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Coordinated Control of PSS and FACTS Devices to Improve Power System Stability

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Abstract. The paper describes the coordination control of PSS (power system stabilizer) and FACTS (flexible AC transmission system) devices in order to improve low-frequency oscillation followed by disturbances. The PSS is generally used to mitigate the low-frequency oscillation and the FACTS is used to enhance the transfer capacity for the transmission line in power system. In order to improve small signal and transient stability in power system, the paper proposes the combination of the PSS and FACTS. The performances of the proposed method are carried out by time-domain simulation with single-machine connected to infinite bus system.

Keywords: Low-frequency oscillation, flexible AC transmission system, power system stabilizer, transient stability.

1 Introduction

The power system stabilizer (PSS) is a supplementary controller for the excitation system in power system. The output of the PSS is induced to the excitation system in order to improve low frequency oscillation damping followed by disturbances. Meanwhile, in Korea, installation and periodical adjustment of the PSS parameters in all the generators over 500 MVA capacity have been a strict rule in the system reliability regulation since 2005. Also, the dynamic behaviors of the PSS are affected by the linear parameters (gain and time constant of phase compensator). The appropriated selection of linear parameters is very important and has been usually made by using the conventional tuning techniques [1]-[2] based on the small signal stability analysis.

On the other hand, among power-electronic-based controllers that influence power flow in power lines, the controllable series capacitive reactance compensator (SCRC), which is one of the series FACTS devices, has attracted attention not only for its rapid response control capability, but also for the effective damping performance during disturbances [3]-[6]. For the rapid response control capability, the internal controller has been progressively developed to control power flow as maintaining the injected voltage in quadrature with the line current and keeping the capacitor voltage constant. Otherwise, the external controller, which consists of the conventional linear controllers, is used to improve the low-frequency oscillation damping performance during disturbances.

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In this paper, the coordination control of the PSS and FACTS is proposed to improve small signal and transient stability in power system. That is, the FACTS can be designed to bring more damping performance with action of the PSS though the FACTS can achieve its inherent control goal to improve transmission line capacity.

2 Introduction of PSS and FACTS

The PSS in Fig. 1 consists of four controllers, which are the gain, washout filter, phase-lead compensator, and output limits. Generally, the gain (K_{PSS}) is set within the values between 2 to 10 by linear analysis such as root locus. The washout filter is employed as a high-pass filter that removes dc component existing in the input signal. Its time constant, T_W is generally set to 10 s. Also, the phase-lead compensator provides damping to the system by compensating for the phase-lag between the PSS output (V_{PSS}) and electrical torque. Its time constants, T_1 and T_2 are adjusted depending on system conditions [7]-[8].

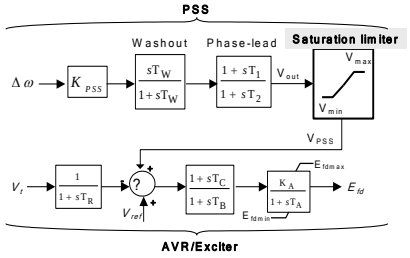


Fig. 1. AVR/PSS block representation.

The main objectives of the internal controller of the series capacitive reactance compensator (SCRC) in Fig. 2 which is one of the FACTS devices are to ensure that the injected voltage, v_c, at the AC terminal of the inverter is in quadrature with the transmission line current i_s and to maintain the constant voltage V_{dc} in steady state [6].

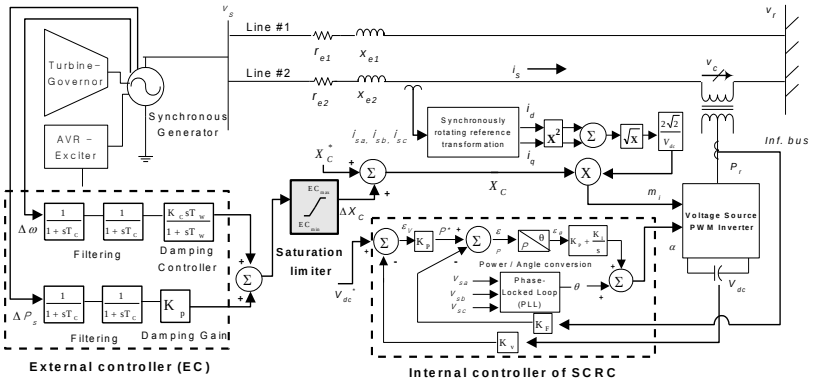
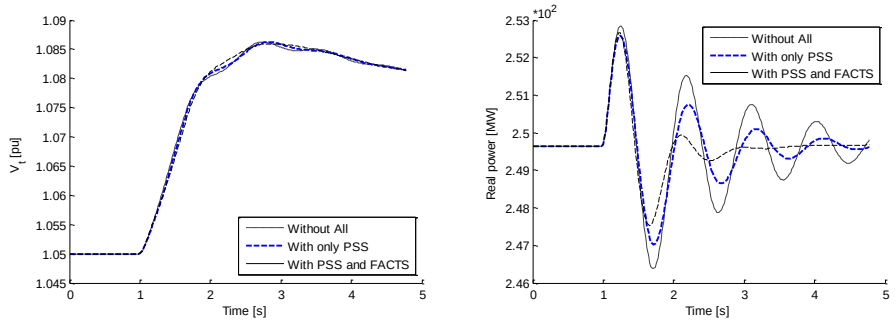


Fig. 2. SCRC with controllers

The objective of the external controller (EC) in Fig. 2 is to improve system damping performance by optimally modulating the reference of the internal controller. By coordinated control with PSS and EC, the small signal and transient stabilities in power system can be improved.

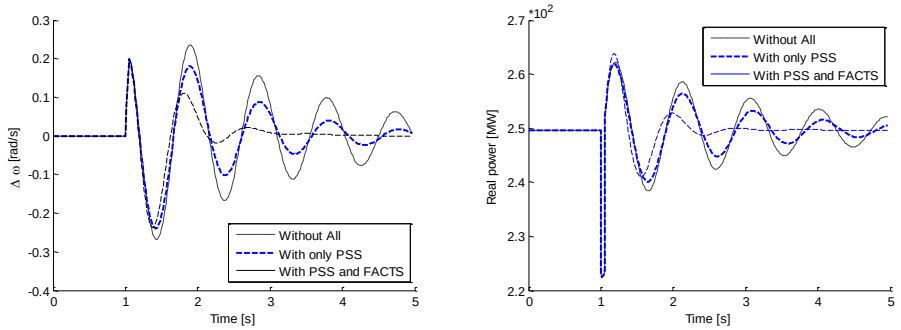
3 Simulation Results

In order to simulate the proposed control scheme, the paper uses Matlab software to build power system and its controllers including the PSS and FACTS. To evaluate the performance on the small signal stability, the terminal voltage of the generator in Fig. 2 is heightened as 3%. Figure 3 shows the performances of the coordinated control of the PSS and FACTS. It is clearly shown that the proposed method can dramatically improve the small signal stability. Also, power system in Fig. 2 is now disturbed by applying a 100 ms three-phase short circuit fault with the fault-impedance of 0.05 pu to the generator terminal bus at 1 s to see the transient stability. The proposed method can bring the best performances on the transient stability as shown in Fig. 4.



(a) Terminal voltage response [pu] (b) Real power response [MW]

Fig. 3. 3% step responses.



(a) Generator speed deviation [rad/s] (b) Real power response [MW]

Fig. 4. Three-phase fault responses.

4 Conclusions

The paper described the coordination control of PSS (power system stabilizer) and FACTS (flexible AC transmission system) in order to improve low-frequency oscillation followed by disturbances. The paper carried out two simulation tests to evaluate the performance of the proposed method. One is a small signal stability test and the other is transient stability test. By both tests, it was guaranteed that the coordination control could improve quite system stability.

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