Wide Area Damping Controller of Power System with Emphasis on Damping of Critical Inter Area Mode

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ABSTRACT

With the growing electricity demand and the aging utility infrastructure, the present-day power systems are operating close to their maximum transmission capacity and stability limit. In the past few decades, the angular instability, caused by small signal oscillations, has been observed in the power systems under certain system conditions, such as during the transmission of a large amount of power over long distance through relatively weak tie lines and under use of high gain exciters. These conditions introduce inter-area oscillation in the power system and which may cause a black out of the whole power 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.

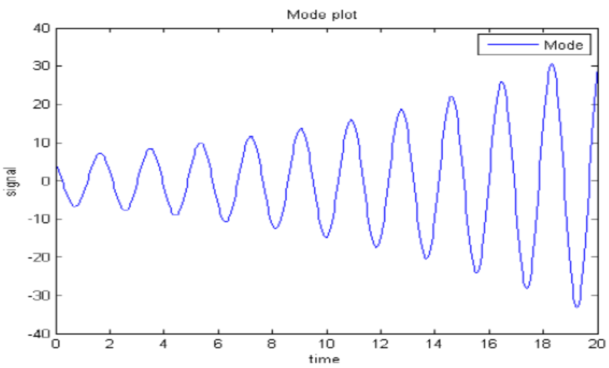
Keywords: Wide Area Damping Controller, Synchronous Generator

1. INTRODUCTION

. 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.

Oscillations in power systems are classified by the system components that they effect. Electromechanical oscillations are of the following types:

- **a)** Intra-plant mode oscillations(2.0 -3.0 Hz)
- **b)** Local plant mode oscillations(1.0-2.0 Hz)
- **c)** Inter-area mode oscillations(0.1-1.0 Hz)
- **d)** Control mode oscillations mechanical oscillations
- **e)** Torsional modes between rotating plant (10-46 Hz). [Pal, 2005]



Inter-area oscillations with frequency of 0.53 Hz (31st July 2012) mode (Damping: -2%): Pre-Disturbance

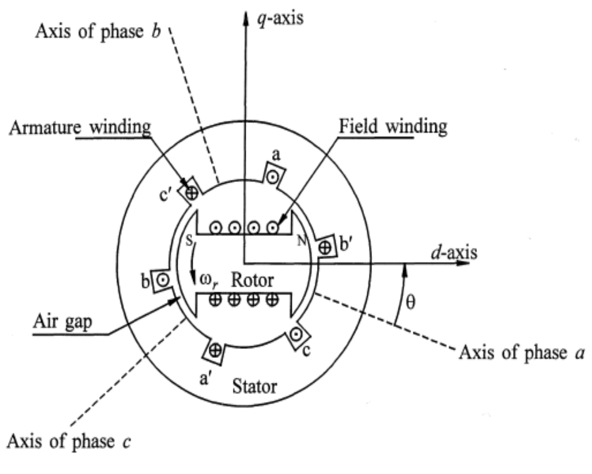
indicates the pre-disturbance inter-area oscillations with frequency of 0.53 Hz and negative value of damping ratio. When damping ratio is negative, then amplitude of oscillation is continually increases with respect to time which make power system unstable.

2 Synchronous Generator Modelling

Synchronous generators are the principal source of electric energy in power system. The power system stability is the main problem that deals with the inter connections of synchronous machines in synchronism. The synchronous generator mainly consists of two essential components. First one is field and the second is the armature. The field winding carries direct current and produces a magnetic field which induces alternating current and produces a magnetic field which induces alternating voltages in the armature windings.

consists of six power switches which may be metal-oxide-semiconductor-field-effect transistors (MOSFET), gate-turn-off thyristor (GTO), or insulated-gate-bipolar transistors (IGBT), depending on the drive power capacity and the inverter switching frequency. The inverter converts the DC link voltage into an adjustable three-phase AC voltage to supply to motor .Diverse control

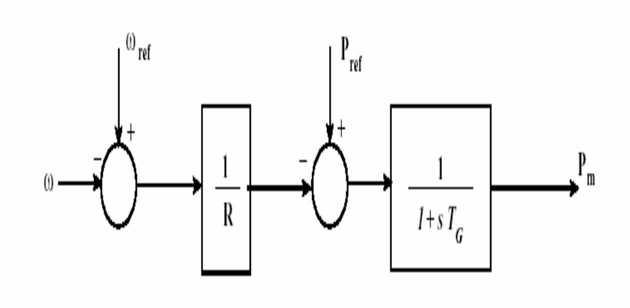
In this research steam turbines of high speed round rotors are used. From design simplicity point of view dampers of rotors are not used in this research



Schematic Diagram of a Three Phase Synchronous Machine

2.1 Governor Modelling

The prime mover provides the mechanism for controlling the synchronous machine speed and hence voltage frequency. Consecutively to automatic control speed and frequency, adevice must be there to sense either speed or frequency in such a way that comparison with a desired value can be used to create an error signal to get corrective action. The control system diagram of such amodel for time constant governor 'T_G' with speed regulation 'R' is shown in figure.



Block Diagram of Governor Model

2.2 Excitation Modelling with AVR and PSS

The exciter supplies D.C. power to the synchronous machine field winding. There are 12 numbers of IEEE standard excitation systems used in power system namely IEEE DC1A, IEEE AC1A, IEEE AC4A, IEEE ST1A, IEEE ST2A exciter model.In this dissertation IEEE ST1A exciter model used.The control system diagram is shown in figure 3.3. The excitation system surrounded byAutomatic Voltage Regulator(AVR) and Power System Stabilizer (PSS). The basic function of a PSS is to add damping to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signals. A PSS is added with AVR to control the generator stator terminal voltage. PSS uses stabilizing feedback signals such as shaft speed, terminal frequency and power to change the input signal of the AVR.The PSS represented in figure 3.3 consist of three block: a phase compensation block, a signal washout block and a gain block.

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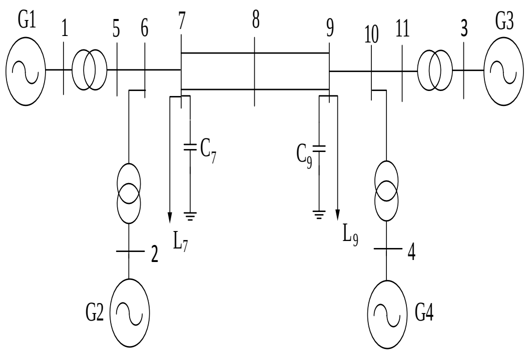
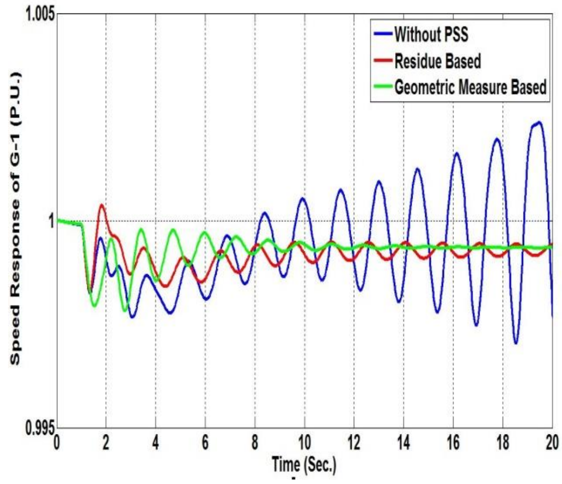
The simulation of complete system has been developed in Mat-lab Sim PowerSystem environment. To perform the non-linear time domain simulation Mat-lab Control System Toolbox has been used.The Simulink library has been used to develop the complete model of Kundur's proposed test system. The detail descriptions of the Kundur's two area four machine system are given in Appendix *A* which is adopted from [Kundur, 2004].In the test system all the generators are equipped with governor, AVR, and IEEE ST1A type static exciter. The loads taken here are constant impendence type and connected to bus no. 7 and 9.The structure of the case study power system is given in figure3.7. It is assumed that the Local signal based



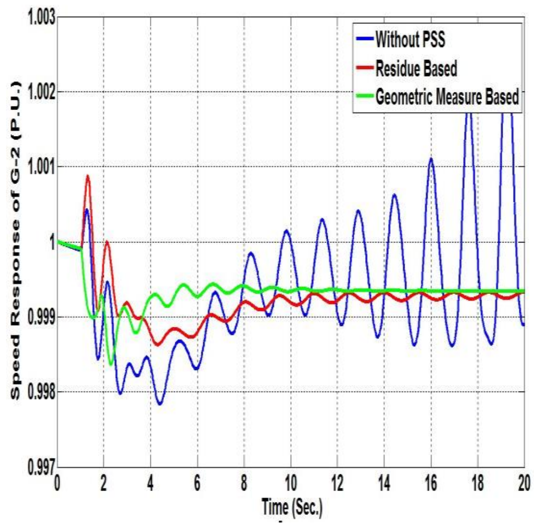
Kundur's two area four machine system

4 RESULTS AND DISCUSSION

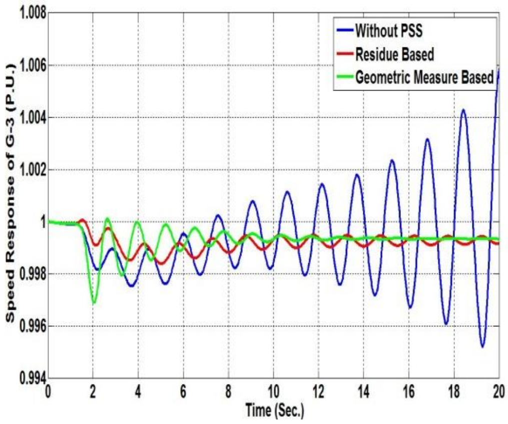
The plots of speed response for generator no.1, 2, 3 and 4 are represented. In this case when its AVR is feedback by the signal i.e. $P_{7\text{-}8}$ which is selected by the geometric approach of signal selection shown there is no oscillation in speed response of generators. However the oscillations still remains in speed response of generators in case the signal is selected by residue approach. Here also it is evident that signal selected by geometric method gives very good result as compared to residue method.



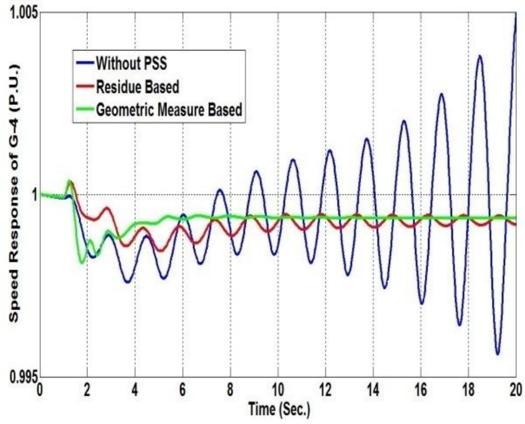
Speed response of Generator-1



Speed response of Generator-2



Speed response of Generator-3



Speed response of generator-4

The plots of speed response for generator no.1, 2, 3 and 4 are represented. In this case when its AVR is feedback by the signal i.e. $P_{7\text{-}8}$ which is selected by the geometric approach of signal selection shown there is no oscillation in speed response of generators. However the oscillations still remains in speed response of generators in case the signal is selected by residue approach. Here also it is evident that signal selected by geometric method gives very good result as compared to residue method.

5 CONCLUSION

Based on the experimental simulation of the designed WADC, the results and conclusion that can be drawn based on the interpretation of the results, in chapter 6 the following conclusion are arrived for Kundur two area four machines system.

The major work in this dissertation is to select the most suitable stabilizing feedback signal to the wide area controller. The selection of most suitable stabilizing feedback signal is the majorobjective 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 is based on residue and geometric measure of joint controllability/observability. 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.

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