Improvement of an Oscillatory Stability in a SMIB (HEFFRON – PHILIPS MODEL) by Using Different Tuning Techniques of Power System Stabilizer

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Abstract: ***One of the major concern in power system operation is related to damping of low frequency oscillation and small signal instability caused by insufficient synchronizing and damping to rquein the system. It can cause generators pull out from synchronism and sometimes it is also reason for blackout. The main objective of this paper is to install power system stabilizer (PSS) to achieve desired comparative analysis is explored within corporation of power system stabilizer AVR, PSS AND AVR, PSS WITH PID AND AVRfor damping of low frequency oscillation and small signal stability enhancement of SMIB systems***

Keyword: Automatic Voltage Regulator (AVR), Power System Stabilizer (PSS), PID Controller

1. Introduction

Power system stability may be broadly defined as that property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance. Power system rely on synchronous machines for generation of electrical power, a necessary condition for satisfactory system operation is that all synchronous machines remain in synchronism. This aspect of stability is influenced by the dynamics of generator rotor angles and power angle relationships.

2. Classification of Power System Stability[A]

Instability of a power system can take different forms and can be influenced by a wide range of factors. The classification of stability into appropriate categories are based on the following considerations. The physical nature of the resulting instability The size of the disturbance considered The devices, processes, and time span that must be taken into consideration in order to determine stability The most appropriate method of calculation and prediction of stability

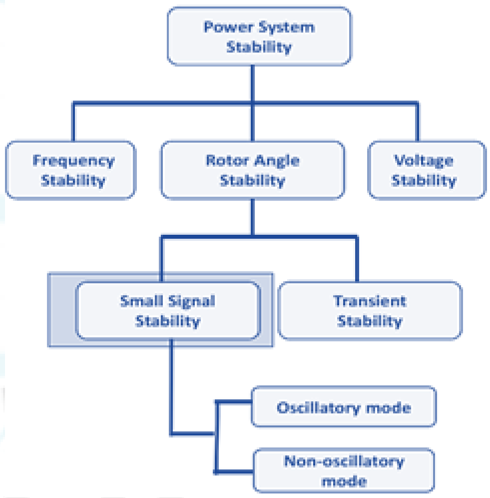

Figure 1: Classification of Power System Stability

3. Small Signal Stability

Small signal stability is the ability of the power system to maintain synchronism when subjected to small disturbances. Instability may result can be of two forms Steady increase in generator rotor angle due to lack of synchronizing torque. Rotor oscillations of increasing amplitude due to lack of sufficient damping toque. The small signal stability problem is usually one of insufficient damping of system oscillations. Small signal analysis using linear techniques provides valuable information about the inherent dynamic characteristics of the power system and assists in its design. Electric power systems are highly nonlinear systems and constantly experience changes ingeneration, transmission and load conditions. With the enormous increase in the demand for the electricity almost all major transmission networks in the world are operated close to their stability limits

4. Low Frequency Oscillation

Low frequency oscillations (LFO) are generator rotor angle oscillations having a frequency between 0.1 Hz to 3.0 Hz and are defined by how they are created or where they are located in the power system. The use of high gain exciters, poorly turned generation excitation, HVDC converters may create LFO with negative damping; this is a small-signal stability problem. Mitigation of these oscillations is commonly performed with "supplementary stabilizing signals" and the networks used to generate these signals have come to be known as "power system stabilizer" networks. Major transmission networks in the world are operated close to their stability limits. LFO include local plant modes, control modes, torsional modes induced by the interaction between the mechanical and electrical modes of a turbine-generator system, and inter-area modes, which may be caused by either high gain exciters or heavy power transfers across weak tie lines.

Low frequency oscillations can be created by small disturbances in the system, such as changes in the load, and are normally analysed through the small-signal stability (linear response) of the power system. These small disturbances lead to a steady increase or decrease in generator rotor angle caused by the lack of synchronizing torque, or to rotor oscillations of increasing amplitude due to a lack of sufficient damping torque. The most typical instability is the lack of a sufficient damping torque on the rotor's low frequency oscillations. LFO include local plant modes, control modes, torsional modes, and global modes in power system.

Low Frequency Oscillation Mode [1-3]

The disturbances occurring in power system include electromechanical oscillations of electrical generators. These oscillations are also called power swings and these must be effectively damped to maintain the system stability. Electromechanical oscillations can be classified in four main categories.

Local Mode

In this mode of oscillation typically one or more generators swing against the rest of the power system in a frequency range from 0.7 Hz to 2 Hz. This oscillation may occur and become a problem if the generator is highly loaded and connected to a weak grid. In an excitation system containing a high transient gain and no PSS, these local machine oscillations may increase. A correctly tuned PSS in such a system may decrease the local machine oscillation

Inter-Area Mode

The inter-area oscillation mode can be seen in a large part of a network where one part of the system oscillates against other parts at a frequency below 0.5 Hz. Since there is a large amount of generating units involved in these oscillations, the network operators must cooperate, tune and implement applications that will damp this mode of oscillations. A PSS is often a good application to provide positive damping of the inter-area modes. Also a higher frequency inter-area oscillation can appear (from 0.4 to 0.7 Hz) when side groups of generating units oscillate against each other

Torsional Mode

Torsional mode will act on the generator-turbine shaft and create twisting oscillations in a frequency above 4 Hz and is most distinctive in turbo machines with long shafts. These oscillations are usually difficult to detect with the generator models used to detect oscillations with lower frequencies. If the excitation system is powerful enough the

5. Methods For Improving Low Frequency Oscillation [A]

FACTS devices and PSS are generally use for damping low frequency oscillation. Now days PSS with PID controller is widely used for damping function of low frequency oscillation. The goal of using the stabilizer of the power system is that expand the stability limit of transmission of electrical energy through strengthening the damping of system vibration by generator excitation control. It can provide the additional excitation control of positive damping. The common parameters are angular velocity, power and frequency, and mainly consist by the magnification, reduction, and lead-lag links and other corrective connections. It takes the output and terminal voltage as the input of excitation system. PSS is designed approximate linearized pattern based on layout in a balance point of the system. It has a strong pertinence and easily realize and restrain the low frequency oscillation effectively. It has widespread application.

6. Simulation and Results

For the particular system analyze the damping of low frequency oscillations characteristics for given initial operating condition. The simulation done in MATLAB for the system for following cases.

1) Simulation for the system with effect of AVR
2) Simulation for the system with effect of AVR and PSS
3) Simulation for the system with effect of AVR,PSS and PID

The simulation results are also discuss for above the cases to analyze the damping of low frequency oscillation.

7. Case Study

Figurer shows the system representation applicable to a thermal generating station consisting of four 555 MVA, 24 kV, and 60 Hz units.

Initial Operating Condition Parameters for PSS

$P = 0.85$ p.u, $Q = 0.3$ p.u, $H = 3.5$ MW*s/MVA$E_T = 1.0\angle 36$ $E_B = 0.995\angle 0$ $X'_d = 0.3$, $D = 0$ $V_b = 1.0$ p.u $Xt_E = 0.1$ p.u $T'_{do} = 5.044$ s $V_t = 1.032$ p.u

The excitation system with $PSSK_{STAB}$ = 9.5 T_W = 1.4 s T_1 = 0.154 s T_2 = 0.033 sA Thyristor exciter with $AVRK_A$ = 200 T_R=0.02sUPFC parameter for modulating indexm_B = 1.0, m_E = 1.0 δ_E = 28.1 ,δ_B = − 21.1 UPFC parameter for Controllability IndexΔm_B = 0.0133, $\Delta\delta_E$ = 0.1916, $\Delta\delta_B$ = 3.6 ×10^{-4}UPFC Excitation system parameterKa = 50 Ta = 0.05secTransformer ParameterX_{t1} = 1.0 p.u X_{t2} = 1.3 p.u

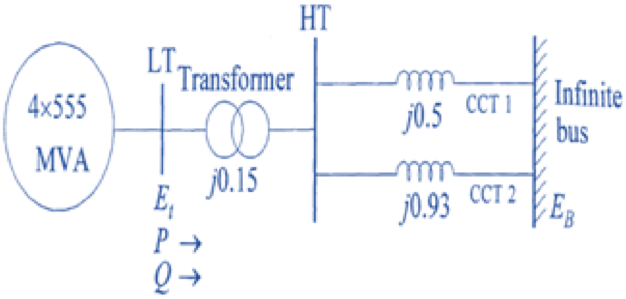

Figure 2: Four generator infinite bus system

Different type controller such as AVR, PSS, PID-PSS are implemented for damping of low frequency oscillation. This particular case study with initial operating conditions. Simulations are done with the help of MATLAB/SIMULINK. And results are obtained for three different controllers.

Comparison done for the parameters
1. Rotor Speed Deviation.
2. Rotor Angle Deviation.

Finally conclusion is derived from comparisonbetween them for calculating different parameters of SMIB system using equations program has been developed for initial operating conditions to find out different parameters of SMIB system. Resulting value of a parameter (K_1-K_6) and other parameter associated with a synchronous generator for value of a P=0.85 and Q=0.30

Apply the values of K1 to K6 constants to simulation and find results

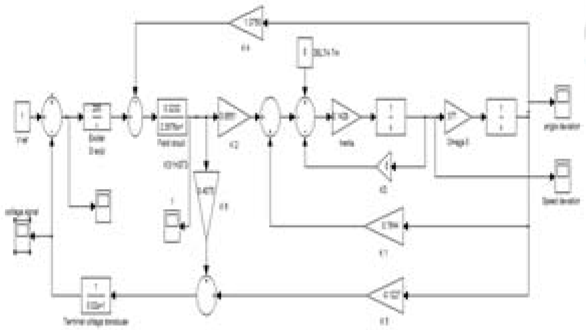

Figure 3: Simulation of Heffron – Philips model with AVR

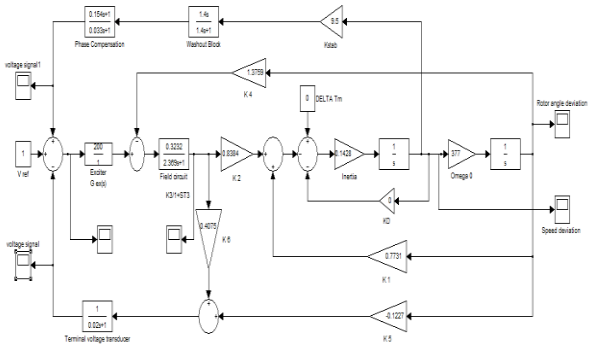

Figure 4: Simulation of Heffron – Philips model with AVR and PSS

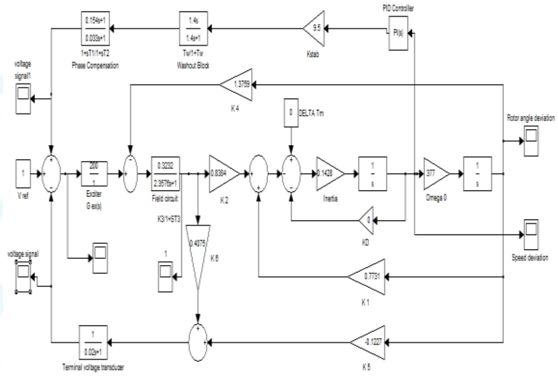

Figure 5: Simulation of Heffron – Philips model with AVR, PSS and PID Controller

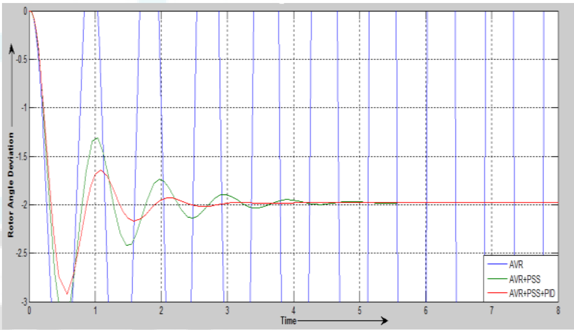

Figure 6: Simulation Result for a Rotor angle Deviation

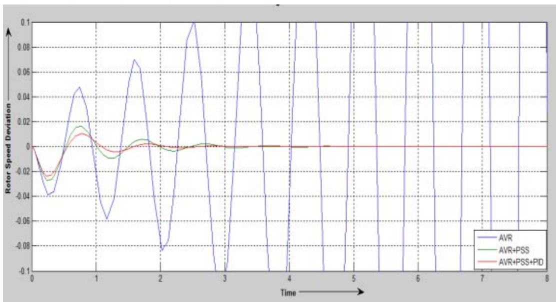

Figure 7: Simulation Result for a Rotor Speed Deviation

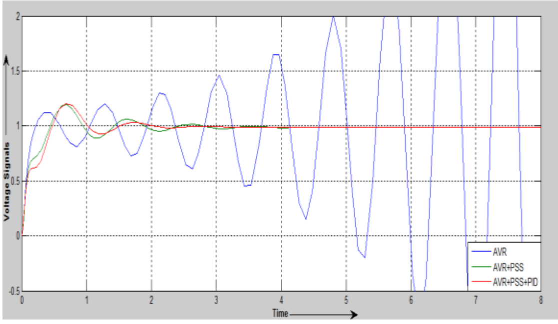

Figure 8: Simulation Result for a voltage signal

8. Conclusion

For damping of low frequency oscillations of SMIB system different of controllers are used for initial operating conditions and there. Results of simulations for the respective controller are obtained using MATLAB /SIMULINK. Relation between K- constants (K1 to K9) of Heffron – Philips Model with the active power (P) and reactive power (Q) of SMIB system is considered. After comparing the results of AVR, PSS And PID-PSS it is clearly indicative that PID-PSS controller has small overshoot and gives fast response to damp-out oscillations in rotor speed and rotor angle as compared to other controllers. PID-PSS controller has minimum settling time and it can effectively eliminate low frequency oscillations and also provides smooth operation Comparing output of different controllers, it can be concluded that output of PID-PSS is stabilized very fast as compared to other controllers

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