Power System Stabilizers For Damping Oscillati ons In Rotors Of Generators

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Abstract: **When there are small variations of load or small or large fault the output power of generator changes rapidly, but the mechanical power into the machine is relatively slow to that change. Due to this the rotor angle changes and oscillations are produced. Power system stabilizers are used to damp the oscillations of rotors. In this paper a 3 machine 9 bus system is considered and in turbines and regulator block we used power system stabilizers to add damping to the electromechanical oscillations by controlling its excitation. The relative angular positions of rotors are observed and it is seen that the initial oscillations in relative angular position of rotors are damped to maintain stability of the system.**

Keywords: Power System Stability, Small Signal Stability, Power System Stabilizers, Generic Power system Stabilizer, Multiband Power System Stabilizer, Simulink model, Relative angular position of rotors.

I. INTRODUCTION

In system operation the stability of power system has been a major concern. When the angular speed of all the generators remains same anywhere in the system the system is said to be in steady state. This is also known as synchronous operation of a system. The synchronous operation can get affected by any small or large fault. After the transient disappears whether the system can settle down to the original or close to its original position is determined by the stability of the system. This ability of a power system to bring back itself to the condition where operation is again normal after responding to the disturbance when earlier it was in normal operating condition is called power system stability.

Power system stability concept is actually defined as the property of a power system that enables a power system to maintain its state of operating equilibrium during its normal operation and to regain an acceptable state of equilibrium after it is subjected to a disturbance.

Stability as per IEEE (USA) can be defined as:

"That attribute of a system or part of the system which enables it to develop restoring forces between elements of equal or greater than distributing forces

II. SMALL SIGNAL STABILITY

It is defined as the ability of system to maintain its synchronism when there are small disurbances. Minor variations in load or generation can cause small disturbances on system. These can lead to rotor angle oscillations of increasing amplitude, if there is no sufficient damping torque. Generators connecting to grid that utilize high gain automatic regulators are unable to provide sufficient damping to the oscillations in the system. There are three types of oscillations in inter connected generators and transmission networks.

- Inter Unit Oscillations
- Local Mode Oscillations
- Inter Area Oscillations

Inter Unit Oscillations: These inter unit oscillations involve two or more than two synchronous machines at a power plant. The machines swing against each other and the frequency of the oscillations lie in the range of 1.5 to 3 Hz.

Local Mode Oscillations: These local mode oscillations involve one or more than synchronous machines at a power system. The machines swing together against a comparatively large power system or load centre. Range of frequency of these oscillations is the range of 0.7 Hz to 2 Hz. When the plant is at high load with a high reactance transmission system, these oscillations become troublesome.

Inter Area Oscillations: These oscillations involve combination of machines on one part of system swinging against machines on the other part of the power system. Range of frequency of these oscillations is less than 0.5 Hz.

When there is a suuden change then the generator speed and electrical power varies around their steady state operating points.

$$\Delta Te = KS\Delta\delta + KD\Delta\omega$$

where ΔTe is difference in mechanical and electrical torque. KS is synchronising coefficient. KD is damping coefficient. $\Delta\delta$ is rotor angle change. $\Delta\omega$ is change in angular speed.

In order to dmap these oscillations positive synchronising torque can be provided which brings the system to stability. In most of the power systems the configuration of the network and generator control systems maintains stable damping forces that brings system to stable condition. But in some system configurations unstable oscillations are produced by introduction of negative damping torques which are caused by fast responding excitation systems. This problem arises when the system is connected to a transmission system of high impedance as compared to that of low impedance. To solve this problem one solution is to reduce the reactance between the generators and load centres by adding more parallel transmission lines. This is not mainly used because of cost involved in building new transmission lines. An alternative method is to add Power System Stabilizers through voltage regulators. This combination enables excitation system to provide positive damping torque.

III. POWER SYSTEM STABILIZERS

To add damping to the electromechanical oscillations Power System stabilizers are used. It is used to provide stable voltage input to the excitation system of generator. Excitation system is used to excitation to a synchronous machine and to regulate its terminal voltage during generating mode. In addition to the damping oscillations PSS will act through generator excitation system according to the speed deviation generated, which produces a electrical torque component. To provide additional modulation signal to the reference of automatic voltage regulators , PSS are also used. According to the speed deviation an electrical torque is produced in the generator. This torque is proportional to this speed deviation. If the PSS is not used then the oscillations will keep on growing and it will keep on deteriorating the performance of system and hence leading to instability. In interconnected power system PSS are of great use. Power system stabilizers are most effective one in damping oscillations in such interconnected system. In this paper we are considering a 3 machine 9 bus interconnected system. In turbine and regulation block, the PSS are used to damp oscillations to make system stable.

IV. MATLAB MODEL OF PSS

There are two types of PSS models in matlab.

- Generic Power System Stabilizer.
- Multiband Power System Stabilizer.

Generic Power System Stabilizer: It is used to add damping to the rotor oscillations of the synchronous machine by controlling its excitation. The model consists of a low-pass filter, a general gain, a washout high-pass filter, a phase-compensation system, and an output limiter. The general gain K determines the amount of damping produced by the stabilizer. The washout high-pass filter eliminates low frequencies that are present in the dw signal and allows the PSS to respond only to speed changes. The phase-compensation system is represented by a cascade of two first-order lead-lag transfer functions used to compensate the phase lag between the excitation voltage and the electrical torque of the synchronous machine. Input signal to this block ican be of two types one is speed deviation dw and other is acceleration power Pa = Pm – Pe of the synchronous machine. Pm is mechanical power and Pe is electrical power. The output signal is Vstab to the exciter system.

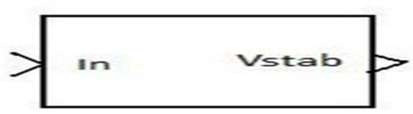

FIG 1. GENERIC POWER SYSTEM STABILIZER

Multiband Power System Stabilizer: As its name reveals, the MB-PSS structure is based on multiple working bands. Three separate bands are used, respectively dedicated to the low, intermediate, and high-frequency modes of oscillations. The low band is typically associated with the power system global mode, the intermediate with the inter area modes, and the high with the local modes. Each of the three bands is made of a differential band pass filter, a gain, and a limiter. The outputs of the three bands are summed and passed through a final limiter producing the stabilizer output Vstab. This signal then modulates the set point of the generator voltage regulator so as to improve the damping of the electromechanical oscillations. Speed deviation dw is its input and Vstab to the exciter is its output.

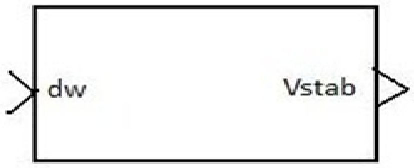

FIG 2. MULTIBAND POWER SYSTEM STABILIZER

In our model we are giving accelerating power input Pa to Generic Power System Stabilizer and speed deviation input dw to multiband stabilizer. A multiport switch is used to select the output signal of these stabilizers.

V. SIMULATIONS AND RESULTS

The popular Western System Coordinated Council (WSCC) 3-machine 9-bus practical power system is a widely used one and found very frequently in the relevant literature as presently appearing in references. A 3-machine 9-bus WSCC system is shown in Fig 2. The loads here have been assumed to be represented by constant impedance model. The base MVA of the system is 100, and the frequency of the system is 60 Hz. By using MATLAB/Simulink Blocks the complete system with all the required components has been modeled.

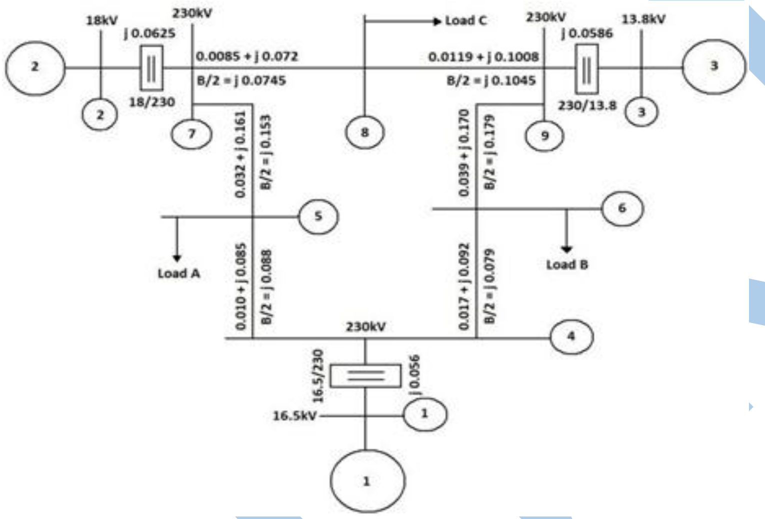

FIG 3. 3-MACHINE 9-BUS WSCC SYSTEM

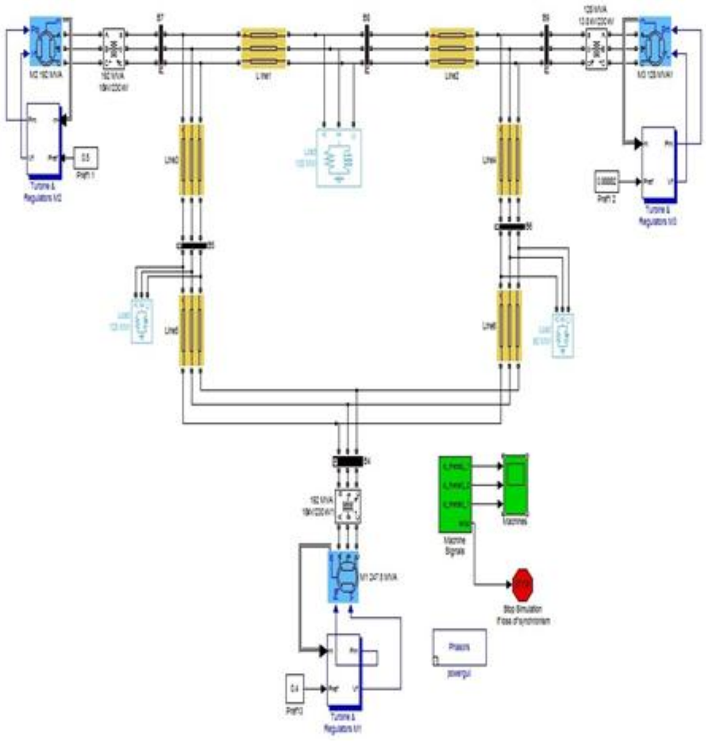

FIG 4. Matlab model of a 3 machine 9 bus system

The turbine and regulator block with Power System Stabilizers is modelled as under

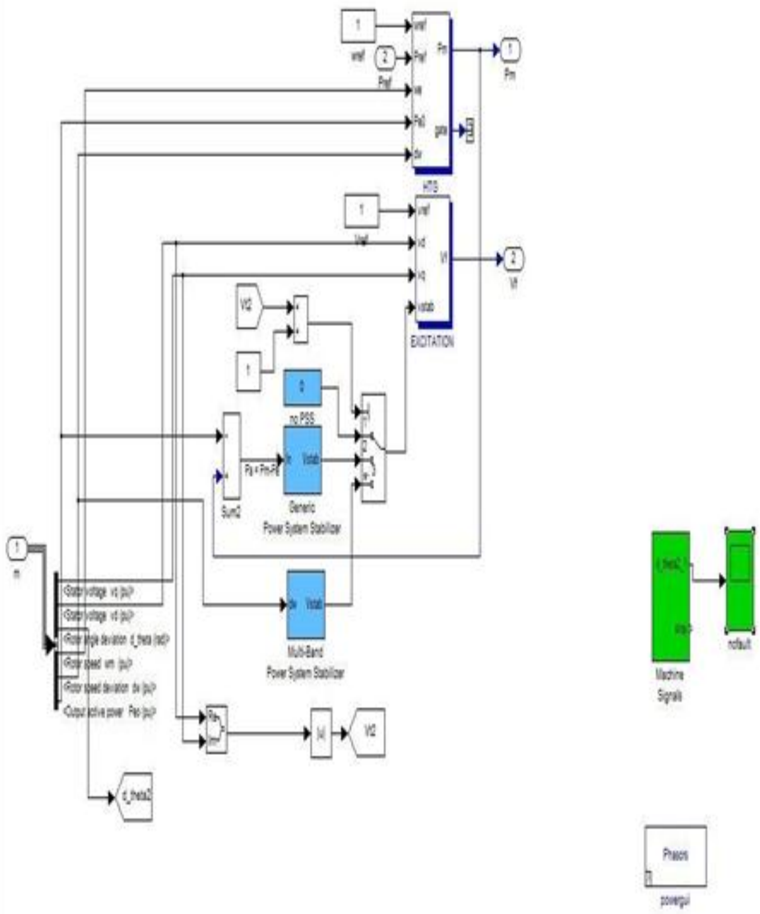

FIG 5. Matlab model of turbine and regulator block of Machines with PSS.

The relative angular position of generator M2 of our model using power system stabilizers in the turbine and regulator model which controls the excitation of the generator M2.

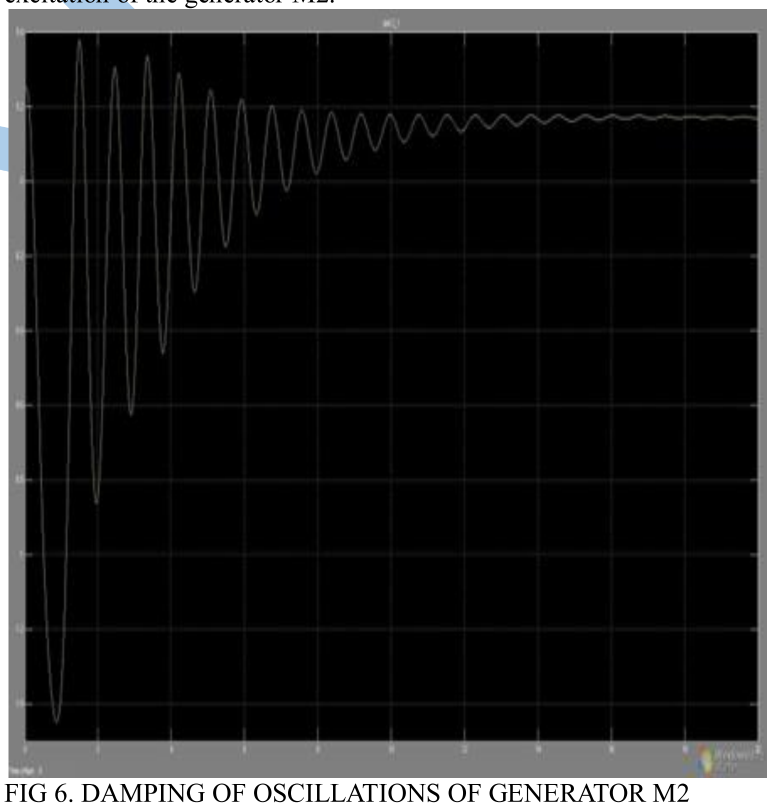

FIG 6. DAMPING OF OSCILLATIONS OF GENERATOR M2

VI. CONCLUSION

Power system stabilizers are used to damp initial oscillations in the rotor of machine in the system which on later can cause instability of the system. In our results on one of the generator of our system with PSS we observed that the oscillations were damped and thus makes the operation of generator stable.

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