Study of Excitation System and Power System Stabilizer for Single Machine Infinite Bus System

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Abstract - A Power system is a dynamic system, and constantly being subjected to disturbances. This disturbance must create the unstable condition such as the small-signal instability also affect system stability. For this to add the sufficient damping torque for electromechanical modes of oscillation. The Heffron-Phillips model in the single bus infinite bus system considers for it. Power system stabilizer and automatic voltage regulator produce sufficient damping torque in the synchronous generator. The mathematical solution of the Heffron-Phillips model at different operating condition and analysis in MATLAB software with time domain. A comparison between different condition such as a constant field, excitation system and Power system stabilizer controller. To add the fuzzy logic in the single machine infinite bus system reduce the oscillation and gain the stable condition.

Keyword: Small-signal stability, Generator excitation system, Automatic voltage regulator (AVR), Power system stabilizer (PSS).

I. INTRODUCTION

Nonlinear power systems continuously experience generation and load change conditions along with severe disturbance causing a change in the power system operating conditions [1]. It is constantly subjected to disturbance, according to which generator outage, load changes, voltage collapse. Due to this small-signal instability, it includes in the system and affects system performance, so the power system instability is a major concern for the modern power system operation. For each power system, the synchronous generator is the most important component. The most control of the synchronous generators is through the excitation system. An excitation system is mostly used to maintain the system’s stability. The excitation system has a fast-acting AVR to eliminate the synchronous torque but affect the damping torque. The additional signals are mostly derived from excitation system deviation, speed deviation or accelerating power. This is accomplished by inserting a stabilizing signal into the excitation system voltage reference summing point junction. The device arrangement is to provide the signal is called "power system stabilizer" [2]. PSS provides the supplementary signal to the excitation system to improve the oscillatory instability, and the PSS is also faster to improve stability.

II. SYSTEM MODELLING

A. Small signal stability

Small signal stability of the power system to maintain the synchronism under small disturbance. Small disturbance occurs due to change in load and generation. The unstable condition caused by the increase in the rotor angle in the system. This condition caused insufficient synchronizing torque is called non-oscillatory instability. Another instability is oscillatory instability due to insufficient damping torque.

Classification of the power system stability,

Fig. 1.1 Classification of power system stability

A. Synchronous machine modelling

The synchronous machine is extensive equipment in the power system. A synchronous machine connected with an infinite bus through the transmission line.

Fig.1.2 Single machine infinite bus

The machine response in two cases one is constant field voltage with no voltage regulator, the second one is excitation control. To present the equivalent circuit of the synchronous machine connected to an infinite bus system.
B. classical system model

For small signal stability analysis, dynamic modelling is required for the major component of the power system. It includes a synchronous generator, excitation control, voltage regulator and also a different parameter. The different type of model used for the dynamic analysis and it depends on their parameter. The single machine infinite bus system model used to obtain the Heffron-Phillips model K constant.

\[
\Delta \delta = \frac{\omega B_s \delta_{sm}}{2} \Delta \delta = \frac{\omega B_s \Delta \omega}{2} \\
\Delta E'q = 0 \text{ and the characteristic equation,} \\
2H_s^2 + D_s + K_1 \omega B = 0
\]

For stability, both K and D should be positive, if D is negligible then the characteristic equation,

\[
s_1, s_2 = \pm K_1 \omega B_2 H = \pm j \omega m
\]

In this paper, the Heffron-Phillips model, shown in fig (1.4).in. This Ks is called synchronizing coefficient, Kd is damping coefficient, H is inertia constant, s is Laplace operator, wB is rated speed, T’d0 is direct axis transient open circuit time-constant, K1 to K6 is K constant. Synchronizing torque and damping torque introduce by the AVR and it depends on the K5 value.

\[
K_1 = \frac{E_b E_q \cos \delta_0}{(x_e + x_q)} \left( \frac{x_q - x_e'}{x_e + x_q'} \right) E_b l_q \sin \delta_0 \\
K_2 = \frac{(x_e + x_q)}{(x_e + x_q') t_q} \left( \frac{E_b \sin \delta_0}{x_e + x_q} \right) \\
K_3 = \frac{(x_e + x_q)}{(x_e + x_q')} \\
K_4 = \frac{(x_d - x_q)}{(x_d + x_q)} E_b \sin \delta_0 \\
K_5 = \frac{-x_q V_d d B \cos \delta_0}{(x_e + x_q) V_0} - \frac{x_d V_q d B \sin \delta_0}{(x_e + x_q') V_0} \\
K_6 = \frac{x_e}{(x_e + x_q')}
\]

C. Power system stabilizer

The basic function of a power system stabilizer is as known as an auxiliary device. It provides positive damping of electrical torque in phase with rotor speed deviation in the system. To add the Automatic voltage regulator block with the PSS block, it’s called the 'Excitation controller' described in figure (1.5).

### Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Nominal values</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.8</td>
</tr>
<tr>
<td>Q</td>
<td>-0.2</td>
</tr>
<tr>
<td>Xd</td>
<td>1.6</td>
</tr>
<tr>
<td>Xq</td>
<td>1.55</td>
</tr>
<tr>
<td>0.5X'd</td>
<td>0.32</td>
</tr>
<tr>
<td>T’d0</td>
<td>6</td>
</tr>
<tr>
<td>H</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>50 HZ</td>
</tr>
<tr>
<td>Eb</td>
<td>1 P.u</td>
</tr>
<tr>
<td>Et</td>
<td>1 P.u</td>
</tr>
<tr>
<td>Ke</td>
<td>200</td>
</tr>
<tr>
<td>Te</td>
<td>0.05 sec</td>
</tr>
<tr>
<td>Efd max</td>
<td>6 P.u</td>
</tr>
<tr>
<td>Efd min</td>
<td>-6 P.u</td>
</tr>
</tbody>
</table>
A. Performance with constant field voltage

This represents the dynamic characteristic of constant k. the values of the k constant calculate using the above parameter values.

<table>
<thead>
<tr>
<th>k</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.078</td>
</tr>
<tr>
<td>T2</td>
<td>0.026</td>
</tr>
<tr>
<td>Kpss</td>
<td>16</td>
</tr>
<tr>
<td>Tw</td>
<td>2</td>
</tr>
<tr>
<td>Re</td>
<td>0</td>
</tr>
<tr>
<td>Xe</td>
<td>0.04</td>
</tr>
</tbody>
</table>

B. Performance with Excitation system

K1 = 1.0789, K2 = 1.3659, K3 = 0.3600, K4 = 1.7484

C. Performance with PSS

The standard IEEE type ST1A excitation system model has been considering for analysis with a single machine infinite bus. The excitation parameter is K = 200, Te = 0.05.

The value of K constant calculated using above parameter, K1 = 1.0789, K2 = 1.3659, K3 = 0.3600, K4 = 1.7484, K5 = -0.0868, K6 = 0.2701.

IV. CONCLUSION

In the power system, the major component has dynamic behaviour and the important component is the synchronous generator associate controls excitation and prime mover. The main aim is analyse the stability of the system. So, consider the excitation system and ignore the prime mover. After the study of the
Mathematical equation of the SMIB system and analysis of the Heffron-Phillips model in the SMIB system in Mat-lab. To analysis in a different condition, the effect of different value of active and reactive power in the system and use the AVR and PSS for stability. Observe the analysis, the PSS gives a better solution over the AVR.

V. REFERENCES


