INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 2)
Available online at: www.ijariit.com

Dynamic stability improvement for single machine infinite bus system installed with PSS

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ABSTRACT

Power system stabilizer is suppressing the low-frequency oscillation of the power system to improve the dynamic stability of the power system. The need of power system stabilizer (PSS) or supplementary excitation control is to apply a stabilizing signal through the excitation system to produce additional damping torque of the generator in a power system at all operating and system conditions. In this paper, the study of the dynamic behavior and small signal stability of the single-machine infinite bus (SMIB) with CPSS under various loading condition is presented. Simulation result in with and without PSS results is shown.

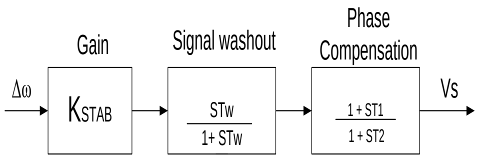
Keywords: *Voltage regulator, Power system stabilizer, Low-frequency oscillation, Synchronous machine, Excitation.*

1. INTRODUCTION

The power system is a dynamic system. Nowadays, the electric power systems are not operated as an isolated system, but as interconnected systems which had thousands of electrical elements and be spread over wide areas. Synchronous Generator is widely used in a power system as a source of electrical energy. The power systems are frequently exposed to different instabilities such as low-frequency oscillations and disturbances that occur due to minor variation in load and generation. Which results in a change in Generator rotor angle. Excitation control is very useful for maintaining the stability of power system. Excitation systems constitute the fast acting AVR. However, it produces a negative damping at higher values of system reactance high generator output. Thus, it is very important to increase the damping torque in order to reduce the rotor angle oscillations. The Power system stabilizer (PSS) is added to damp the Generator rotor oscillations by controlling its excitation by providing a supplementary signal in the excitation system to damp out low-frequency Oscillations. The use of PSS has become very common in operation of large power system.

The Conventional Power system stabilizer (CPSS), which uses lead-lag compensation, where gain settings designed for the specific operating condition is giving poor performance under different synchronous generator loading condition.

Basic Power System Stabilizer



A fig.1 Block diagram of conventional PSS

The basic function of a PSS is to add damping to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signal. To provide damping, the stabilizer must produce a component of electrical torque in phase with the rotor speed deviation.[5]

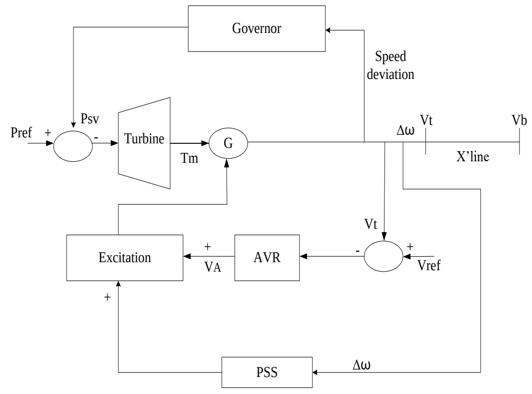
The CPSS design consists Of Stabilizer gain, signal Washout, and phase compensation.

Phase compensation block provides the appropriate phase lead characteristics to compensate for the phase lag between exciter input and generator electrical torque.

Signal washout block serves as high pass filter, with a time constant Tw high enough to allow signals associated with oscillations in ωr to pass unchanged, which removes D.C. signals. Without it, steady changes in speed would modify the terminal voltage. It allows PSS to respond only to changes in speed.

Stabilizer gain KSTAB determines the amount of damping introduced by PSS. Ideally, the gain should be set at a value corresponding to maximum damping.

2. PROBLEM FORMULATION



A fig.2 Basic block diagram of power system configuration for SMIB

1) Synchronous generator: The Synchronous Generator is a most common source of Electric power because it is simple to control, robust and maintenance free in a brushless system.
2) Turbine: Turbine converts the Kinetic energy of a steam, fuel, water into rotational energy. It works as the prime mover. And thus provide mechanical input required to the Generator.
3) Governor: The job of the Governor is to maintain the speed that changes with variation in load. It provides the correct amount of mechanical power input to the turbine to match the electrical output of the corresponding Generator.
4) Excitation: Excitation system provides the D.C current required for the field winding of a synchronous Generator to produce rated terminal voltage at the generator terminal.
5) AVR: Automatic voltage regulator is used to maintaining a constant terminal voltage across load by varying the excitation of the field.
6) PSS: The fast-acting AVR produce negative damping.Therefore PSS is used to provide additional damping to excitation control to reject the oscillations from the power grid and to prevent rotor speed or angle from oscillation.

3. BLOCK DIAGRAM REPRESENTATION OF SMIB WITH PSS

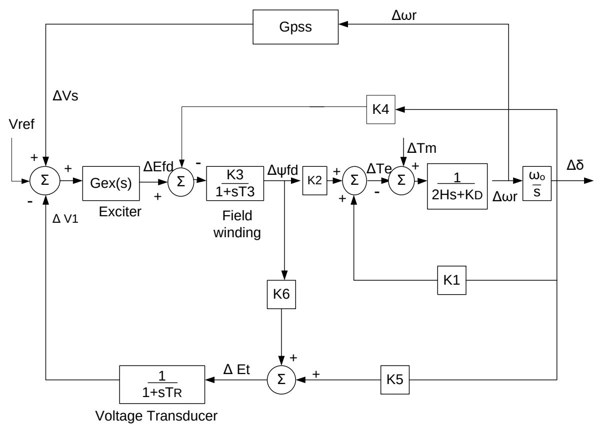


Fig.3 The block diagram representation of PSS for SMIB system

The power system under consideration is called single machine infinite bus (SMIB) system. Because only one synchronous generator is connected via a transmission line to the infinite bus. Here, K1 to K6 are Heffron Phillips constants. There are two types of loop exists namely mechanical loop and electrical loop.

Here, the mechanical loop is represented by the system inertia and the damping constant, where the input is torque balance ΔTm−ΔTe and the output is incremental torque angle Δδ.

The electrical loop of the system consists of three main parts:

1) The composition of the electrical torque influenced by Δδ over constant K1 and the internal incremental voltage Δe′q over constant K2. 2) The effect of the field winding determined by the field winding constant K3 and influenced by Δδ over constant K4and 3)

the effect of the excitation system influenced by Δδ over constantK5 and Δe′q over constant K6.The excitation system itself is modeled by a first-order transfer function including the amplification factor KA and the time constant TA.

4. SIMULATION OF PSS AND AVR VARIOUS LOADING CONDITION

Case 1: P=0.5 and Q=0.3

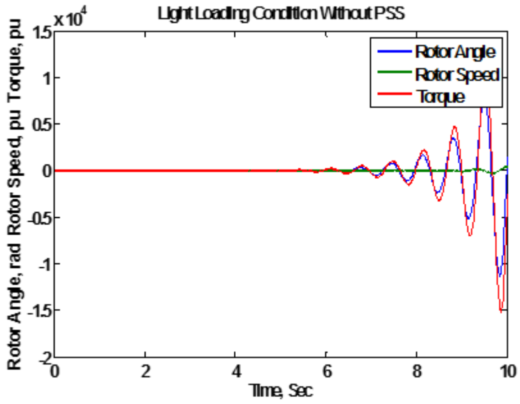


Fig. 4 Measurements for Light Loading Condition without PSS

Case 2: P=1.0 and Q=0.5

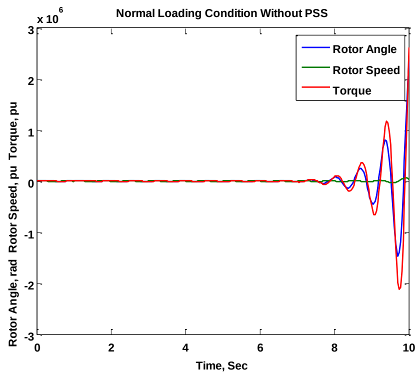


Fig. 5 Measurements for Light Loading Condition without PSS

In this representation, the dynamic characteristics of the system are expressed in terms of so-called K constants. The analysis is done for three various loading condition and according to that the value of K1 to K6 constant are calculated. And the variation in speed, angular position, and the electric torque are analyzed. For case1, the value of K5 is positive, and the system becomes stable after some period. As loading increases for all another case 2, 3, K5 becomes negative which cause under damped oscillations and system become unstable is shown in fig.With negative K5, the AVR produce positive synchronizing torque and negative damping torque component which leads to instability.[3]

Case 3: P=1.5 and Q=0.8

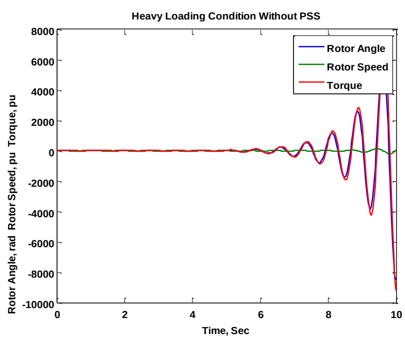


Fig .6 Measurements for Light Loading Condition without PSS

Now, the simulation of SMIB system with CPSS is shown below: Case 1: P=1.5 and Q=0.8

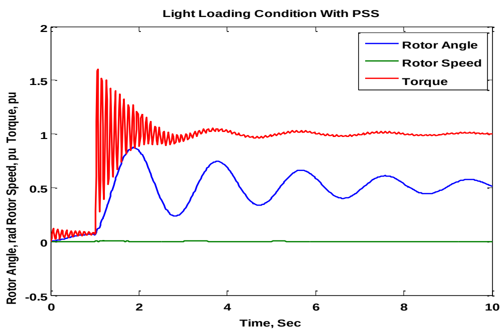


Fig.7 measurements for Light Loading Condition with PSS

Case 2: P=1.0 and Q=0.5

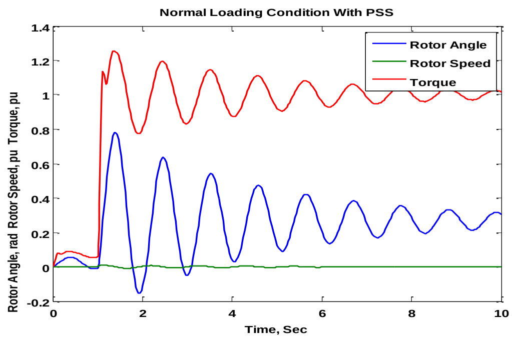


Fig.8 measurements for Normal Loading Condition with PSS

The CPSS, the system becomes stable in all cases. The damping ratio and damping coefficient increases with increase in exciter gain.

Case 3: P=1.5 and Q=0.8

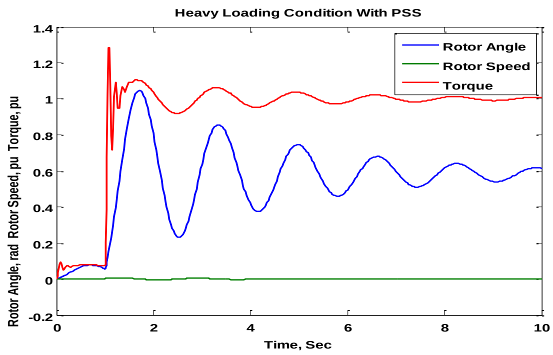


Fig.9 measurements for Heavy Loading Condition with PSS

When the value of K5 is negative, transients are more as loading increases and when the value of K5 is positive, higher rotor angle position is attained. Thus, CPSS design performance not proven effective in heavy loading condition. To overcome these limitations, different intelligent techniques like ANN, FLC, GA have been proposed.

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5. CONCLUSION

In this paper single machine connected to the infinite bus in the power system of dynamic stability improvement for power system stabilizer are connected. In this paper need of PSS have been discussed. The simulation of SMIB system with AVR and CPSS results shows the effectiveness of CPSS control techniques to enhance the stability of thee system under a variety of operating conditions. But, as well as loading increases, the CPSS design not proves better, thus to achieve more accurate result for different intelligent techniques can be used.

6. APPENDIX

The Generator data: Xd=1.7, Xd'=0.245, Xq=1.64, Xq'=0.38, T"do=5.9,D=0 ,H=2.37, F=50

The Transmission line data:Re=0.02,Xe=0.4

AVR data: KA=50, TA=0.01

CPSS data:T1=0.154 sec, T2=0.033 sec, TW=1.4 sec,Kstab=9.5

Heffron-Philips constant=K1=1.0749, K2=1.2576, K3=0.3072, K4=1.7124, K5=-0.3988, K6=0.4657

7. NOMENCLATURE

K1, K2= Constants derived from electrical torque

K3, K4= Constants derived from field voltage equation

K5, K6= Constants derived from terminal voltage magnitude

KA= Voltage regulator gain

H= Inertia moment coefficient

Xd, Xq= Synchronous reactance in d and q axis

D= Damping torque coefficient

M= Inertia coefficient

Tm, Te=Mechanical and electrical torque

Efd=Excitation field voltage

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