APPENDIX 1

Thermal Power Plant

\( R_i \) = Speed regulation of governor = 2 Hz/p.u. MW;

\( T_{g} \) = Turbo governor time constant = 0.08 sec;

\( T_r \) = Non-reheat turbine time constant = 0.3 sec;

\( K_{p1} = K_{p2} \) = Power system gain constant of area1 and area2 = 120;

\( T_{p1} = T_{p2} \) = Power system time constant of area1 and area2 = 20 sec;

\( \Delta P_{p1} = \Delta P_{p2} \) = Change in load demand power in area1 and area2 = 0.01 p.u;

\( B_1 = B_2 \) = Frequency bias constant of area1 and area2 = 0.425 p.u.MW/Hz;

Hydro power plant

\( R_2 \) = Speed regulation = 2.4 Hz/p.u. MW;

\( K_i \) = Hydro governor gain = 1;

\( T_1 \) = Hydro governor time constant = 48.7 sec;

\( T_{r1}, T_2 \) = Hydro power plant time constants = 5.0 sec, 0.513 sec;

\( T_w \) = Water time constant = 1.0 sec;
Tie-line

\[ A_{t2} = \text{Synchronizing power coefficient} = -1; \]

\[ T = \text{Synchronizing coefficient} = 10\% \text{ of area capacity} = 0.1\cos \delta_{12} = 0.0707; \]

**SMES**

\[ T_{\text{SMES}} = \text{SMES time constant} = 0.03 \text{ sec}; \]

\[ K_{\text{SMES}} = \text{SMES gain constant} = 0.297; \]

\[ T_{21}, T_{22}, T_{3}, T_{4} = \text{Second order frequency stabilizer constants} \]

\[ = 0.121 \text{ sec}, 0.800 \text{ sec}, 0.011 \text{ sec}, 0.148 \text{ sec respectively}; \]

**UPFC**

\[ T_{\text{UPFC}} = \text{UPFC time constant} = 0.01 \text{ sec}; \]

\[ K_{\text{UPFC}} = \text{UPFC gain constant} = 0.1; \]

\[ T_{w} = \text{Wash out time constant} = 10 \text{ sec}; \]

\[ T_{9}, T_{10}, T_{21}, T_{12} = \text{Second order frequency stabilizer constants} \]

\[ = 0.5251 \text{ sec}, 0.6110 \text{ sec}, 0.9836 \text{ sec}, 0.1256 \text{ sec respectively}; \]

**SSSC**

\[ T_{\text{SSSC}} = \text{SSSC time constant} = 0.03 \text{ sec}; \]

\[ K_{\text{SSSC}} = \text{SSSC gain constant} = 0.001; \]

\[ T_{w} = \text{Wash out time constant} = 10 \text{ sec}; \]

\[ T_{5}, T_{6}, T_{7}, T_{8} = \text{Second order frequency stabilizer constants} \]

\[ = 0.2651 \text{ sec}, 0.2011 \text{ sec}, 0.6851 \text{ sec}, 0.2258 \text{ sec respectively}; \]
Boiler dynamics

\( K_1, K_2, K_3 = 0.85, 0.095 \) and 0.92 respectively;

\( C_B = \) Storage constant of the boiler = 200;

\( T_D, T_F = \) Fuel system time constant = 0 sec, 10 sec;

\( K_B = \) Gain of the pressure control = 0.030;

\( T_{FB}, T_{RB} = \) Time constant of pressure control = 26 sec, 69 sec;

Reheat steam turbine

\( K_r = \) Reheat steam turbine gain = 0.333;

\( T_r = \) Reheat steam turbine time constant = 10 sec;
APPENDIX 2

Figure 1 Simulink model of Thermal Power Plant

Figure 2 Simulink model of Hydro Power Plant
Figure 3 Simulink model of single source multi area hydro thermal system

Figure 4 Simulink model of multi source multi area hydro thermal system
Figure 5 Simulink model of SMES

Figure 6 Simulink model of SSSC

Figure 7 Simulink model of UPFC
Figure 8. Simulink model of Boiler dynamics