CHAPTER – 10

APPENDICES
Appendix I

Data for SMIB Power System with SSSC:

System data: All data are in pu unless specified otherwise.

**Generator:**
Nominal power: $S_B = 2100$ MVA
Nominal voltage: $V_B = 13.8$ kV
Nominal frequency: $f = 60$ Hz
Reactances: $X_d = 1.305$, $X' = 0.296$, $X'' = 0.252$, $X_q = 0.474$, $X'_q = 0.243$, $X''_q = 0.18$

Time constants: $T_d = 1.01$ s, $T'_d = 0.053$ s, $T''_{dq} = 0.1$ s
Stator resistance: $R_s = 2.8544 \times 10^{-3}$
Coefficient of inertia and pair of poles: $H = 3.7$ s, $p = 32$

**Excitation System:**
Low-pass filter time constant: $T_{LP} = 0.02$ s
Regulator gain and time constant: $K_A = 200$, $T_A = 0.001$ s
Exciter gain and time constant: $K_e = 1$, $T_e = 0$
Transient gain reduction: $T_b = 0$, $T_c = 0$
Damping filter gain and time constant: $K_f = 0.001$, $T_f = 0.1$ s
Regulator output limits and gain: $E_{f_{\text{min}}} = 0$, $E_{f_{\text{max}}} = 7$, $K_p = 0$

**Hydraulic Turbine and Governor:**
Servo-motor gain and time constant: $K_a = 3.33$, $T_a = 0.07$
Gate opening limits: $G_{\text{min}} = 0.01$, $G_{\text{max}} = 0.97518$, $V_{g_{\text{min}}} = -0.1$ pu/s, $V_{g_{\text{max}}} = 0.1$ pu/s
Permanent droop: $R_p = 0.05$
PID regulator: $K_p = 1.163$, $K_i = 0.105$, $K_d = 0$, $T_d = 0.01$ s
Hydraulic turbine: $\beta = 0$, $T_w = 2.67$ s
Transformer:
Nominal power: \( S_B = 2100 \) MVA
Winding connection: \( D_1/Y_g \) connection
Winding parameters: \( V_1 = 13.8 \) kV, \( V_2 = 500 \) kV, \( R_1 = R_2 = 0.002 \), \( L_1 = 0 \), \( L_2 = 0.12 \)
Magnetization resistance: \( R_m = 500 \)
Magnetization reactance: \( L_m = 500 \)

Transmission line:
Number of phases: 3-Ph
Resistance per unit length: \( R_1 = 0.02546 \) \( \Omega/\) km, \( R_0 = 0.3864 \) \( \Omega/km \)
Inductance per unit length: \( L_4 = 0.9337 \times 10^{-3} \) H/\( km \), \( L_0 = 4.1264 \times 10^{-3} \) H/\( km \)
Capacitance per unit length: \( C_1 = 12.74 \times 10^{-9} \) F/\( km \), \( C_0 = 7.751 \times 10^{-9} \) F/\( km \)
Line length = 300 km each

Load at Bus 2:
250 MW (500 kV, 60 Hz, Y-grounded)

SSSC:
Converter rating: \( S_{nom} = 100 \) MVA
System nominal voltage: \( V_{nom} = 500 \) kV
Frequency: \( f = 60 \) Hz
Maximum rate of change of reference voltage \(( V_{qref} ) = 3 \) pu/s
Converter impedances: \( R = 0.00533 \), \( L = 0.16 \)
DC link nominal voltage: \( V_{DC} = 40 \) kV
DC link equivalent capacitance \( C_{DC} = 375 \times 10^{-6} \) F
Injected Voltage regulator gains: \( K_p = 0.00375 \), \( K_i = 0.1875 \)
DC Voltage regulator gains: \( K_p = 0.1 \times 10^{-3} \), \( K_i = 20 \times 10^{-3} \)
Injected voltage magnitude limit: \( V_q = \pm 0.2 \)
Appendix II

Data of SMIB Power System with SVC and STATCOM:
Data are in pu unless specified otherwise.

**Generator:**
Nominal power: $S_B = 2100$ MVA
Nominal voltage: $V_B = 13.8$ kV
Nominal frequency: $f = 60$ Hz
Reactances: $X_d = 1.305$, $X'_{d} = 0.296$, $X''_{d} = 0.252$, $X_q = 0.474$, $X'_{q} = 0.243$, $X''_{q} = 0.18$
Time constants: $T_d = 1.01$ s, $T'_{d} = 0.053$ s, $T''_{qo} = 0.1$ s
Stator resistance: $R_S = 2.8544 \times 10^{-3}$
Coefficient of inertia and pair of poles: $H = 3.7$ s, $p = 32$

**Excitation System:**
Low-pass filter time constant: $T_{LP} = 0.02$ s
Regulator gain and time constant: $K_A = 200$, $T_A = 0.001$ s
Exciter gain and time constant: $K_e = 1$, $T_e = 0$
Transient gain reduction: $T_b = 0$, $T_c = 0$
Damping filter gain and time constant: $K_f = 0.001$, $T_f = 0.1$ s
Regulator output limits and gain: $E_{f \min} = 0$, $E_{f \max} = 7$, $K_p = 0$

**Hydraulic Turbine and Governor:**
Servo-motor gain and time constant: $K_a = 3.33$, $T_a = 0.07$
Gate opening limits: $G_{\min} = 0.01$, $G_{\max} = 0.97518$, $V_{g \min} = -0.1$ pu/s, $V_{g \max} = 0.1$ pu/s
Permanent droop: $R_p = 0.05$
PID regulator: $K_p = 1.163$, $K_i = 0.105$, $K_d = 0$, $T_d = 0.01$ s
Hydraulic turbine: $\beta = 0$, $T_w = 2.67$ s

**Transformer:**
Nominal power: $S_B = 2100$ MVA
Winding connection: $D_1/Y_g$ connection
Winding parameters: \( V_1 = 13.8 \text{ kV}, V_2 = 500 \text{ kV}, R_1 = R_2 = 0.002, L_1 = 0, L_2 = 0.12 \)

Magnetization resistance: \( R_m = 500 \)

Magnetization reactance: \( L_m = 500 \)

**Transmission line:**

Number of phases: 3-Ph

Resistances per unit length: \( R_1 = 0.02546 \ \Omega/\text{km}, R_0 = 0.3864 \ \Omega/\text{km} \)

Inductances per unit length: \( L_1 = 0.9337 \times 10^{-3} \ \text{H/km}, L_0 = 4.1264 \times 10^{-3} \ \text{H/km} \)

Capacitances per unit length: \( C_1 = 12.74 \times 10^{-9} \ \text{F/km}, C_0 = 7.751 \times 10^{-9} \ \text{F/km} \)

Line length = 300 km each

**Load at Bus2:** 250MW

**SVC:**

Three-phase base power: \( S_B = 100 \text{ MVA} \)

System nominal voltage: \( V_{nom} = 500 \text{ kV} \)

System frequency: \( f = 60 \text{ Hz} \)

Reactive power limits: \( = \pm 100 \text{ MVAR} \)

Time delay due to thyristor valve firing: \( T_d = 4 \text{ ms} \)

Droop: \( X_s = 0.03 \)

Voltage regulator gains: \( K_p = 3, K_i = 500 \)

**STATCOM:**

Converter rating: \( S_{nom} = 100 \text{ MVA} \)

System nominal voltage: \( V_{nom} = 500 \text{ kV} \)

Frequency: \( f = 60 \text{ Hz} \)

Converter impedance: \( R = 0.073, L = 0.22 \)

DC link nominal voltage: \( V_{DC} = 40 \text{ kV} \)

DC link equivalent capacitance: \( C_{DC} = 375 \times 10^{-6} \ \text{F} \)

Droop = 0

AC voltage regulator gains: \( K_p = 50, K_i = 1000 \)

DC voltage regulator gains: \( K_p = 1 \times 10^{-3}, K_i = 20 \times 10^{-3} \)

Current regulator gains: \( K_p = 0.3, K_i = 10, K_f = 0.22 \)

STATCOM bus voltage limit: \( V_{q_{min}} = 0.9, V_{q_{max}} = 1.1 \)
Appendix III

Data of 3-Machine 6-Bus Power System:

Generators:
Nominal powers: $S_{B1} = 4200$ MVA, $S_{B2} = S_{B3} = 2100$ MVA
Nominal voltage: $V_B = 13.8$ kV
Nominal frequency: $f = 60$ Hz
Reactances: $X'_d = 1.305, X''_d = 0.296, X'''_d = 0.252, X'_{q} = 0.474, X''_{q} = 0.243,$

\[ X''_{q} = 0.18 \]

Time constants: $T_d = 1.01 \text{ s}, T''_d = 0.053 \text{ s}, T''_{qo} = 0.1 \text{ s}$
Stator resistance: $R_S = 2.8544 \times 10^{-3}$
Coefficient of inertia and pair of poles: $H = 3.7 \text{ s}, p = 32$
Operating point: $P_1 = 6.068 \times 10^3 \text{ MW}, P_2 = 6.4 \times 10^2 \text{ MW}, P_3 = 4.4 \times 10^2 \text{ MW}$

Excitation Systems:
Low-pass filter time constant: $T_{LP} = 0.02 \text{ s}$
Regulator gains and time constants: $K_A = 200, T_A = 0.001 \text{ s}$
Exciter gains and time constants: $K_e = 1, T_e = 0$
Transient gain reduction: $T_b = 0, T_c = 0$
Damping filter gains and time constants: $K_f = 0.001, T_f = 0.1 \text{ s}$
Regulator output limits and gains: $E_{f_{\text{min}}} = 0, E_{f_{\text{max}}} = 7, K_p = 0$

Hydraulic Turbine and Governor:
Servo-motor gains and time constants: $K_a = 3.33, T_a = 0.07$
Gate opening limits: $G_{\text{min}} = 0.01, G_{\text{max}} = 0.97518, V_{g_{\text{min}}} = -0.1 \text{ pu/s}, V_{g_{\text{max}}} = 0.1 \text{ pu/s}$
Permanent droops: $R_p = 0.05$
PID regulators: $K_p = 1.163, K_i = 0.105, K_d = 0, T_d = 0.01 \text{ s}$

Hydraulic turbines: $\beta = 0, T_w = 2.67 \text{ s}$

Loads:
Loads: Load 1 = 7500 MW + 1500 MVAR, Load 2 = Load 3 = 25 MW, Load 4 = 250 MW
Transformers:
Nominal powers: $S_{B1} = 4200$ MVA, $S_{B2} = S_{B3} = 2100$ MVA
Winding connections: $D_1/Y_g$ connection
Winding parameters: $V_1 = 13.8$ kV, $V_2 = 500$ kV, $R_1 = R_2 = 0.002$, $L_1 = 0$, $L_2 = 0.12$
Magnetization resistances: $R_m = 500$
Magnetization reactances: $L_m = 500$

Transmission lines:
Number of phases: 3-Ph
Resistance per unit length: $R_1 = 0.02546$ $\Omega$/km, $R_0 = 0.3864$ $\Omega$/km
Inductance per unit length: $L_1 = 0.9337 \times 10^{-3}$ H/km, $L_0 = 4.1264 \times 10^{-3}$ H/km
Capacitance per unit length: $C_1 = 12.74 \times 10^{-9}$ F/km, $C_0 = 7.751 \times 10^{-9}$ F/km
Line lengths: $L_1 = 175$ km, $L_2 = 50$ km, $L_3 = 100$ km

SSSC:
Converter rating: $S_{nom} = 100$ MVA,
System nominal voltage: $V_{nom} = 500$ kV,
Frequency: $f = 60$ Hz,
Maximum rate of change of reference voltage ($V_{qref}$) = 3 pu/s
Converter impedances: $R = 0.00533$, $L = 0.16$
DC link nominal voltage: $V_{DC} = 40$ kV
DC link equivalent capacitance $C_{DC} = 375 \times 10^{-6}$ F
Injected Voltage regulator gains: $K_p = 0.00375$, $K_i = 0.1875$
DC Voltage regulator gains: $K_p = 0.1 \times 10^{-3}$, $K_i = 20 \times 10^{-3}$
Injected voltage magnitude limit: $V_q = \pm 0.2$
Appendix IV

Data of SMIB Power System with SSSC:
All data are in pu unless specified otherwise.

Generator:
Nominal power: \( S_B = 2100 \) MVA
Nominal voltage: \( V_B = 13.8 \) kV
Nominal frequency: \( f = 60 \) Hz
Reactances: \( X_d = 1.305, \ X'_d = 0.296, \ X''_d = 0.252, \ X_q = 0.474, \ X'_q = 0.243, \ X''_q = 0.18 \)
Time constants: \( T_d = 1.01 \) s, \( T'_d = 0.053 \) s, \( T''_q = 0.1 \) s
Stator resistance: \( R_S = 2.8544 \times 10^{-3} \)
Coefficient of inertia and pair of poles: \( H = 3.7 \) s, \( p = 32 \)

Excitation System:
Low-pass filter time constant: \( T_{LP} = 0.02 \) s
Regulator gain and time constant: \( K_A = 200, \ T_A = 0.001 \) s
Exciter gain and time constant: \( K_e = 1, \ T_e = 0 \)
Transient gain reduction: \( T_b = 0, \ T_c = 0 \)
Damping filter gain and time constant: \( K_f = 0.001, \ T_f = 0.1 \) s
Regulator output limits and gain: \( E_{f_{\text{min}}} = 0, \ E_{f_{\text{max}}} = 7, \ K_p = 0 \)

Hydraulic Turbine and Governor:
Servo-motor gain and time constant: \( K_a = 3.33, \ T_a = 0.07 \)
Gate opening limits: \( G_{\text{min}} = 0.01, \ G_{\text{max}} = 0.97518, \ V_{g_{\text{min}}} = -0.1 \) pu/s, \( V_{g_{\text{max}}} = 0.1 \) pu/s
Permanent droop: \( R_p = 0.05 \)
PID regulator: \( K_p = 1.163, \ K_i = 0.105, \ K_d = 0, \ T_d = 0.01 \) s
Hydraulic turbine: \( \beta = 0, \ T_w = 2.67 \) s

Transformer:
Nominal power: \( S_B = 2100 \) MVA
Winding connection: \( D_1/Y_g \) connection
Winding parameters: \( V_1 = 13.8 \text{ kV}, \ V_2 = 500 \text{ kV}, \ R_1 = R_2 = 0.002, \ L_1 = 0, \ L_2 = 0.12 \)
Magnetization resistance: \( R_m = 500 \)
Magnetization reactance: \( L_m = 500 \)

**Transmission line:**
Number of phases: 3-Ph
Resistance per unit length: \( R_1 = 0.02546 \Omega/\text{km}, \ R_0 = 0.3864 \Omega/\text{km} \)
Inductance per unit length: \( L_1 = 0.9337 \times 10^{-3} \text{H/km}, \ L_0 = 4.1264 \times 10^{-3} \text{H/km} \)
Capacitance per unit length: \( C_1 = 12.74 \times 10^{-9} \text{F/km}, \ C_0 = 7.751 \times 10^{-9} \text{F/km} \)
Line length = 300 km each

**Load at Bus2:**
250 MW (500 kV, 60 Hz, Y-grounded)

**Conventional Power System stabilizer Parameters:**
Gain \( K_{PS} = 30 \), Washout time constant \( T_W = 10 \text{ s} \), Lead-lag structure time constants: \( T_{1CP} = 0.05 \text{ s}, \ T_{2CP} = 0.02 \text{ s}, \ T_{3CP} = 3 \text{ s}, \ T_{4CP} = 5.4 \text{ s} \), Output limits of \( V_S = \pm 0.15 \)
Appendix V

Data of 3-Machine 6-Bus Power System:

Generators:
Nominal powers: $S_{B1} = 4200$ MVA, $S_{B2} = S_{B3} = 2100$ MVA
Nominal voltage: $V_B = 13.8$ kV
Nominal frequency: $f = 60$ Hz
Reactances: $X_d = 1.305$, $X'_d = 0.296$, $X''_d = 0.252$, $X_q = 0.474$, $X'q = 0.243$, $X''_q = 0.18$
Time constants: $T_d = 1.01$ s, $T'_d = 0.053$ s, $T''_{qo} = 0.1$ s
Stator resistance: $R_S = 2.8544 \times 10^{-3}$
Coefficient of inertia and pair of poles: $H = 3.7$ s, $p = 32$
Operating point: $P_1 = 6.068 \times 10^3$ MW, $P_2 = 6.4 \times 10^2$ MW, $P_3 = 4.4 \times 10^2$ MW

Excitation Systems:
Low-pass filter time constant: $T_{LP} = 0.02$ s
Regulator gains and time constants: $K_A = 200$, $T_A = 0.001$ s
Exciter gains and time constants: $K_e = 1$, $T_e = 0$
Transient gain reduction: $T_p = 0$, $T_c = 0$
Damping filter gains and time constants: $K_f = 0.001$, $T_f = 0.1$ s
Regulator output limits and gains: $E_{f_{min}} = 0$, $E_{f_{max}} = 7$, $K_p = 0$

Hydraulic Turbine and Governor:
Servo-motor gains and time constants: $K_a = 3.33$, $T_a = 0.07$
Gate opening limits: $G_{min} = 0.01$, $G_{max} = 0.97518$, $V_{g_{min}} = -0.1$ pu/s, $V_{g_{max}} = 0.1$ pu/s
Permanent droops: $R_p = 0.05$
PID regulators: $K_p = 1.163$, $K_i = 0.105$, $K_d = 0$, $T_d = 0.01$ s
Hydraulic turbines: $\beta = 0$, $T_w = 2.67$ s

Loads:
Load1 = $15000$ MW+$1500$ MVAR, Load2 = Load3 = $25$ MW, Load4 = $250$ MW
Transformers:
Nominal powers: \( S_{B1} = 4200 \text{ MVA}, \ S_{B2} = S_{B3} = 2100 \text{ MVA} \)
Winding connections: \( D_1/Y_g \) connection
Winding parameters: \( V_1 = 13.8 \text{ kV}, \ V_2 = 500 \text{ kV}, \ R_1 = R_2 = 0.002, \ L_1 = 0, \ L_2 = 0.12 \)
Magnetization resistances: \( R_m = 500 \)
Magnetization reactances: \( L_m = 500 \)

Transmission lines:
Number of phases: 3-Ph
Resistance per unit length: \( R_1 = 0.02546 \Omega/\text{km}, \ R_0 = 0.3864 \Omega/\text{km} \)
Inductance per unit length: \( L_1 = 0.9337 \times 10^{-3} \text{ H/km}, \ L_0 = 4.1264 \times 10^{-3} \text{ H/km} \)
Capacitance per unit length: \( C_1 = 12.74 \times 10^{-9} \text{ F/km}, \ C_0 = 7.751 \times 10^{-9} \text{ F/km} \)
Line lengths: \( L_1 = 175 \text{ km}, \ L_2 = 50 \text{ km}, \ L_3 = 100 \text{ km} \)

SSSC:
Converter rating: \( S_{nom} = 100 \text{ MVA} \).
System nominal voltage: \( V_{nom} = 500 \text{ kV} \).
Frequency: \( f = 60 \text{ Hz} \).
Maximum rate of change of reference voltage (\( V_{qref} \)) = 3 pu/s
Converter impedances: \( R = 0.00533, \ L = 0.16 \)
DC link nominal voltage: \( V_{DC} = 40 \text{ kV} \)
DC link equivalent capacitance \( C_{DC} = 375 \times 10^{-6} \text{ F} \)
Injected Voltage regulator gains: \( K_p = 0.00375, \ K_i = 0.1875 \)
DC Voltage regulator gains: \( K_p = 0.1 \times 10^{-3}, \ K_i = 20 \times 10^{-3} \)
Injected voltage magnitude limit: \( V_q = \pm 0.2 \)

Initial operating conditions:
Machine 1: \( P_e^1 = 3480.6 \text{ MW} \ (0.8287 \text{ pu}), \ Q_e^1 = 2577.2 \text{ MVAR} \ (0.6136 \text{ pu}) \),
Machine 2: \( P_e^2 = 1280 \text{ MW} \ (0.6095 \text{ pu}), \ Q_e^2 = 444.27 \text{ MVAR} \ (0.2116 \text{ pu}) \),
Machine 3: \( P_e^3 = 880 \text{ MW} \ (0.419 \text{ pu}), \ Q_e^3 = 256.33 \text{ MVAR} \ (0.1221 \text{ pu}) \)
Appendix VI

Data of SMIB Power System with SSSC:

System data: All data are in pu unless specified otherwise.

Generator:
Nominal power: $S_B = 2100$ MVA
Nominal voltage: $V_B = 13.8$ kV
Nominal frequency: $f = 60$ Hz

Reactances: $X_d = 1.305$, $X_d' = 0.296$, $X_d'' = 0.252$, $X_q = 0.474$, $X_q' = 0.243$, $X_q'' = 0.18$

Time constants: $T_d = 1.01$ s, $T_d' = 0.053$ s, $T_q = 0.1$ s

Stator resistance: $R_S = 2.8544 \times 10^{-3}$

Coefficient of inertia and pair of poles: $H = 3.7$ s, $p = 32$

Excitation System:
Low-pass filter time constant: $T_{LP} = 0.02$ s
Regulator gain and time constant: $K_A = 200$, $T_A = 0.001$ s
Exciter gain and time constant: $K_e = 1$, $T_e = 0$

Transducer output limits and gain: $E_{f_{min}} = 0$, $E_{f_{max}} = 7$, $K_p = 0$

Hydraulic Turbine and Governor:
Servo-motor gain and time constant: $K_a = 3.33$, $T_a = 0.07$

Gate opening limits: $G_{min} = 0.01$, $G_{max} = 0.97518$, $V_{g_{min}} = -0.1$ pu/s, $V_{g_{max}} = 0.1$ pu/s
Permanent droop: $R_p = 0.05$

PID regulator: $K_p = 1.163$, $K_i = 0.105$, $K_d = 0$, $T_d = 0.01$ s

Hydraulic turbine: $\beta = 0$, $T_w = 2.67$ s

Transformer:
Nominal power: $S_B = 2100$ MVA
Winding connection: $D_1/Y_g$ connection

Winding parameters: $V_1 = 13.8$ kV, $V_2 = 500$ kV, $R_1 = R_2 = 0.002$, $L_1 = 0$, $L_2 = 0.12$

Magnetization resistance: $R_m = 500$

Magnetization reactance: $L_m = 500$

Transmission line:

Number of phases: 3-Ph

Resistance per unit length: $R_1 = 0.02546$ Ω/km, $R_0 = 0.3864$ Ω/km

Inductance per unit length: $L_1 = 0.9337 \times 10^{-3}$ H/km, $L_0 = 4.1264 \times 10^{-3}$ H/km

Capacitance per unit length: $C_1 = 12.74 \times 10^{-9}$ F/km, $C_0 = 7.751 \times 10^{-9}$ F/km

Line length = 300 km each

Load:

Load at Bus1: $P_0 = 0.5 \times 2100$ MW, $Q_0 = 0.25 \times 2100$ MW, $T_{P1} = T_{P2} = T_{P3} = T_{P4} = 0$, $V_0 = 0.994$ (pu), Phase (degree) = -11.8

SSSC:

Converter rating: $S_{nom} = 100$ MVA

System nominal voltage: $V_{nom} = 500$ kV

Frequency: $f = 60$ Hz

Maximum rate of change of reference voltage ($V_{qref}$) = 3 pu/s

Converter impedances: $R = 0.00533$, $L = 0.16$

DC link nominal voltage: $V_{DC} = 40$ kV

DC link equivalent capacitance $C_{DC} = 375 \times 10^{-6}$ F

Injected Voltage regulator gains: $K_p = 0.00375$, $K_i = 0.1875$

DC Voltage regulator gains: $K_p = 0.1 \times 10^{-3}$, $K_i = 20 \times 10^{-3}$

Injected voltage magnitude limit: $V_q = \pm 0.2$
Appendix VII

Data of 3-Machine 6-Bus Power System:

Generators:
Nominal powers: \( S_{B1} = 4200 \text{ MVA}, \ S_{B2} = S_{B3} = 2100 \text{ MVA} \)
Nominal voltage: \( V_B = 13.8 \text{ kV} \)
Nominal frequency: \( f = 60 \text{ Hz} \)
Reactances: \( X_d = 1.305, \ X'_d = 0.296, \ X''_d = 0.252, \ X_q = 0.474, \ X'_q = 0.243, \ X''_q = 0.18 \)
Time constants: \( T_d = 1.01 \text{ s}, \ T'_d = 0.053 \text{ s}, \ T''_{qo} = 0.1 \text{ s} \)
Stator resistance: \( R_s = 2.8544 \times 10^{-3} \)
Coefficient of inertia and pair of poles: \( H = 3.7 \text{ s}, \ p = 32 \)
Operating point: \( P_1 = 6.068 \times 10^3 \text{ MW}, \ P_2 = 6.4 \times 10^2 \text{ MW}, \ P_3 = 4.4 \times 10^2 \text{ MW} \)

Excitation Systems:
Low-pass filter time constant: \( T_{LP} = 0.02 \text{ s} \)
Regulator gains and time constants: \( K_A = 200, \ T_A = 0.001 \text{ s} \)
Exciter gains and time constants: \( K_e = 1, \ T_e = 0 \)
Transient gain reduction: \( T_b = 0, \ T_c = 0 \)
Damping filter gains and time constants: \( K_f = 0.001, \ T_f = 0.1 \text{ s} \)
Regulator output limits and gains: \( E_{f_{\text{min}}} = 0, \ E_{f_{\text{max}}} = 7, \ K_p = 0 \)

Hydraulic Turbine and Governor:
Servo-motor gains and time constants: \( K_a = 3.33, \ T_a = 0.07 \)
Gate opening limits: \( G_{\text{min}} = 0.01, \ G_{\text{max}} = 0.97518, \ V_{g_{\text{min}}} = -0.1 \text{ pu/s}, \ V_{g_{\text{max}}} = 0.1 \text{ pu/s} \)
Permanent droops: \( R_p = 0.05 \)
PID regulators: \( K_p = 1.163, \ K_i = 0.105, \ K_d = 0, \ T_d = 0.01 \text{ s} \)
Hydraulic turbines: \( \beta = 0, \ T_w = 2.67 \text{ s} \)

Loads:
Load 1=7500 MW+1500 MVAR, Load 2=Load 3=25 MW, Load 4=250 MW,
Load 5= \( (P_0=0.5 \times 2100 \text{ MW}, \ Q_0=0.25 \times 2100 \text{ MVAR}, \ T_{P1}=T_{P2}=T_{P3}=T_{P4}=0, \ V_0=0.994 \text{ pu} \).
Transformers:
Nominal powers: $S_{B1} = 4200$ MVA, $S_{B2} = S_{B3} = 2100$ MVA
Winding connections: $D_1/Y_g$ connection
Winding parameters: $V_1 = 13.8$ kV, $V_2 = 500$ kV, $R_1 = R_2 = 0.002$, $L_1 = 0$, $L_2 = 0.12$
Magnetization resistances: $R_m = 500$
Magnetization reactances: $L_m = 500$

Transmission lines:
Number of phases: 3-Ph
Resistance per unit length: $R_1 = 0.02546$ Ω/km, $R_0 = 0.3864$ Ω/km
Inductance per unit length: $L_1 = 0.9337 \times 10^{-3}$ H/km, $L_0 = 4.1264 \times 10^{-3}$ H/km
Capacitance per unit length: $C_1 = 12.74 \times 10^{-9}$ F/km, $C_0 = 7.751 \times 10^{-9}$ F/km
Line lengths: $L_1 = 175$ km, $L_2 = 50$ km, $L_3 = 100$ km

SSSC:
Converter rating: $S_{nom} = 100$ MVA.
System nominal voltage: $V_{nom} = 500$ kV,
Frequency: $f = 60$ Hz,
Maximum rate of change of reference voltage ($V_{qref}$) = 3 pu/s
Converter impedances: $R = 0.00533$, $L = 0.16$
DC link nominal voltage: $V_{DC} = 40$ kV
DC link equivalent capacitance $C_{DC} = 375 \times 10^{-6}$ F
Injected Voltage regulator gains: $K_p = 0.00375$, $K_i = 0.1875$
DC Voltage regulator gains: $K_p = 0.1 \times 10^{-3}$, $K_i = 20 \times 10^{-3}$
Injected voltage magnitude limit: $V_q = \pm 0.2$