CHAPTER 3

PERFORMANCE EVALUATION OF POWER SYSTEM STABILIZER

3.1 INTRODUCTION

A power system stabilizer (PSS) installed in the excitation system of the synchronous generator improves the low-signal power system stability by damping out low-frequency oscillations in the Power System. It manages that by providing additional perturbation signals in a feedback path to the alternator excitation system. Many different methods and approaches have been investigated to design PSS. In this chapter, a comprehensive study of the PSS designing methods is presented. For simulations, we practice three different designs of PSS, multiband PSS (MB-PSS), conventional delta w PSS (Delta w) and conventional acceleration power PSS (Delta Pa). The MATLAB software program with Control System Toolbox and SIMULINK is used for the design and simulations for symmetrical and asymmetrical fault analysis of the proposed system. The slack machine is such that all generators are producing about 700 MW each. The results can be seen by opening the Powerful and selecting Machine and Load-Flow Initialization. They are slightly different from (Kundur 1994) because the load voltage profile was improved (made closer to unity) by installing 187 MVAr more capacitors in each area. Also, transmission and generation losses may vary depending on the detail level in line and generator representation.
3.2 Symmetrical Fault Analysis of Proposed power system

Figs. 3.1-3.20 show the simulated responses of four-machine power system with symmetrical fault analysis. Figs. 3.1-3.5 show the symmetrical fault analysis of the proposed system without the PSS implementation. Figs. 3.6-3.10 show the symmetrical fault analysis of the four machine two area power system with multiband PSS; Figs. 3.11-3.15 show with Delta w PSS and Figs. 3.16-3.20 show with Delta Pa PSS respectively. From the reflection of the three PSS, the multiband PSS responses are superior to other two.

Fig. 3.1 Simulated response of active power and voltage for bus 1 and 2 without PSS

Fig. 3.2 Simulated response of rotor angle deviation for two area four-machine power system without PSS
Fig. 3.3 Simulated response of rotor speed for two area four-machine power system without PSS

Fig. 3.4 Simulated response of power loss for two area four-machine power system without PSS

Fig. 3.5 Simulated response of machine voltage for two area four-machine power system without PSS
Fig. 3.6 Simulated response of active power and voltage for bus 1 and 2 with delta w PSS

Fig. 3.7 Simulated response of rotor angle deviation for two area four-machine power system with Delta w PSS

Fig. 3.8 Simulated response of rotor speed for two area four-machine power system with Delta w PSS
Fig. 3.9 Simulated response of power loss for two area four-machine power system with Delta w PSS

Fig. 3.10 Simulated response of machine voltage for two area four-machine power system with Delta w PSS

Fig. 3.11 Simulated response of active power and voltage for bus 1 and 2 with multiband PSS
Fig.3.12 Simulated response of rotor angle deviation for two area four-machine power system with multiband PSS

Fig.3.13 Simulated response of rotor speed for two area four-machine power system with multiband PSS

Fig.3.14 Simulated response of power loss for two area four-machine power system with multiband PSS
Fig. 3.15 Simulated response of machine voltage for two area four-machine power system with multiband PSS

Fig. 3.16 Simulated response of active power and voltage for bus 1 and 2 with delta Pa PSS

Fig. 3.17 Simulated response of rotor angle deviation for two area four-machine power system with Delta Pa PSS
Fig. 3.18 Simulated response of rotor speed for two area four-machine power system with Delta Pa PSS

Fig. 3.19 Simulated response of power loss for two area four-machine power system with Delta Pa PSS

Fig. 3.20 Simulated response of machine voltage for two area four-machine power system with Delta Pa PSS
3.3 Asymmetrical Fault Analysis of Proposed power system

Figs.3.21-3.60 show the simulated responses of four-machine power system with asymmetrical fault analysis such as L-G and LL-G fault. Figs.3.21-3.25 show the L-G fault analysis of the proposed system without the PSS implementation. Figs.3.26-3.30 show the L-G fault analysis of the four machine two area power system with multiband PSS; Figs.3.31-3.35 show with Delta w PSS and Figs.3.36-3.40 show with Delta Pa PSS respectively. From the simulation of the three PSS, the multiband PSS responses are superior to other two. Similarly, for the LL-G fault analysis, the multiband PSS is superior to others. The simulated responses of a double line to ground fault analysis are shown in Figs.3.41-3.60. Symmetrical and Asymmetrical fault analysis of proposed power systems are shown in Tables 3.1 and 3.2.

Fig.3.21 Active power and voltage for bus 1 and 2 without PSS during L-G fault

Fig.3.22 Rotor angle deviation for two area four-machine power system without PSS during L-G fault
Fig. 3.23 Rotor speed for two area four-machine power system without PSS during L-G fault

Fig. 3.24 Power loss for two area four-machine power system without PSS during L-G fault

Fig. 3.25 Machine voltage for two area four-machine power system without PSS during L-G fault
Fig. 3.26 Active power and voltage for bus 1 and 2 with multiband PSS during L-G fault

Fig. 3.27 Rotor angle deviation for two area four-machine power system with multiband PSS during L-G fault

Fig. 3.28 Rotor speed for two area four-machine power system with multiband during L-G fault
Fig. 3.29 Power loss for two area four-machine power system with multiband PSS during L-G fault.

Fig. 3.30 Machine voltage for two area four-machine power system with multiband during L-G fault.

Fig. 3.31 Active power and voltage for bus 1 and 2 with delta w PSS during L-G fault.
Fig. 3.32 Rotor angle deviation for two area four-machine power system delta w PSS during L-G fault

Fig. 3.33 Rotor speed for two area four-machine power system with Delta w PSS during L-G fault

Fig. 3.34 Power loss for two area four-machine power system with Delta w PSS during L-G fault
Fig. 3.35 Machine voltage for two area four-machine power system with Delta w PSS during L-G fault

Fig. 3.36 Active power and voltage for bus 1 and 2 with delta Pa PSS during L-G fault

Fig. 3.37 Rotor angle deviation for two area four-machine power system delta Pa PSS during L-G fault
Fig. 3.38 Rotor speed for two area four-machine power system with Delta Pa PSS during L-G fault

Fig. 3.39 Power loss for two area four-machine power system with Delta Pa PSS during L-G fault

Fig. 3.40 Machine voltage for two area four-machine power system with Delta Pa PSS during L-G fault
Fig. 3.41 Active power and voltage for bus 1 and 2 without PSS during LL-G fault

Fig. 3.42 Rotor angle deviation for two area four-machine power system without PSS during LL-G fault

Fig. 3.43 Rotor speed for two area four-machine power system without PSS during LL-G fault
Fig. 3.44 Power loss for two area four-machine power system without PSS during LL-G fault

Fig. 3.45 Machine voltage for two area four-machine power system without PSS during LL-G fault

Fig. 3.46 Active power and voltage for bus 1 and 2 with multiband PSS during LL-G fault
Fig. 3.47 Rotor angle deviation for two area four-machine power system with multiband PSS during LL-G fault

Fig. 3.48 Rotor speed for two area four-machine power system with multiband during LL-G fault

Fig. 3.49 Power loss for two area four-machine power system with multiband PSS during LL-G fault
Fig. 3.50 Machine voltage for two area four-machine power system with multiband during LL-G fault

Fig. 3.51 Active power and voltage for bus 1 and 2 with delta w PSS during LL-G fault

Fig. 3.52 Rotor angle deviation for two area four-machine power system delta w PSS during LL-G fault
Fig. 3.53 Rotor speed for two area four-machine power system with Delta w PSS during LL-G fault

Fig. 3.54 Power loss for two area four-machine power system with Delta w PSS during LL-G fault

Fig. 3.55 Machine voltage for two area four-machine power system with Delta w PSS during LL-G fault
Fig. 3.56 Active power and voltage for bus 1 and 2 with delta Pa PSS during LL-G fault

Fig. 3.57 Rotor angle deviation for two area four-machine power system delta Pa PSS during LL-G fault

Fig. 3.58 Rotor speed for two area four-machine power system with Delta Pa PSS during LL-G fault
Fig. 3.59 Power loss for two area four-machine power system with Delta Pa PSS during LL-G fault

Fig. 3.60 Machine voltage for two area four-machine power system with Delta Pa PSS during LL-G fault
### Table 3.1. Symmetrical fault analysis of proposed power system

<table>
<thead>
<tr>
<th>Response</th>
<th>Without PSS</th>
<th>With PSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MB PSS</td>
<td>Delta W PSS</td>
</tr>
<tr>
<td>Voltage (p.u)</td>
<td>Oscillation</td>
<td>1</td>
</tr>
<tr>
<td>Active Power (MW)</td>
<td>Not settled</td>
<td>400</td>
</tr>
<tr>
<td>Rotor speed/sec (p.u)</td>
<td>Oscillation</td>
<td>1.036</td>
</tr>
<tr>
<td>Power loss (pu)</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 3.2. Asymmetrical fault analysis of proposed power system

<table>
<thead>
<tr>
<th>Response</th>
<th>LG Fault Analysis</th>
<th>LL-G Fault Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without PSS</td>
<td>Delta W PSS</td>
</tr>
<tr>
<td>Voltage (p.u)</td>
<td>Unstable</td>
<td>1</td>
</tr>
<tr>
<td>Active power (MW)</td>
<td>Unstable</td>
<td>400</td>
</tr>
<tr>
<td>Rotor speed(p.u)</td>
<td>Unstable</td>
<td>1.003</td>
</tr>
<tr>
<td>Power loss(p.u)</td>
<td>Unstable</td>
<td>0</td>
</tr>
</tbody>
</table>
3.4 SUMMARY

This chapter presented three types of PSSs. The simulated responses of the system power transfer from area 1 to 2, M1 speed, M1 acceleration power and M1 terminal voltage are observed. All PSSs do a good job stabilizing the naturally unstable system. However, it is clear that the multiband PSS (MB-PSS) is superior to the other two PSSs, providing significantly more damping to all modes, in particular on the Delta w PSS and Delta Pa PSS. The system lost its synchronism while the MB-PSS and the Delta W PSS succeed in maintaining stability. The latter are both very effective in damping the oscillation of the power transfer. In addition, the power acceleration is more damped with the MB-PSS than any other PSS.