Performance Evaluation of Combined PSS, POD and SSSC FACTS Device using PI controller

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Abstract: In emerging electric power systems, enlarged communication often leads to situations where the structure no longer remains in the secure operating region. The flexible AC transmission system (FACTS) controllers can take part in an important role in the power system security enhancement. However, due to high capital investment, it is necessary to locate these controllers optimally in the power system. This paper presents PI controller approach for the coordination between the conventional Power Oscillation Damping (POD) and Power System Stabilizer (PSS) controllers with an SSSC in a SMIB power system with the help of MATLAB to enhance the transient stability region and reduce the power oscillation damping.

***Index Terms* - SSSC, PI Controller, Power System Stabilizer, Power Oscillation Damping.**

I. INTRODUCTION

The power system operating conditions and topologies is time varying and the disturbances are unforeseeable especially in the new scenario of deregulated market. These uncertainties make very difficult to effectively deal with power system stability problems by conventional controllers, based on system model linearized around a specific operating point [1-3]. FACTS devices can provide power modulation for power oscillation damping by a supplementary damping controller, conventionally referred as FACTS Device Stabilizer (FDS). Generally, the FDS has the same structure of a conventional PSS. As a consequence, conventional PSS and FDS may fail, threatening the stability of the system so that a lot of interest has been placed in the use of more robust nonconventional controllers [6-9].

The Static Synchronous Series Compensator (SSSC) is a series connected FACTS controller dependent on VSC and can be considered as advanced kind of controlled series compensation, just as a STATCOM is an advanced SVC. A SSSC has several merits over SVC and STATCOM such as (a) elimination of bulky passive components (capacitors and reactors), (b) improved technical characteristics (c) symmetric capability in both inductive and capacitive operating modes (d) the connection availability of an energy source on the DC port to exchange active power with the AC grid. A solid-state synchronous voltage source, consisting of a multi-pulse, voltage sourced inverter and a DC capacitor in series with the transmission line is shown in Fig. 1 [10-11].

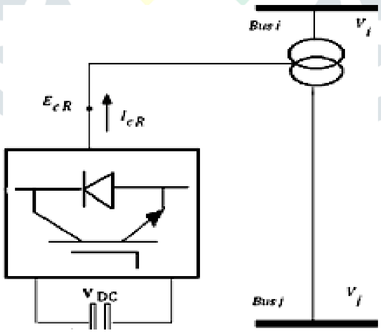

Fig. 1 Schematic diagram of SSSC

SSSC is a series-connected synchronous voltage source that can vary the effective impedance of a transmission line by injecting a voltage containing an appropriate phase angle in relation to the line current. If the injected voltage is in phase with the line current, then the voltage would exchange the real power. On the other hand, if the injected voltage injected in quadrature with line current, then reactive power would be exchanged and it can emulate as inductive or capacitive reactance so as to influence the power flow through the transmission line [12].

The series inverter injects voltage of variable magnitude and phase into the transmission line at the point of its connection, thereby controlling real and reactive power flow through the line. The active power flow through the line is supplied by SSSC. This real power is obtained from the DC source connected to its DC terminals. The shunt inverter provides the required power to the series inverter through the DC link [13].

Oscillations in power systems possessing SSSC have to be taken a serious note of concern when the fault takes place in any part of the system; else this might lead to the instability mode & shutting down of the power system [14]. In order to damp out the swinging oscillations, a PI controller is designed for SSSC connected in a multi-machine power system, when a three-phase line to line ground fault takes place at one of the generators.

II. Problem Formulation

The main aim is to apply PI control approach for the coordination between the conventional Power Oscillation Damping (POD) and Power System Stabilizer (PSS) controllers with an SSSC in a SMIB power system with the help of MATLAB to enhance the transient stability region and reduce the power oscillation damping.

III. Proposed Method

The SSSC has been applied to different power system studies to improve the system performance. The characteristics of the SSSC to enhance power system stability are utilized and the damping control function of an SSSC installed in a power system is investigated. The linearized model of the SSSC integrated into power systems was established and methods to design the SSSC damping controller were proposed and demonstrated the capability of the SSSC to control the line flow and to improve the power system stability.

IV. Simulation Results and Discussion

A Standard 3-phase, six bus system is taken as a test system to evaluate the performance of SSSC with a proposed PI controller with PSS in the multi-machine system. To evaluate the system an LG Fault was established/ implemented between the BUS 1 and BUS 4 at the duration of 1.4 to 1.5 sec. Corresponding Voltage and current waveforms for SSSC controlled by a PI controller is shown below Figs. 2 – 8. Fig. 2 shows the voltage and current waveforms of Bus 1 with SSSC controlled by a PI controller. Fig. 3 shows the voltage and current waveforms of Bus 2 with SSSC controlled by a PI controller. Fig. 4 shows the voltage and current waveforms of Bus 3 with SSSC controlled by a PI controller. Fig. 5 shows the voltage and current waveforms of Bus 4 with SSSC controlled by a PI controller. Fig. 6 shows the voltage and current waveforms of Bus 5 with SSSC controlled by PI controller and Fig. 7 shows the voltage and current waveforms of Bus 6 with SSSC controlled by a PI controller. From the waveform, it is clear that the voltage magnitude of during fault as well as a normal condition to employ the performance over PI controller, comparison of voltage magnitude also shown Table 1. Figs. 2.9 show the angle deviation of PI SSSC. It is also clearly seen that the performance of PSS improved in PI controller.

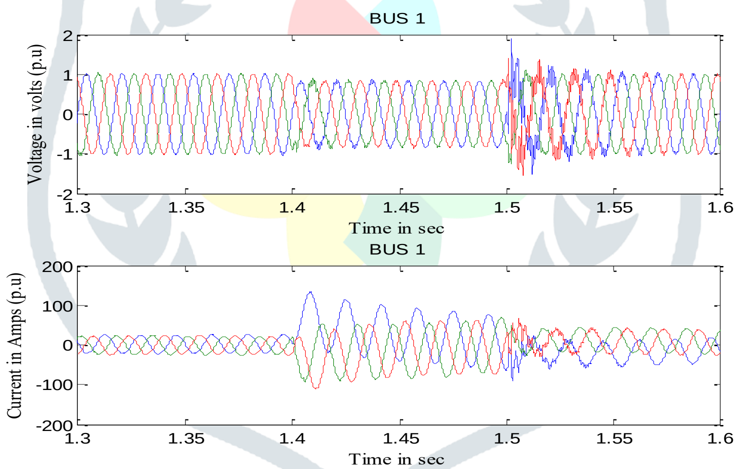

Fig. 2 Voltage and current waveforms of Bus 1 with SSSC controlled by PI controller

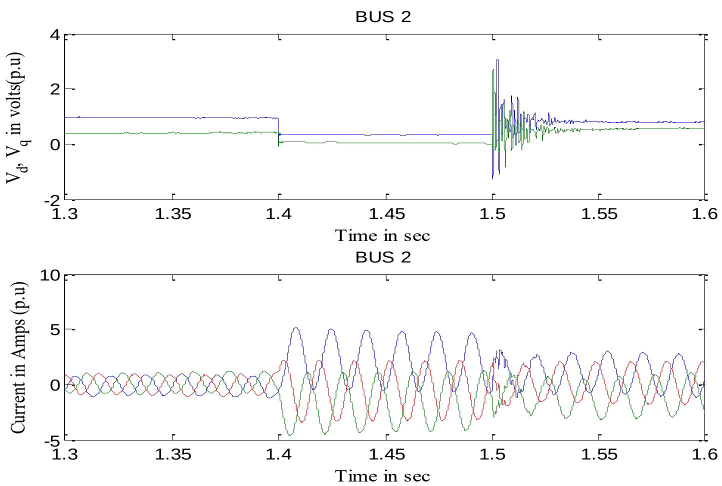

Fig. 3 Voltage and current waveforms of Bus 2 with SSSC controlled by PI controller

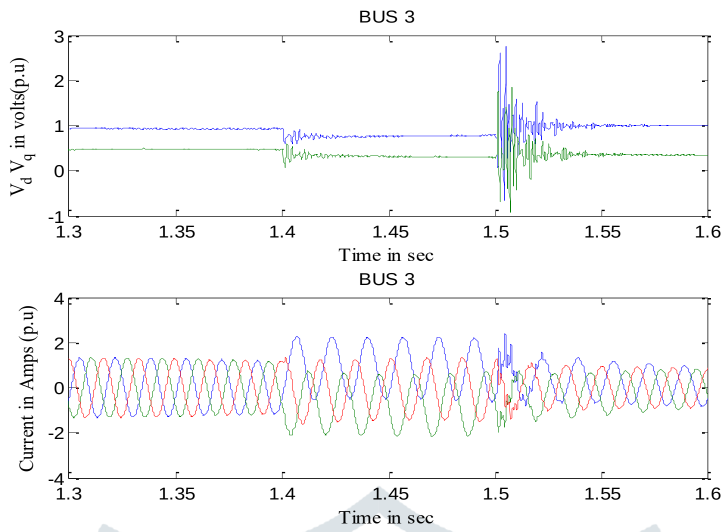

Fig. 4 Voltage and current waveforms of Bus 3 with SSSC controlled by PI controller

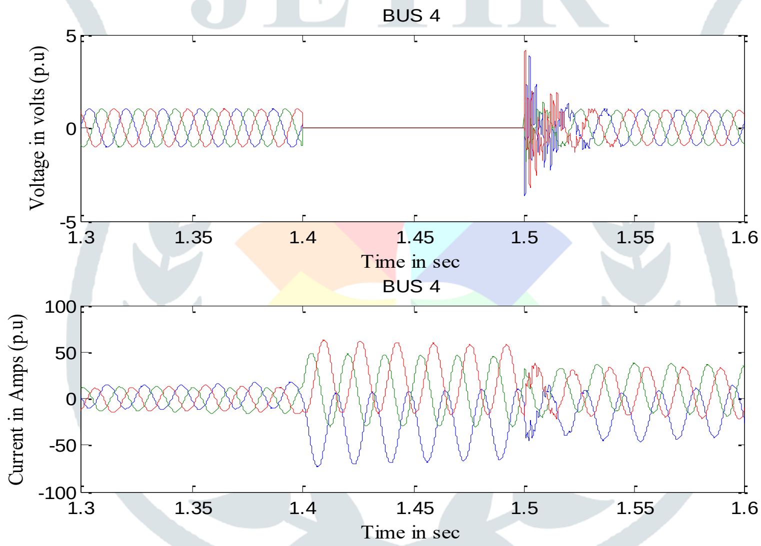

Fig. 5 Voltage and current waveforms of Bus 4 with SSSC controlled by PI controller

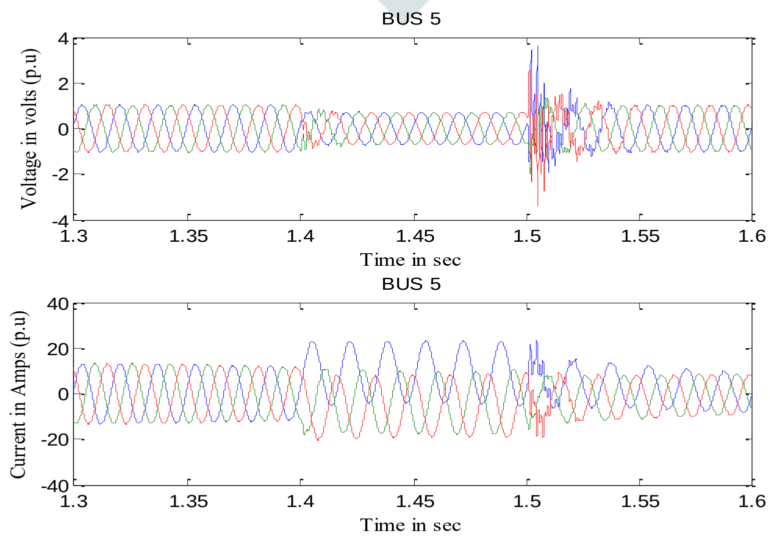

Fig. 6 Voltage and current waveforms of Bus 5 with SSSC controlled by PI controller

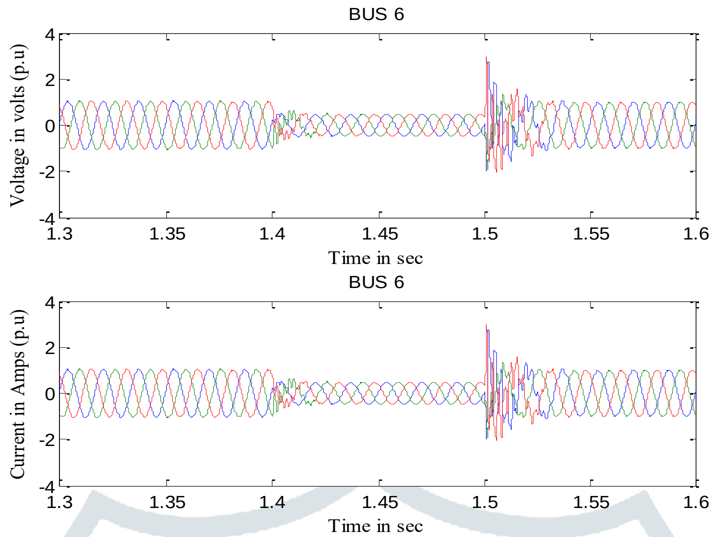

Fig. 7 Voltage and current waveforms of Bus 6 with SSSC controlled by PI controller

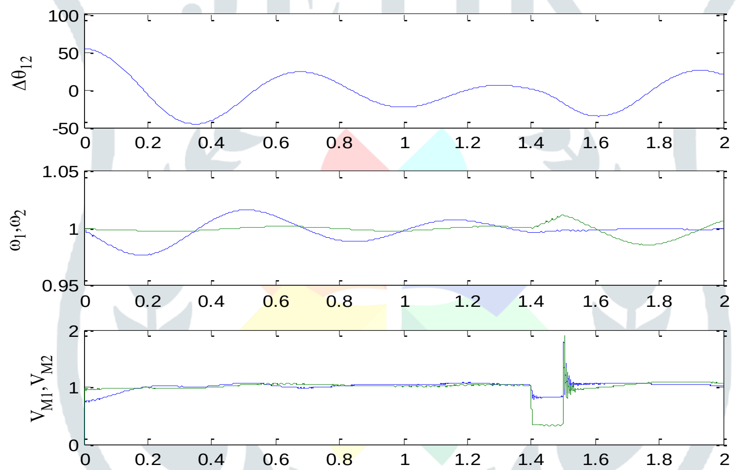

Fig. 8 Simulation waveform of Machine1&2 (Angle Difference, Speed & Voltage) with PI controller

Table 1 Voltage Magnitude of 6-Bus system

	PI voltage in p.u
Bus 1	0.86
Bus 2	0.33
Bus 3	0.77
Bus 4	0
Bus 5	0.72
Bus 6	0.47

V. Conclusion

The performance of the developed method demonstrates the effectiveness of the SSSC based fuzzy coordination concepts in damping power system oscillations over the SSSC with PI controller. The PI tuned SSSC with additional supplementary damping controllers gives better dynamic stability performances than SVC and is very much effective in damping oscillations since the number of oscillations and the settling time are less.

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