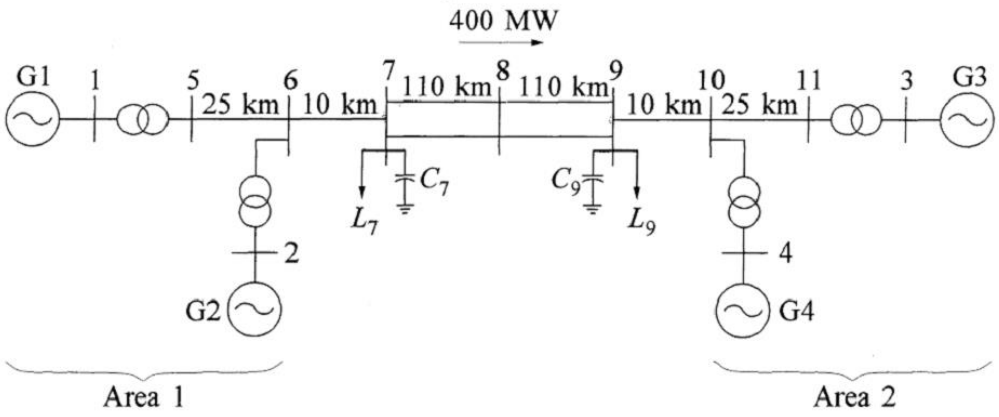
1 Two-area (11-bus) Power System Model



Generating units: Each rated at 900 MVA and 20kV. Generator parameters in per unit on the rated MVA and kV base are:

$X_d = 1.8$	$X_q = 1.7$	$X_l = 0.2$	$X'_d = 0.3$	$X'_q = 0.55$
$X''_d = 0.25$	$X''_q = 0.25$	$R_a = 0.0025$	$T'_{d0} = 8.0$ s	$T'_{q0} = 0.4$ s
$T''_{d0} = 0.03$ s	$T''_{q0} = 0.05$ s	$A_{Sat} = 0.015$	$B_{Sat} = 9.6$	$\Psi_{T1} = 0.9$
H = 6.5 (for G1 and G2)		H = 6.175 (for G3 and G4)		$K_D = 0$

Each step-up transformer has an impedance of 0+j0.15 per unit on the 900 MVA and 20/230 kV base and has an off-nominal tap ratio of 1.0.

The transmission system nominal voltage is 230 kV. The line lengths are shown in the figure. Parameters of the lines on a 100 MVA, 230 kV base are:

r = 0.0001 pu/km $x_l = 0.001$ pu/km $b_c = 0.00175$ pu/km

The system is operating with area 1 exporting 400 MW to area 2, and the generating units are loaded as follows:

G1:	P = 700 MW	Q = 185 Mvar	Et = 1.03 ∠ 20.2°
G2:	P = 700 W	Q = 235 Mvar	Et = 1.01 ∠ 10.5°
G3:	P = 719 MW	Q = 176 Mvar	Et = 1.03 ∠ -6.8°
G4:	P = 700 MW	Q = 202 Mvar	Et = 1.01 ∠-17.0°

The load and reactive power supplied (Q_c) by the shunt capacitors at busses 7 and 9 are as follows:

Bus 7:	$P_L = 967$ MW	$Q_L = 100$ Mvar	$Q_c = 200$ Mvar
Bus 9:	$P_L = 1{,}767$ MW	$Q_L = 100$ Mvar	$Q_c = 350$ Mvar

2 PSSE Load Flow Results

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PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     MON, SEP 19 2022   9:02
 IEEE BENCHMARK SYSTEM VII                                        RATING   %MVA FOR TRANSFORMERS
 HTTP://WWW.SEL.EESC.USP.BR/IEEE/                                  SET  1   % I  FOR NON-TRANSFORMER BRANCHES

 BUS      1     GEN G1      20.000 CKT     MW     MVAR     MVA    % 1.0300PU   20.07  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      1
  FROM GENERATION                        700.0   185.0R  724.0   80 20.600KV              MW     MVAR    1 LEFT           1 1
  TO       5     G1          230.00  1    700.0   185.0   724.0   80 1.0000UN             0.00   82.36    1 LEFT           1 1

 BUS      2     GEN G2      20.000 CKT     MW     MVAR     MVA    % 1.0100PU   10.31  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      2
  FROM GENERATION                        700.0   234.6R  738.3   82 20.200KV              MW     MVAR    1 LEFT           1 1
  TO       6     G2          230.00  1    700.0   234.6   738.3   82 1.0000UN             0.00   89.05    1 LEFT           1 1

 BUS      3     GEN G3      20.000 CKT     MW     MVAR     MVA    % 1.0300PU   -7.00  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      3
  FROM GENERATION                        719.1   176.0R  740.3   82 20.600KV              MW     MVAR    2 RIGHT          1 1
  TO      11     G3          230.00  1    719.1   176.0   740.3   82 1.0000UN             0.00   86.10    2 RIGHT          1 1

 BUS      4     GEN G4      20.000 CKT     MW     MVAR     MVA    % 1.0100PU  -17.19  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      4
  FROM GENERATION                        700.0   202.1R  728.6   81 20.200KV              MW     MVAR    2 RIGHT          1 1
  TO      10     G4          230.00  1    700.0   202.1   728.6   81 1.0000UN             0.00   86.73    2 RIGHT          1 1

 BUS      5     G1          230.00 CKT     MW     MVAR     MVA    % 1.0065PU   13.61  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      5
                                                                    231.49KV              MW     MVAR    1 LEFT           1 1
  TO       1     GEN G1      20.000  1   -700.0  -102.6   707.5   79 1.0000LK             0.00   82.36    1 LEFT           1 1
  TO       6     G2          230.00  1    350.0    51.3   353.7   47                     6.18   61.82    1 LEFT           1 1
  TO       6     G2          230.00  2    350.0    51.3   353.7   47                     6.18   61.82    1 LEFT           1 1

 BUS      6     G2          230.00 CKT     MW     MVAR     MVA    % 0.9781PU    3.52  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      6
                                                                    224.97KV              MW     MVAR    1 LEFT           1 1
  TO       2     GEN G2      20.000  1   -700.0  -145.6   715.0   79 1.0000LK             0.00   89.05    1 LEFT           1 1
  TO       5     G1          230.00  1   -343.8     8.3   343.9   47                     6.18   61.82    1 LEFT           1 1
  TO       5     G1          230.00  2   -343.8     8.3   343.9   47                     6.18   61.82    1 LEFT           1 1
  TO       7     LOAD A      230.00  1    462.5    42.9   464.5   68                     6.77   67.67    1 LEFT           1 1
  TO       7     LOAD A      230.00  2    462.5    42.9   464.5   68                     6.77   67.67    1 LEFT           1 1
  TO       7     LOAD A      230.00  3    462.5    42.9   464.5   68                     6.77   67.67    1 LEFT           1 1

 BUS      7     LOAD A      230.00 CKT     MW     MVAR     MVA    % 0.9610PU   -4.89  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      7
                                                                    221.03KV              MW     MVAR    1 LEFT           1 1
  TO LOAD-PQ                             967.0   100.0   972.2
  TO SHUNT                                 0.0  -184.7   184.7
  TO       6     G2          230.00  1   -455.8    24.2   456.4   68                     6.77   67.67    1 LEFT           1 1
  TO       6     G2          230.00  2   -455.8    24.2   456.4   68                     6.77   67.67    1 LEFT           1 1
  TO       6     G2          230.00  3   -455.8    24.2   456.4   68                     6.77   67.67    1 LEFT           1 1
  TO       8     MID POINT   230.00  1    200.2     6.1   200.3   52                     4.80   47.99    1 LEFT           1 1
  TO       8     MID POINT   230.00  2    200.2     6.1   200.3   52                     4.80   47.99    1 LEFT           1 1

 BUS      8     MID POINT   230.00 CKT     MW     MVAR     MVA    % 0.9486PU  -18.76  X--- LOSSES ---X X---- AREA -----X X---- ZONE -----X      8
                                                                    218.18KV              MW     MVAR    1 LEFT           1 1
  TO       7     LOAD A      230.00  1   -195.4    24.3   196.9   52                     4.80   47.99    1 LEFT           1 1
  TO       7     LOAD A      230.00  2   -195.4    24.3   196.9   52                     4.80   47.99    1 LEFT           1 1
  TO       9     LOAD B      230.00  1    195.4   -24.3   196.9   52                     4.70   46.96    2 RIGHT          1 1
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TO	9	LOAD B	230.00	2	195.4	-24.3	196.9	52				4.70	46.96	2 RIGHT		1 1		
BUS	9	LOAD B	230.00	CKT	MW	MVAR	MVA	%	0.9714PU	-32.35	X--- LOSSES ---X			X---- AREA -----X	X---- ZONE -----X		9	
									223.42KV		MW	MVAR	2 RIGHT		1 1			
TO	LOAD-PQ				1767.0	100.0	1769.8											
TO	SHUNT				0.0	-330.2	330.2											
TO	8	MID POINT	230.00	1	-190.7	53.6	198.1	51				4.70	46.96	1 LEFT		1 1		
TO	8	MID POINT	230.00	2	-190.7	53.6	198.1	51				4.70	46.96	1 LEFT		1 1		
TO	10	G4	230.00	1	-461.9	41.1	463.7	68				6.84	68.37	2 RIGHT		1 1		
TO	10	G4	230.00	2	-461.9	41.1	463.7	68				6.84	68.37	2 RIGHT		1 1		
TO	10	G4	230.00	3	-461.9	41.1	463.7	68				6.84	68.37	2 RIGHT		1 1		
BUS	10	G4	230.00	CKT	MW	MVAR	MVA	%	0.9835PU	-23.94	X--- LOSSES ---X			X---- AREA -----X	X---- ZONE -----X		10	
									226.20KV		MW	MVAR	2 RIGHT		1 1			
TO	4	GEN G4	20.000	1	-700.0	-115.4	709.4	79	1.0000LK			0.00	86.73	2 RIGHT		1 1		
TO	9	LOAD B	230.00	1	468.7	26.8	469.5	68				6.84	68.37	2 RIGHT		1 1		
TO	9	LOAD B	230.00	2	468.7	26.8	469.5	68				6.84	68.37	2 RIGHT		1 1		
TO	9	LOAD B	230.00	3	468.7	26.8	469.5	68				6.84	68.37	2 RIGHT		1 1		
TO	11	G3	230.00	1	-353.1	17.5	353.5	48				6.46	64.63	2 RIGHT		1 1		
TO	11	G3	230.00	2	-353.1	17.5	353.5	48				6.46	64.63	2 RIGHT		1 1		
BUS	11	G3	230.00	CKT	MW	MVAR	MVA	%	1.0083PU	-13.63	X--- LOSSES ---X			X---- AREA -----X	X---- ZONE -----X		11	
									231.90KV		MW	MVAR	2 RIGHT		1 1			
TO	3	GEN G3	20.000	1	-719.1	-89.9	724.7	81	1.0000LK			0.00	86.10	2 RIGHT		1 1		
TO	10	G4	230.00	1	359.5	45.0	362.4	48				6.46	64.63	2 RIGHT		1 1		
TO	10	G4	230.00	2	359.5	45.0	362.4	48				6.46	64.63	2 RIGHT		1 1		