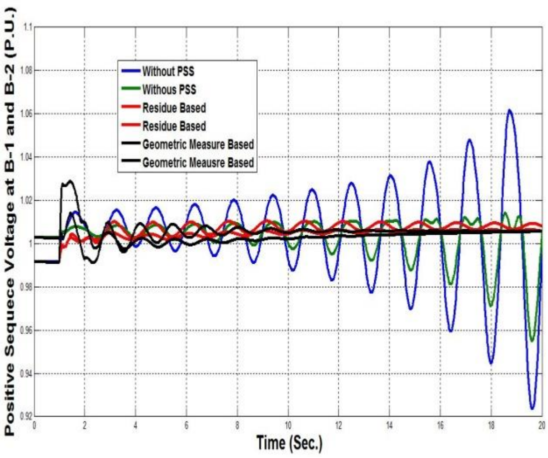
To evaluate the effectiveness of the controller under system nonlinearities, the two area 4 machine system has been disturbed by changing the reference voltage of Generator 1. The tie-line active power, Positive sequence voltage of bus-1and bus-2, speed response of Generators and rotor mechanical response of generator-1 w.r.t. generator-4 have been observed for 20s under the presence of selected feedback signalsby both the residue and geometric approach.

Tie-line active power flow after stepping up voltage reference at Generator-1



horizontal axis represent the simulation time in seconds(sec) and vertical line represent the tie-line active power flow in Mega Watt (MW). The graph explains the responses of the line active power flow connecting the tie-line from area-1 to area-2 in both the cases of signal selection by based on residue and geometric measure approachalong with without PSS. The plots have been taken by perturbing the voltage reference of Generator 1 AVR input. It can be observed that the signal selected by geometric approach gives better response as compared to the stabilizing signal selected by residue approach with respect to its settling time, peak over shoot and no. of oscillations.

Positive sequence voltage at Bus-1 and B-2 for step change at Generator no. 1



shows positive sequence voltage at bus-1 and bus-2 for step change in AVR input voltage of generator 1. It can be seen in this figure that there are more no. of oscillations present in the system if the signal selected by residue approach is used as wide-area signal. In this case also geometric approach for signal selection performs well with respect to with respect to its settling time, peak over shoot and no. of oscillations

4 CONCLUSION

The kundur's two area four machine system was illustrated as test system to examine the effectiveness of the selected control signal to damp a given inter area mode. To determine the suitable control loop both residue and geometric measure of joint controllability/observability based signal selection approaches were carried out.

5 *REFERENCES*

[1] *Aboul-Ela, Sallam A, McCalley J, and Fouad A, "Damping Controller Design For Power System Oscillations Using Global Signals," IEEE Trans. Power Syst., vol. 11, no. 2, May 1996, pp. 767–773.*

[2] *Almutairi A, and Milanovic, "Comparison Of Different Methods For Input/Output Signal Selection For Wide Area Power System Control," IEEE Conf., pp. 1-8, 2009*

[3] *Almutairi A, and Milanovic, "Optimal and Optimal Output Signal Selection For Wide Area Controller," Proceeding Power Tech Conference, pub: IEEE Bucharest, Romania, July 2009, pp. 1-6.*

[4] *AIEE Subcommittee on Interconnections and Stability Factors, "First Report Of Power System Stability," AIEE Trans., 1926,pp. 51-80.*

[5] *Breulmann H, Grebe E, Lösing M, Winter W,Witzmann R, Dupuis P, Houry M. P, T., MargotinJ,Zerenyi, Dudzik J,Machowski J, Martin L,Rodriguez J. M, Urretavizcaya E, "Analysis and Damping of Inter-Area Oscillations In The UCTE/CENTREL Power System," CIGRE, Paris, 2000,pp. 38-113.*

[6] *CIGRE Task Force 38.01.07 on Power System Oscillations, "Analysis and Control Of Power System Oscillations," CIGRE Technical Brochure, no. 111, Dec. 1996.*

[7] *Dominguez-Garcia J. L, Binachi F. D, and Bellmunt O. G, "Control Signal Selection for Damping Oscillations With Wind Power Plants Based On Fundamental Limitations," IEEE Trans. Power Sys., vol. 28, no.4, Nov 2011,pp. 4274-4281.*

[8] *Dominguez-Garcia J. L, Ugalde-Loo C. E, Binachi F. D, and Bellmunt O. G, "Input–Output Signal Selection for Damping of Power System Oscillations Using Wind Power Plants," Elec. Power Syst. Res., vol. 54, pp. 75-84,Jan 2014.*

[9] *Erlich I, Hashmani A, Shewarega F, "Selective Damping Of Inter Area Oscillations Using Phasor Measurement Unit (PMU) Signals," Proceeding of IEEE conference Power Tech, Pub: IEEE, Trondheim, 2011, pp. 1-6.*

[10] Fang Liu-"Robust Design of FACTS Wide-Area Damping Controller Considering Signal Delay