



Significance of PSS and SVC in Power Oscillation Damping

Feba Wilson¹, Jisha James²

PG Student [Power Systems], Dept. of EEE, Saintgits College of Engineering, Pathamuttom, Kerala, India¹

Assistant Professor, Dept. of EEE, Saintgits College of Engineering, Pathamuttom, Kerala, India²

ABSTRACT: Low-area frequency oscillations are one of the major problems in the present power systems for smooth and reliable operation where power is essential to transfer from one area to another remote area through weak tie-lines. This kind of oscillations problem may result into system instability, cascade failure and even in blackouts, if they are not damp out quickly. It have been observed that local mode of oscillations can be damp out by using Power System Stabilizers (PSS) but damping inter-area mode of oscillations using PSS may not be possible always. Majority of the necessary damping torque is delivered by synchronous machines equipped with power system stabilizers (PSS). Nowadays, flexible AC transmission system (FACTS) devices are increasingly used in power systems. They have remarkable effects on increasing the damping of the system.

KEYWORDS: Power system stabilizer, Automatic voltage regulator, Synchronous Generator, governing system, steady-state stability, transient stability, Static VAR compensator.

I. INTRODUCTION

Power System Stability is concerned as one of the main factors that affect the power system in its three main sectors: generation, transmission and distribution. There are several factors that can affect the stability of the system such as sudden load change, fault and generator shaft speed change. The instability problem is resulting in oscillatory behavior that, if undamped may eventually build up. Even undamped oscillations at low frequencies are undesirable because they limit power transfers in transmission lines and induce stress in the mechanical shaft. With proper design and compensation, the excitation system can be an effective means of enhancing stability in the dynamic range as well as in the first few cycles after a disturbance. The compensation by adding damping to the generator rotor oscillations is related to an auxiliary stabilizing signal and the device used to generate this signal is called Power System Stabilizer (PSS).

Stability can be controlled by controlling the excitation of the generator or its speed. In addition, the excitation can be controlled using Automatic Voltage regulator AVR. Nowadays, PSS becomes one of the main solutions to the instability behind the AVR. PSS is a device which provides additional supplementary control loops to the automatic voltage regulators system [1] and/or the turbine governing system of a generating unit. It is considered as one of the most common ways of enhancing both small signal (steady-state) stability and large-signal (transient) stability. PSS are often used as an effective and economic means of damping such oscillations. The automatic voltage regulator (AVR) regulates [2] the generator terminal voltage by controlling the amount of current supplied to the generator field winding by the exciter. It is mainly used to damp any oscillations accrued to the power system when load is changing. It keeps the terminal voltage of the generator constant so that the voltage on the load side will remains almost constant even the load is vary with time.

Power oscillations typically occur in large interconnected power systems, where two or more areas are interconnected through relatively weak alternating current (AC) transmission lines. These power oscillations are also referred to as inter area oscillations. If a power oscillation between two areas of a power system is excited, the rotor angles of synchronous machines in one area will start to oscillate in counter phase with synchronous machines in the other area and thereby force a flow of active power back and forth between the areas.

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If the oscillation is sufficiently damped the oscillation will die out and the rotor angles return to a steady state. However, if there is insufficient damping in the power system for this particular oscillation an ever increasing amount of active power is exchanged between the two areas until other security devices, e.g. synchronous machine or transmission line safety equipment, trip the unit or component. A cascading effect of equipment tripping and ultimately a system black out can be the consequence. Majority of the necessary damping torque is delivered by synchronous machines equipped with power system stabilizers (PSS). A basic concept of a known PSS is to add an auxiliary signal to the voltage reference of the exciter and thereby modulate the excitation voltage of the synchronous machine to damp the power oscillations.

II. POWER SYSTEM MODELLING

Synchronous Generator

The following assumptions are made:

1. Stator winding resistance is neglected.
2. Balancing conditions are assumed and saturation effects are neglected.
3. Damper winding effect is neglected.

The electrical system for each phase consists of a voltage source in series with an RL impedance, which implements the internal impedance of the machine. The value of R can be zero but the value of L must be positive.

The Simplified Synchronous Machine block implements the mechanical system described by

$$\Delta\omega(t) = \frac{1}{2H} \int_0^t (T_m - T_e) dt - K_d \Delta\omega(t)$$

$$\omega(t) = \Delta\omega(t) + \omega_0$$

where

$\Delta\omega$ = Speed variation with respect to speed of operation

H = constant of inertia

T_m = mechanical torque

T_e = electromagnetic torque

K_d = damping factor representing the effect of damper windings

$\omega(t)$ = mechanical speed of the rotor

Static VAR Compensator (SVC)

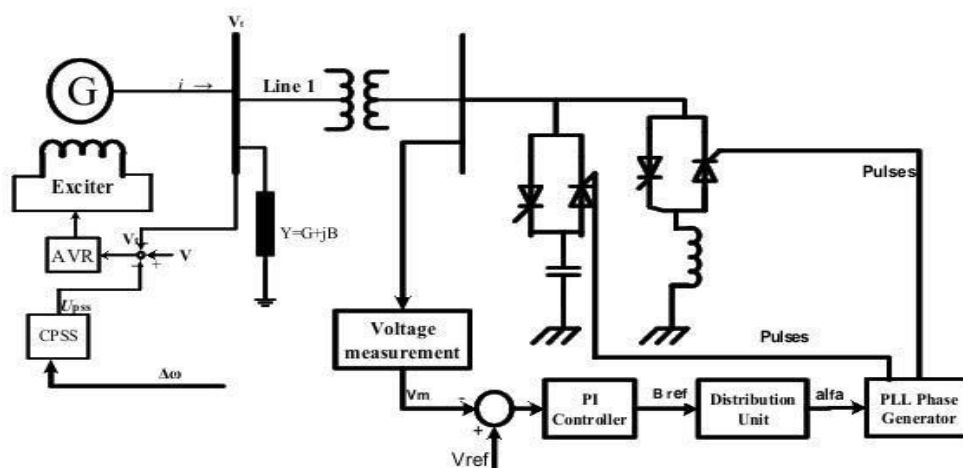


Fig.1 single-line diagram of a SVC and a simplified block diagram of its control system.

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The SVCs is a flexible and continuous reactive power compensator that has been used in power systems to regulate the reactive power and voltage to the actual system needs. It operates in two modes as capacitive and inductive. It consist of a thyristor-switched capacitor (TSC) and/or thyristor-controlled reactor (TCR). The current of SVC's reactor should be controlled in a way that a suitable control range between capacitive mode and inductive mode of SVC is determined. The SVC can be modelled as a first order linear differential equation model. This could be at the middle of a transmission line or at a load bus. When the SVC is operating in voltage regulation mode, its response speed to a change of system voltage depends on the voltage regulator gains (proportional gain K_p and integral gain K_i).

$$B = (K_p + K_i/s) \cdot (V_{SVC} - V_{SVC.ref}) \quad B_{min} \leq B \leq B_{max}$$

III. SIMULATION RESULTS

CASE 1: SINGLE GENERATOR CONNECTED TO GRID(WITHOUT PSS)

Consider a single generator connected to grid. Without power system stabilizer, rotor angle deviation and rotor speed will be as follows.

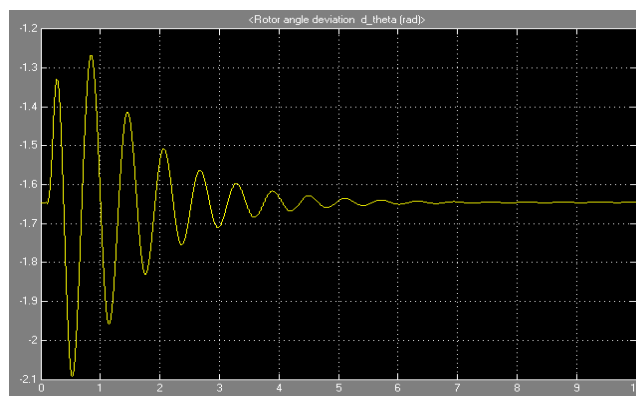


Fig.2 Rotor angle deviation

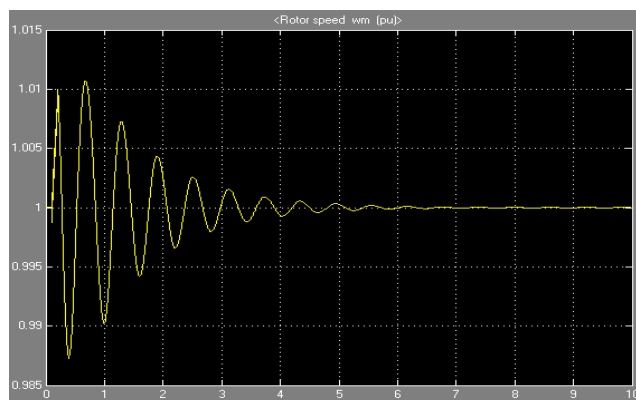


Fig.3 Rotor speed

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CASE 2: SINGLE GENERATOR CONNECTED TO GRID (WITH PSS)

With power system stabilizer, performance of system gets improved. Machine attains stability at faster rate.

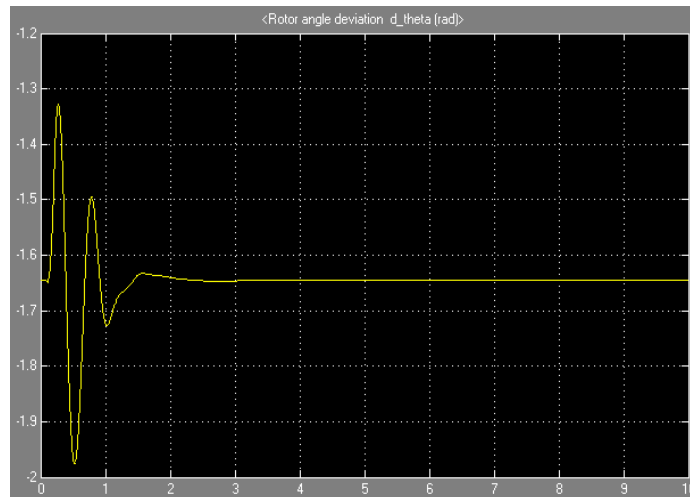


Fig.4 Rotor angle deviation

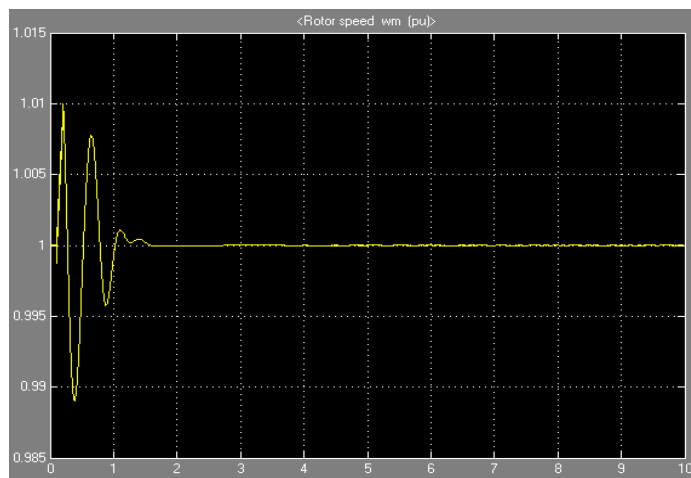


Fig.5 Rotor speed

CASE 3: TWO MACHINE SYSTEM

Consider two machine system connected by a weak tie line. Static Var Compensator is one of a shunt connected FACTS devices, which is used to control the bus voltage at which it is connected to. It can also contribute to the stability of the system. Without SVC if a fault occur in the system, machines in the system may goes to unstable state. This can be understood by examining the rotor angle difference of the machines as well as speed of the machine which is nearer to the fault bus.

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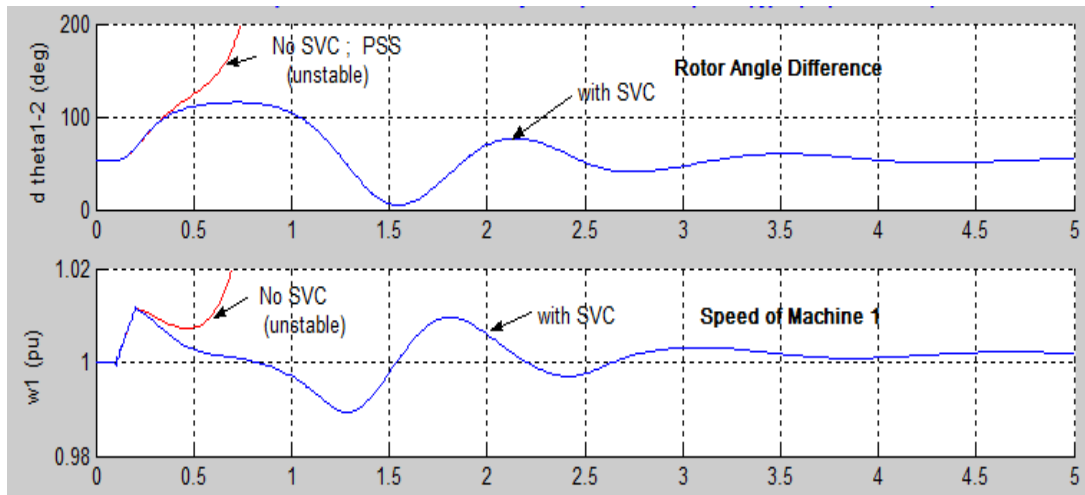


Fig 6. Rotor speed and rotor angle difference of the machines.

VI.CONCLUSION

The power system is subjected to different types of disturbances such as small changes in the load that affects its efficiency and sometimes leads to unstable system. These disturbances cause oscillations at low frequencies that are undesirable since it affects the amount of transferred power through the transmission lines and leads to external stress to the mechanical shaft. To avoid such situation a power system stabilizer is added to the Automatic Voltage Regulator (AVR) to enhance stability in the dynamic range as well as in the first few cycles after a disturbance.

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BIOGRAPHY

Feba Wilson, received B.Tech degree in Electrical and Electronics Engineering under Kerala University in 2013. She is currently pursuing her M.Tech in Power Systems at Saintgits College of Engineering, Kerala, India.

Jisha James received B.Tech degree in Electrical and Electronics Engineering under N.S University, Tamil nadu in 2004, M.Tech in Industrial drives and control under Mahatma Gandhi University in 2012. She is currently working as Assistant Professor at Saintgits College of Engineering, Kerala, India.