International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com || Volume 03 - Issue 07 || July 2017 || PP. 38-44

Power Oscillations Control Using Statics Synchronous Series Compensator with Damping Controller

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Abstract: The focus of this research work is on SSSC-based power oscillation damping controller, which can damp the power oscillations occurring due to the any change in the transmission line like sudden change in load, sudden change of generator output, occurrence of fault, transmission line switching and short circuit. In this research work, simulation models for single machine and two machine infinite bus systems with active power compensation by SSSC has been developed. These simulation models have been incorporated into MATLAB based Power System Toolbox (PST) for their transient stability analysis. These models were also analyzed for such types of changes with the use of SSSC-based power oscillation damping controller Oscillation damping controller has varied the phase angle & magnitude of the series injected voltage in order to remove the power oscillations of the specified bus which arises due to the changes in transmission line.

Keywords: Statics Synchronous Series Compensator, Matlab, Power System Toolbox, Oscillation Damping Controller.

I. INTRODUCTION

In today's high complex and interconnected power systems, there is a great need to improve power utilization while still maintaining reliability and security. Reducing the effective reactance of lines by series compensation is a direct approach to increase transmission capability. However, a power transfer capability of long transmission line is limited by stability consideration [13].Oscillation of generator angle or line angle are generally associated with the transmission system disturbances and can occur due to step changes in load, sudden change of generator output, transmission line switching and short circuit [18]. Different modes of rotor oscillation are local mode, intra-area mode and inter-area mode. The frequency of oscillations of rotor swings varies from 0.2 to 4 Hz [2]. The lower end of frequency spectrum corresponds to inter-area modes, in which a large number of generators participated and their damping is difficult. This low frequency is important to damp as quickly as possible because they cause mechanical wear in power plants and cause power quality problem. If the electromechanical oscillations are not properly controlled in the electric power system operation, it may lead to a partial or total system outage [18]. Instability problems in power systems that can lead to partial or full blackout can be broadly classified into three main categories, namely voltage, phase angle and frequency related problems [3]. In early age this signal instability problem was solved by amortisseurs implemented in generator rotors, later with the application of fast excitation system this was solved by development & utilization of Power System Stabilizer (PSS) and however in modern power system due to the connection of power grids in vast area, for inter area oscillation damping due to the ability of controlling line impedance, power flow and bus voltage, Flexible AC transmission Systems (FACTS) devices implementation offers an alternative solution [19].

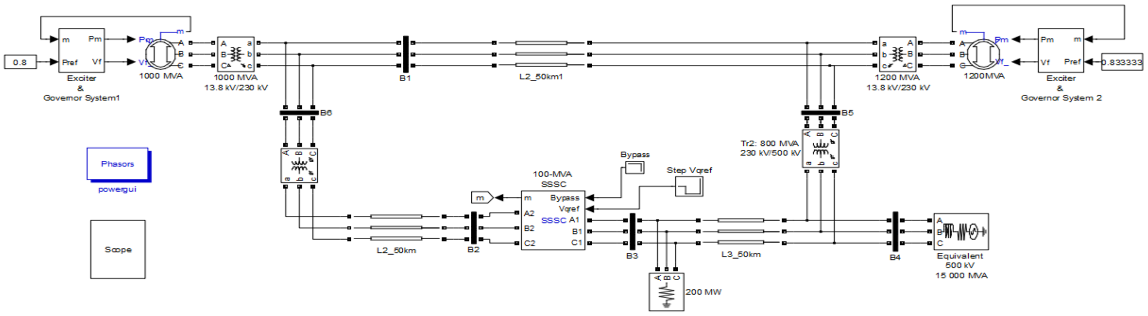
II. POWER SYSTEM MODEL

In order to make a more thorough study for the presence of SSSC & Power Oscillation Damping Controller in a two machine infinite bus system, a study using MATLAB/SIMULINK is done. Such a study will also take into account the transient nature of the system when various changes happened to the two machine infinite bus system. Power System Toolbox (PST) of MATLAB is used for simulation purposes. In the present work active power compensation by injection of different level of voltage (V_q) by SSSC.

1.1 Simulation of Two Machine Infinite Bus System with SSSC

1.1.1 Simulation Model of Two Machine Infinite Bus System with SSSC

In this case SSSC is connected between bus 2 and bus 3 of the above two machine infinite bus system so as to connect it in series with line 2. It has a rating of 100MVA and is capable of injecting up to 10% of the nominal system voltage. It has a DC link nominal voltage of 40 kV with an equivalent capacitance of 375 uF.



1.1 Simulation model of two machine infinite bus system with SSSC

In two machine infinite bus system with the injection of voltage by SSSC, results of the variation of magnitude of injected voltage, magnitude of active & reactive power at bus-2, magnitude of voltages, active & reactive power across bus1-4 versus time are shown in fig. 1.2 to 1.4.

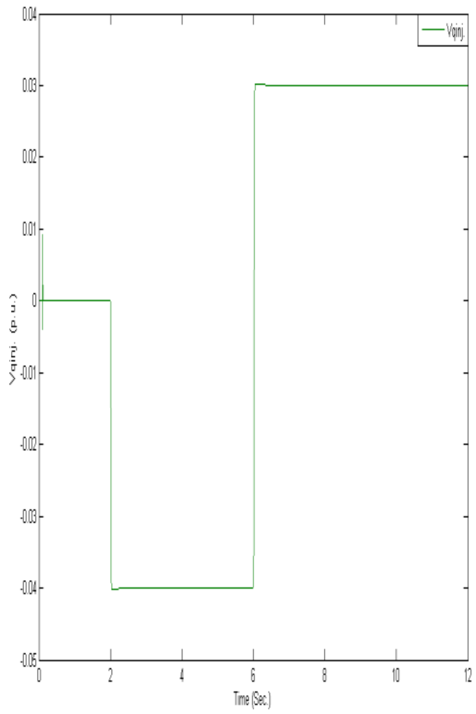


Fig. 1.2 Vqinj. by SSSC

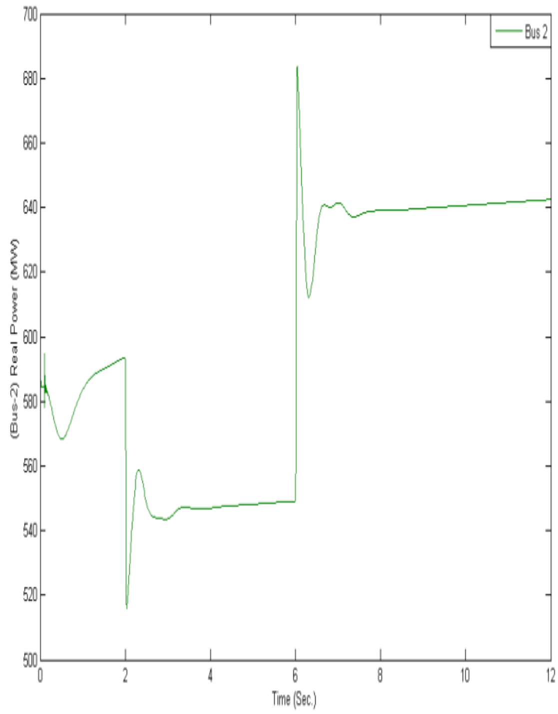


Fig. 1.3Active power (at bus 2) with SSSC

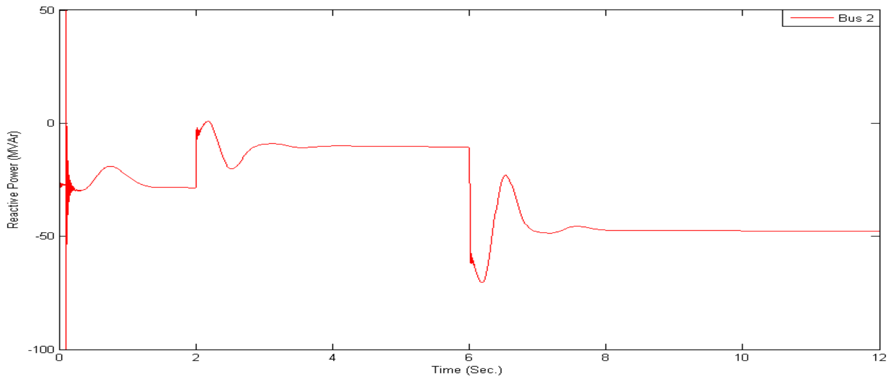


Fig. 1.4 Reactive power (at bus 2) with SSSC

From fig. 1.2 it is seen that at 2 sec. voltage (Vq) of value -0.04 p.u. and at 6 sec. voltage (Vq) of magnitude 0.03 p.u. is injected by SSSC. At 2 sec. due to the injection of negative quadrature voltage (Vq) by SSSC (i.e. inductive compensation) there is a decrease in active power demand and increase in reactive power demand at bus 2. At 6 sec. with injection of positive quadrature voltage (Vq) by SSSC (i.e. capacitive compensation) there is an increase in active power demand and decrease in reactive power demand at bus 2 as shown in fig. 1.3 & fig. 1.4 for active & reactive power respectively. In both fig. it is seen that both active & reactive power changes abruptly in their magnitude.

1.2.1 Simulation Model of Two Machine Infinite Bus System with SSSC-based Damping Controller

In this model a damping controller is connected between SSSC and injected voltage of the above two machine infinite bus system model with SSSC.

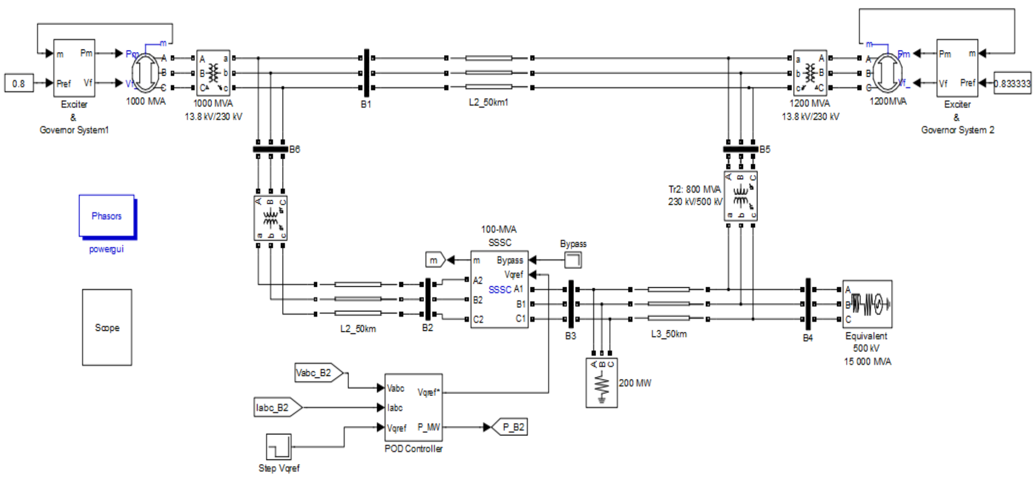


Fig.1.5 Simulation model of two machine infinite bus system with SSSC & POD

In two machine infinite bus system with the control of SSSC-based power oscillation damping controller, results of the variation of magnitude of injected voltage, magnitude of active & reactive power at bus-2, magnitude of voltages, active & reactive power across bus1-4 versus time are shown in fig. 1.6 to 1.10.

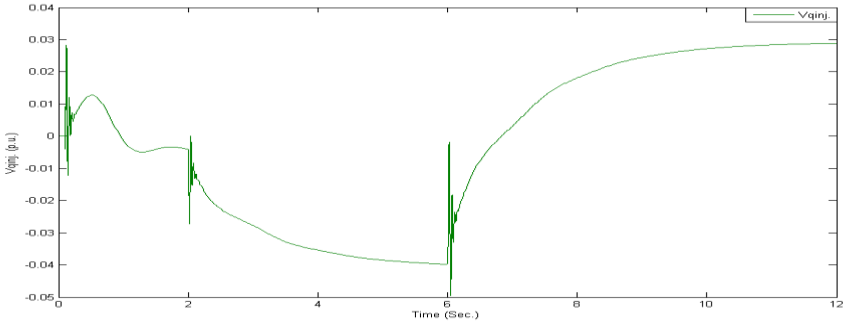
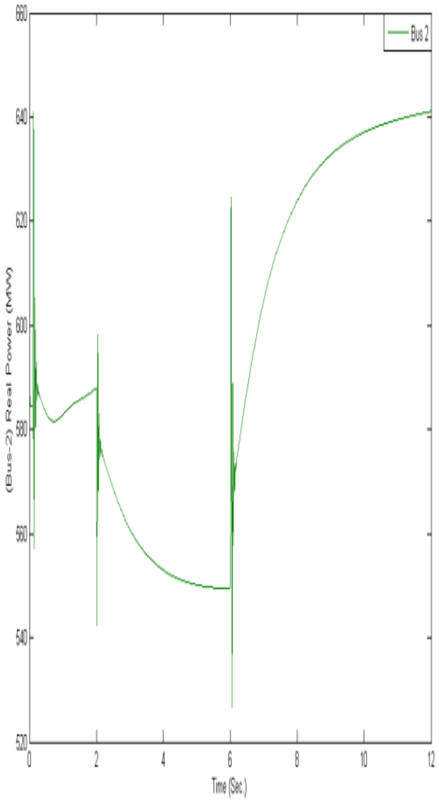


Fig.1.6 Vqinj. by SSSC-based POD



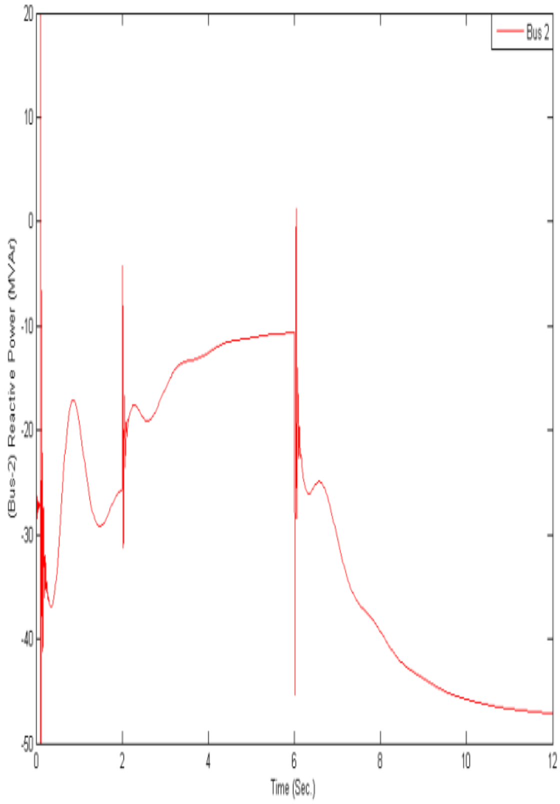


Fig.1.7 Active power using SSSC-based POD & Fig.1.8Reactive power using SSSC-based POD(at bus 2)

From fig. 1.6 it is seen that at 2 sec. voltage (Vq) of value -0.04 p.u. and at 15 sec. voltage (Vq) of magnitude 0.06 p.u. are injected by SSSC through power oscillation damping controller. The injection of voltage through POD changes abruptly. Due to this injection of voltage there is a change in active and reactive power demand at bus 2 in both the cases as shown in fig. 1.7 & fig. 1.8 for active & reactive power respectively. But in both fig. it is seen that magnitude of both active & reactive power change smoothly. While with the injection of voltage (Vq) by SSSC-based damping controller at bus 2, response of voltages, active & reactive power at remaining buses are shown in fig. 1.9 to 1.11 respectively. There is a change in magnitude and some control on oscillations of active & reactive power of all the buses.

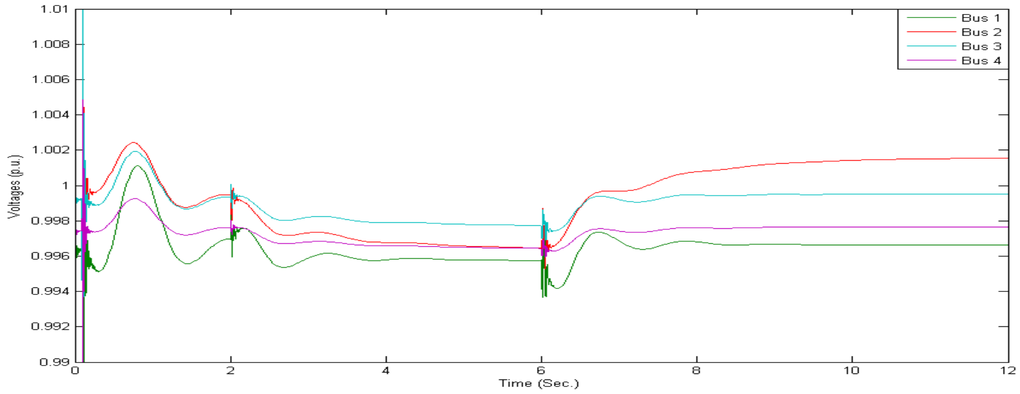


Fig.1.9 Voltages (at bus1-4) using SSSC-based POD

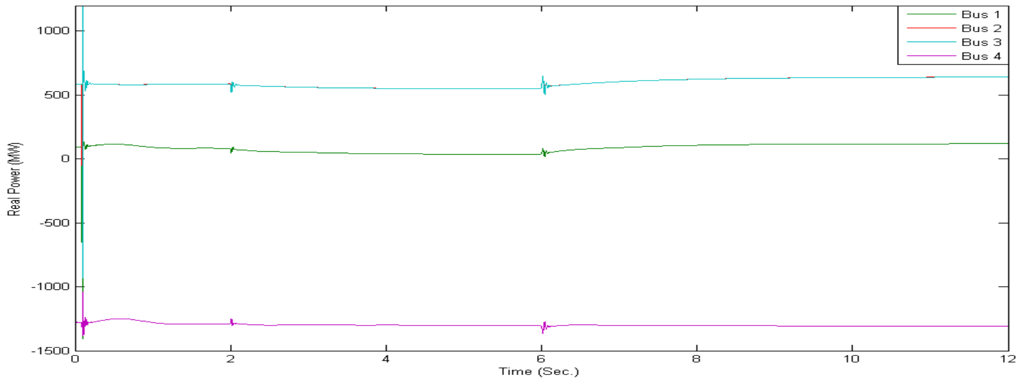


Fig. 1.10 Active power (at bus1-4) using SSSC-based POD

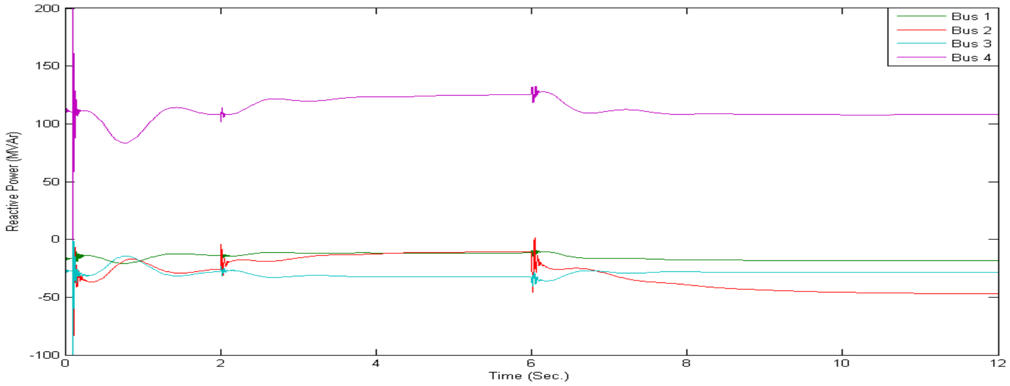


Fig. 1.11 Reactive power (at bus 1-4) using SSSC-based POD

III. PERFORMANCE AND RESULTS

1.3.3 Results of Two Machine Infinite Bus System with and without SSSC-based POD

Comparison of results of two machine infinite bus system with SSSC and with SSSC-based damping controller is analyzed here. Resulting of the comparison of variation of injected voltage and magnitude of active power at bus 2 for above cases are shown in fig. 1.11 and 1.12.

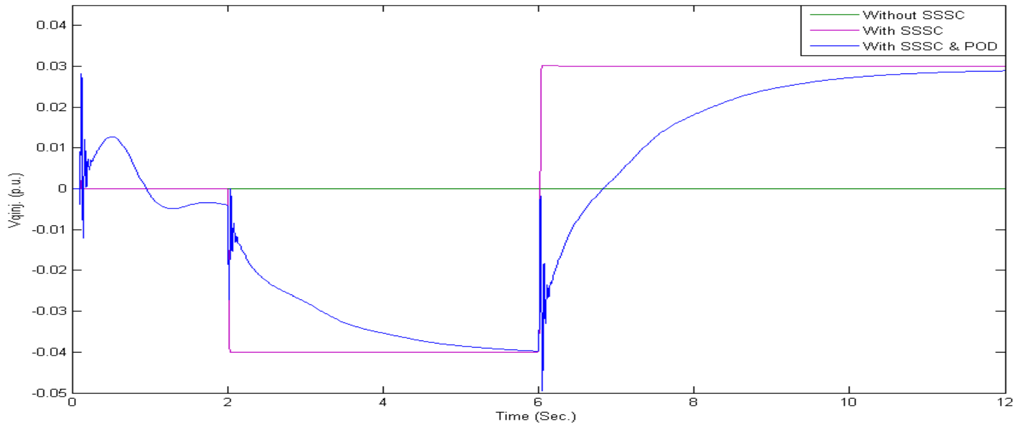


Fig. 1.12 Vqinj. by SSSC & SSSC-based POD

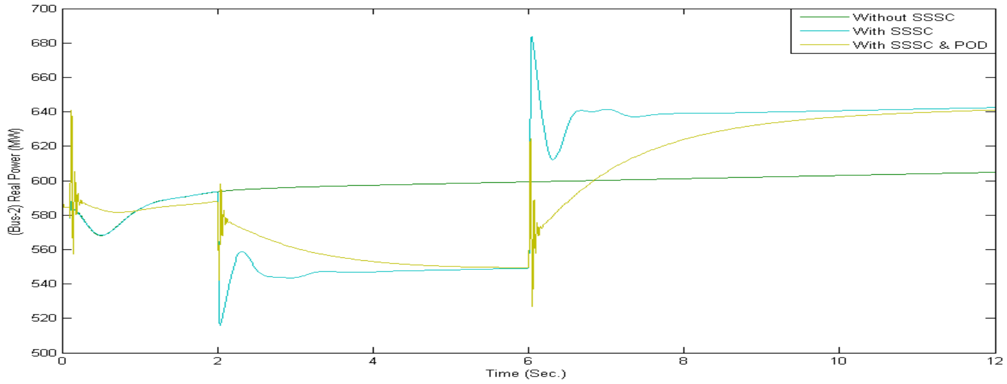


Fig. 1.13 Active power (at bus 2) with SSSC & SSSC-based POD

From fig. 1.12 it is seen that with SSSC at bus 2, the voltage injected is of constant magnitude but with the use of SSSC-based damping controller, the injection of voltage (Vq) changes abruptly. And from fig. 1.13, due to the injection of quadrature voltage (Vq) of value -0.04 p.u. at 2 sec. there is a decrease in active power at bus 2 and this decrease of active power changes abruptly for about 3 sec. and at 6 sec. with the injection of quadrature voltage (Vq) of value 0.03 active power increase with period of oscillations of 3 sec. in both cases of voltage injection by SSSC. But with the use of SSSC-based damping controller, there is a compensation of oscillations produced due to the change in active power at bus 2 and it achieved its final value in about 3 sec. and 3.5 sec. in above cases of voltage injection by SSSC-based damping controller.

IV. CONCLUSION

In this research work, simulation models of two machine infinite bus system with and without SSSC-based power oscillation damping controller has made. A change in active power demand in SMIB and two machine infinite bus system has been compensated by using SSSC and SSSC-based power oscillation damping controller. From the results and observations it is conclude that In two machine systems, due to the injection of quadrature voltage by SSSC at bus 2, voltage, active & reactive power of remaining buses also affected and the oscillations generates due to the injection of voltage (Vq) can be controlled by the use of SSSC-based power oscillation damping controller, which control the injected voltage in such a way so as to get smooth variation in the change of active power. SSSC-based damping controller changes the magnitude and phase angle of the injected voltage according to control the oscillations in the active power of the desired bus so as to damp them out by superimposing a compensating signal.

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