Sharif University Of Technology

Power System Analysis

Project

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Part 1

Based on our student numbers, we have:

$$a_1 = \frac{1}{2}(2+6) = 4 \quad a_2 = \frac{1}{2}(7+7) = 7 \quad a_3 = \frac{1}{2}(2+8) = 5 \quad a_4 = \frac{1}{2}(1+0) = 0.5$$

So, the values for bus data are as follows:

Bus Number	Bus Type	Schedules Voltage	Pgen	Qgenmin	Qgenmax	Pload	Qload
1	Slack	1.00		-100	100	0	0
2	PV	1.045	50	-100	100	0	0
3	PV	1.045	60	-100	100	0	0
4	PQ		0			70	50
5	PQ		0			70	35
6	PQ		0			70	45

The simulation is as follows: Consequently, the demands of the problem are as follows:

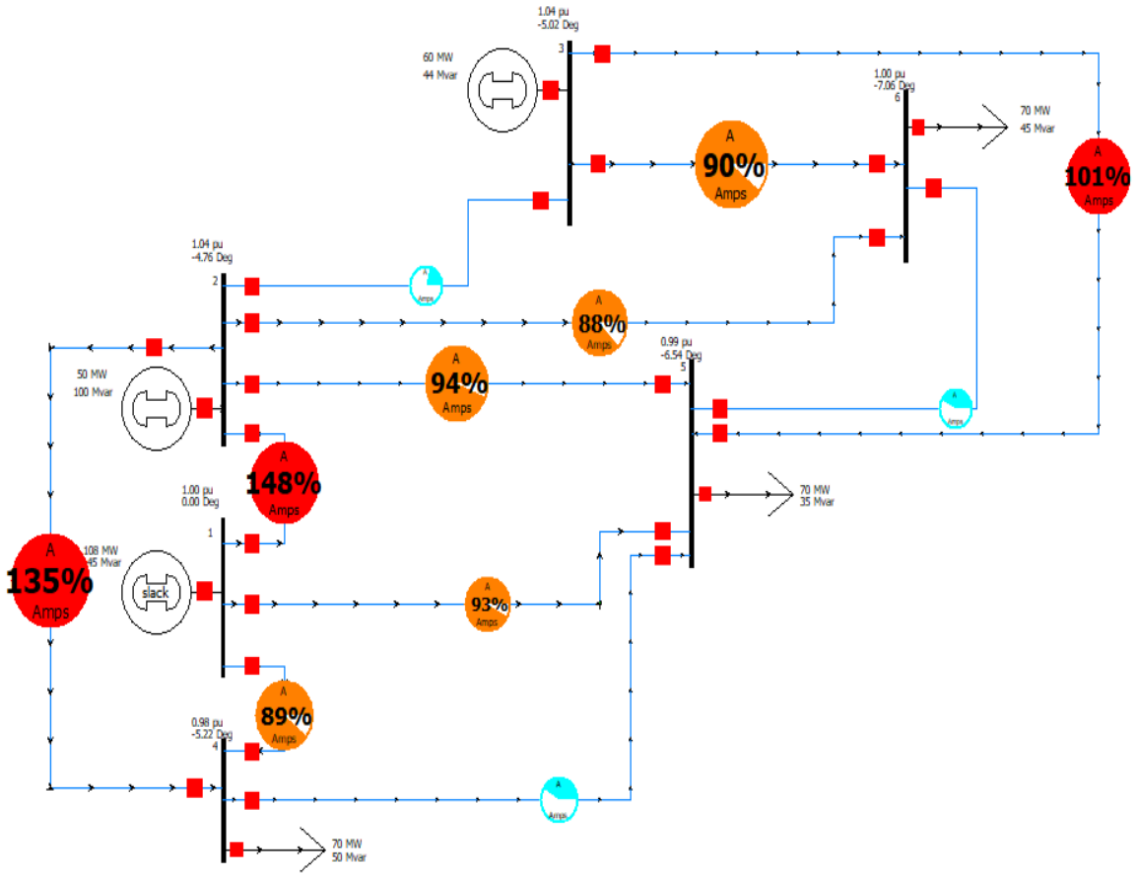

Figure 1: simulation

As shown in the above results, none of the constraints are violated!

Table 1: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-45	0	1000	1.0	-100	100
2	Closed	50	100	0	1000	1.04	-100	100
3	Closed	60	44	0	1000	1.04	-100	100

	Number ▲	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04417	240.159	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98322	226.140	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98852	227.359	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00326	230.750	0.95	1.05	0.90	1.10

Figure 2: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	Violated Normal	Limit Used CTG	% of Limit Used CTG	Violated CTG	MVA or Amps?
1	1	1	2	2	1	YES	Default	44.4	30.0	148.0	YES	30.0	148.0	YES	MVA
2	1	1	4	4	1	YES	Default	44.6	50.0	89.2	NO	50.0	89.2	NO	MVA
3	1	1	5	5	1	YES	Default	37.1	40.0	92.8	NO	40.0	92.8	NO	MVA
4	2	2	3	3	1	YES	Default	4.4	20.0	21.8	NO	20.0	21.8	NO	MVA
5	2	2	4	4	1	YES	Default	56.5	40.0	141.3	YES	40.0	141.3	YES	MVA
6	2	2	5	5	1	YES	Default	21.3	20.0	106.6	YES	20.0	106.6	YES	MVA
7	2	2	6	6	1	YES	Default	28.6	30.0	95.2	NO	30.0	95.2	NO	MVA
8	3	3	5	5	1	YES	Default	23.2	20.0	116.1	YES	20.0	116.1	YES	MVA
9	3	3	6	6	1	YES	Default	56.1	60.0	93.5	NO	60.0	93.5	NO	MVA
10	4	4	5	5	1	YES	Default	8.1	20.0	40.7	NO	20.0	40.7	NO	MVA
11	5	5	6	6	1	YES	Default	8.3	20.0	41.4	NO	20.0	41.4	NO	MVA

Figure 3: lines

Part 2

In this section, we simulate the power flow for each of the 11 possible modes for the lines to leave the network and report 3 related tables and the violation of the limits.

• **Removal of the transmission line connecting between bus 1 and 2:**

Simulation:

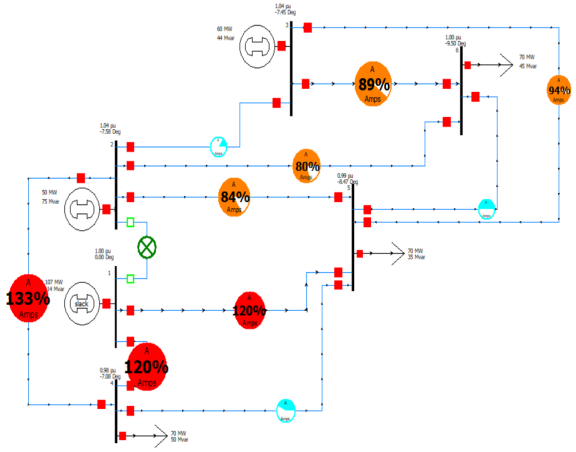

Figure 4: simulation

Table 2: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	107	-14	0	1000	1.0	-100	100
2	Closed	50	75	0	1000	1.04	-100	100
3	Closed	60	44	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	6	6	1	YES	Default	1.00364	230.838	0.95	1.05	0.90	1.10
2	5	5	1	YES	Default	0.98884	227.432	0.95	1.05	0.90	1.10
3	4	4	1	YES	Default	0.98491	226.529	0.95	1.05	0.90	1.10
4	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
5	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
6	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10

Figure 5: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	Violated Normal	Limit Used CTG	% of Limit Used CTG	Violated CTG	MVA or Amps?
1	1	1	2	2	1	YES	Default	0.0	50.0	0.0	NO	50.0	0.0	NO	MVA
2	1	1	4	4	1	YES	Default	60.0	50.0	120.0	YES	50.0	120.0	YES	MVA
3	1	1	5	5	1	YES	Default	47.9	40.0	119.6	YES	40.0	119.6	YES	MVA
4	2	2	3	3	1	YES	Default	3.6	20.0	18.0	NO	20.0	18.0	NO	MVA
5	2	2	4	4	1	YES	Default	55.7	40.0	139.4	YES	40.0	139.4	YES	MVA
6	2	2	5	5	1	YES	Default	19.9	20.0	99.4	NO	20.0	99.4	NO	MVA
7	2	2	6	6	1	YES	Default	26.8	30.0	89.4	NO	30.0	89.4	NO	MVA
8	3	3	5	5	1	YES	Default	22.2	20.0	111.1	YES	20.0	111.1	YES	MVA
9	3	3	6	6	1	YES	Default	56.0	60.0	93.4	NO	60.0	93.4	NO	MVA
10	4	4	5	5	1	YES	Default	8.2	20.0	41.1	NO	20.0	41.1	NO	MVA
11	5	5	6	6	1	YES	Default	9.9	20.0	49.5	NO	20.0	49.5	NO	MVA

Figure 6: lines

• **Removal of the transmission line connecting between bus 1 and 4:**
Simulation:

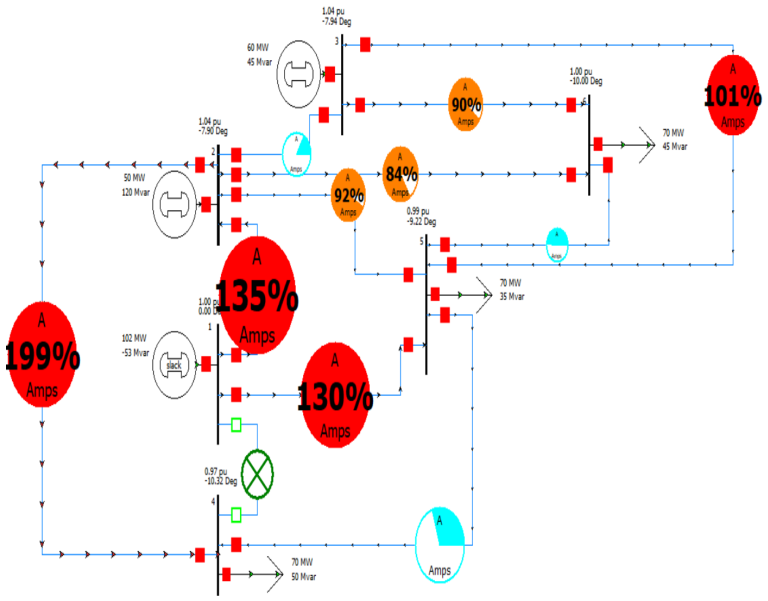

Figure 7: simulation

Table 3: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	102	-53	0	1000	1.0	-100	100
2	Closed	50	120	0	1000	1.04	-100	100
3	Closed	60	45	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.96595	222.169	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98634	226.859	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00315	230.724	0.95	1.05	0.90	1.10

Figure 8: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	67.5	50.0	135.0	MVA
2	1	1	4	4	1	YES	Default	0.0	50.0	0.0	MVA
3	1	1	5	5	1	YES	Default	52.0	40.0	130.0	MVA
4	2	2	3	3	1	YES	Default	3.3	20.0	16.7	MVA
5	2	2	4	4	1	YES	Default	83.2	40.0	208.1	MVA
6	2	2	5	5	1	YES	Default	21.2	20.0	106.1	MVA
7	2	2	6	6	1	YES	Default	27.9	30.0	92.9	MVA
8	3	3	5	5	1	YES	Default	23.4	20.0	117.0	MVA
9	3	3	6	6	1	YES	Default	56.4	60.0	94.0	MVA
10	5	5	4	4	1	YES	Default	8.1	20.0	40.4	MVA
11	5	5	6	6	1	YES	Default	9.5	20.0	47.5	MVA

Figure 9: lines

• **Removal of the transmission line connecting between bus 1 and 5:**
Simulation:

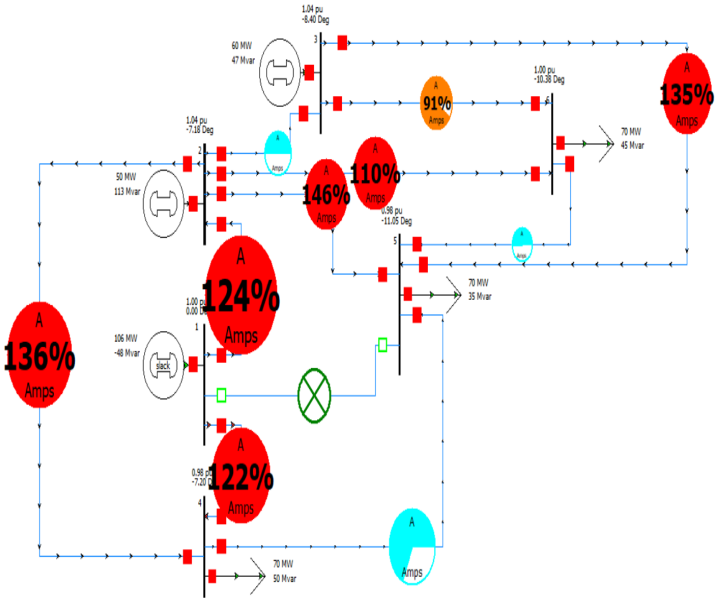

Figure 10: simulation

Table 4: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	106	-48	0	1000	1.0	-100	100
2	Closed	50	113	0	1000	1.04	-100	100
3	Closed	60	47	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98330	226.159	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.97931	225.242	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00142	230.327	0.95	1.05	0.90	1.10

Figure 11: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	62.0	50.0	124.1	MVA
2	1	1	4	4	1	YES	Default	61.1	50.0	122.1	MVA
	1	1	5	5	1	YES	Default	0.0	40.0	0.0	MVA
4	2	2	3	3	1	YES	Default	10.3	20.0	51.3	MVA
5	2	2	4	4	1	YES	Default	56.7	40.0	141.7	MVA
6	2	2	5	5	1	YES	Default	30.4	20.0	152.1	MVA
7	2	2	6	6	1	YES	Default	34.8	30.0	115.9	MVA
8	3	3	5	5	1	YES	Default	28.8	20.0	144.1	MVA
9	3	3	6	6	1	YES	Default	56.8	60.0	94.7	MVA
10	5	5	4	4	1	YES	Default	16.3	20.0	81.7	MVA
11	5	5	6	6	1	YES	Default	9.9	20.0	49.7	MVA

Figure 12: lines

• **Removal of the transmission line connecting between bus 2 and 3:**
Simulation:

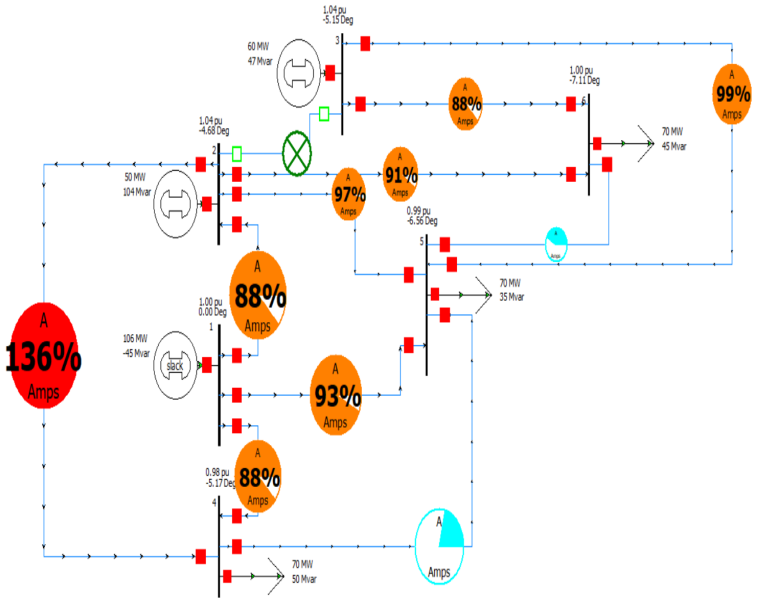

Figure 13: simulation

Table 5: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	106	-45	0	1000	1.0	-100	100
2	Closed	50	104	0	1000	1.04	-100	100
3	Closed	60	47	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98371	226.254	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98883	227.432	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00344	230.791	0.95	1.05	0.90	1.10

Figure 14: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	44.0	50.0	88.0	MVA
2	1	1	4	4	1	YES	Default	44.2	50.0	88.4	MVA
3	1	1	5	5	1	YES	Default	37.2	40.0	93.1	MVA
4	2	2	3	3	1	YES	Default	0.0	20.0	0.0	MVA
5	2	2	4	4	1	YES	Default	57.0	40.0	142.4	MVA
6	2	2	5	5	1	YES	Default	21.7	20.0	108.6	MVA
7	2	2	6	6	1	YES	Default	29.5	30.0	98.5	MVA
8	3	3	5	5	1	YES	Default	22.9	20.0	114.5	MVA
9	3	3	6	6	1	YES	Default	55.0	60.0	91.7	MVA
10	5	5	4	4	1	YES	Default	8.3	20.0	41.7	MVA
11	5	5	6	6	1	YES	Default	8.3	20.0	41.7	MVA

Figure 15: lines

• **Removal of the transmission line connecting between bus 2 and 4:**

Simulation:

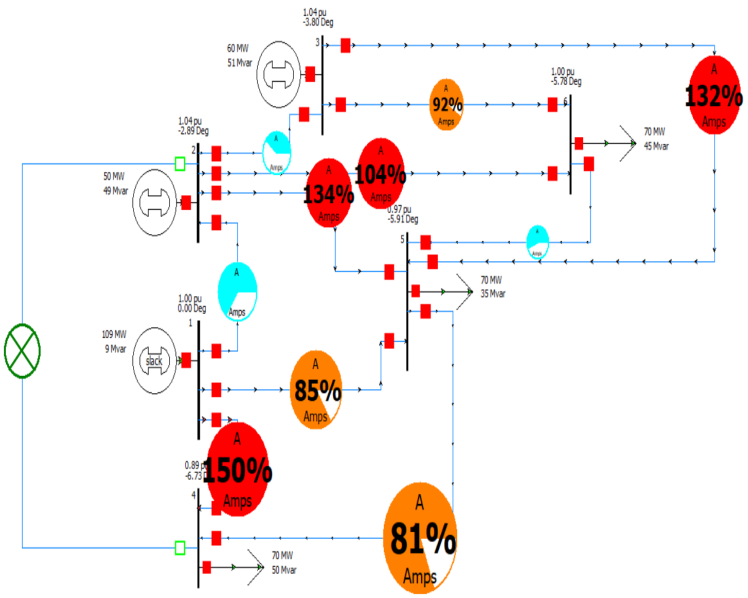

Figure 16: simulation

Table 6: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	109	9	0	1000	1.0	-100	100
2	Closed	50	49	0	1000	1.04	-100	100
3	Closed	60	51	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.88880	204.425	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.97406	224.034	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00055	230.128	0.95	1.05	0.90	1.10

Figure 17: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	32.4	50.0	64.9	MVA
2	1	1	4	4	1	YES	Default	75.0	50.0	150.0	MVA
3	1	1	5	5	1	YES	Default	33.8	40.0	84.5	MVA
4	2	2	3	3	1	YES	Default	8.1	20.0	40.5	MVA
5	2	2	4	4	1	YES	Default	0.0	40.0	0.0	MVA
6	2	2	5	5	1	YES	Default	28.4	20.0	141.9	MVA
7	2	2	6	6	1	YES	Default	33.1	30.0	110.3	MVA
8	3	3	5	5	1	YES	Default	28.7	20.0	143.5	MVA
9	3	3	6	6	1	YES	Default	57.4	60.0	95.7	MVA
10	5	5	4	4	1	YES	Default	19.8	20.0	99.0	MVA
11	5	5	6	6	1	YES	Default	10.9	20.0	54.3	MVA

Figure 18: lines

As can be seen, the voltage magnitude of bus 4 is equal to 0.8888 pu which violates the lower voltage limit.

- **Removal of the transmission line connecting between bus 2 and 5:**

Simulation:

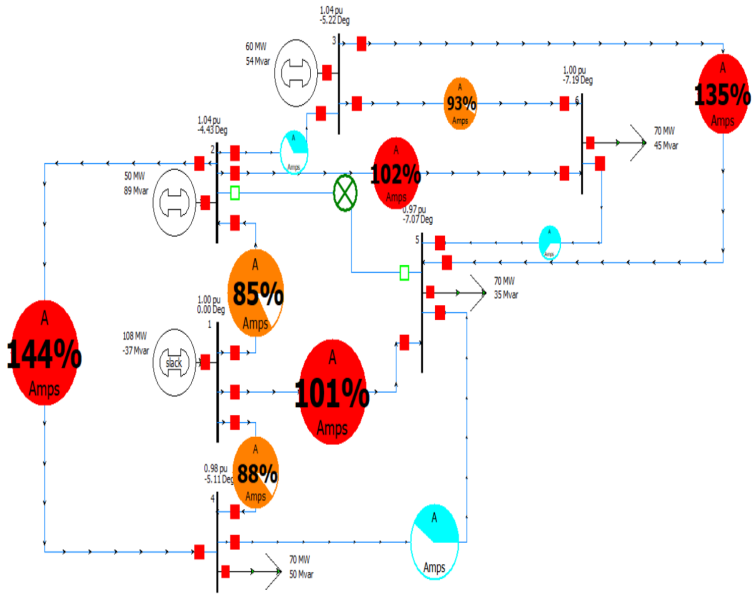

Figure 19: simulation

Table 7: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-37	0	1000	1.0	-100	100
2	Closed	50	89	0	1000	1.04	-100	100
3	Closed	60	54	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98070	225.562	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.96928	222.933	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	0.99970	229.930	0.95	1.05	0.90	1.10

Figure 20: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	42.3	50.0	84.6	MVA
2	1	1	4	4	1	YES	Default	43.8	50.0	87.6	MVA
3	1	1	5	5	1	YES	Default	40.3	40.0	100.8	MVA
4	2	2	3	3	1	YES	Default	7.3	20.0	36.3	MVA
5	2	2	4	4	1	YES	Default	60.3	40.0	150.6	MVA
6	2	2	5	5	1	YES	Default	0.0	20.0	0.0	MVA
7	2	2	6	6	1	YES	Default	32.6	30.0	108.6	MVA
8	3	3	5	5	1	YES	Default	29.5	20.0	147.5	MVA
9	3	3	6	6	1	YES	Default	58.1	60.0	96.8	MVA
10	5	5	4	4	1	YES	Default	9.1	20.0	45.3	MVA
11	5	5	6	6	1	YES	Default	12.1	20.0	60.5	MVA

Figure 21: lines

• **Removal of the transmission line connecting between bus 2 and 6:**
Simulation:

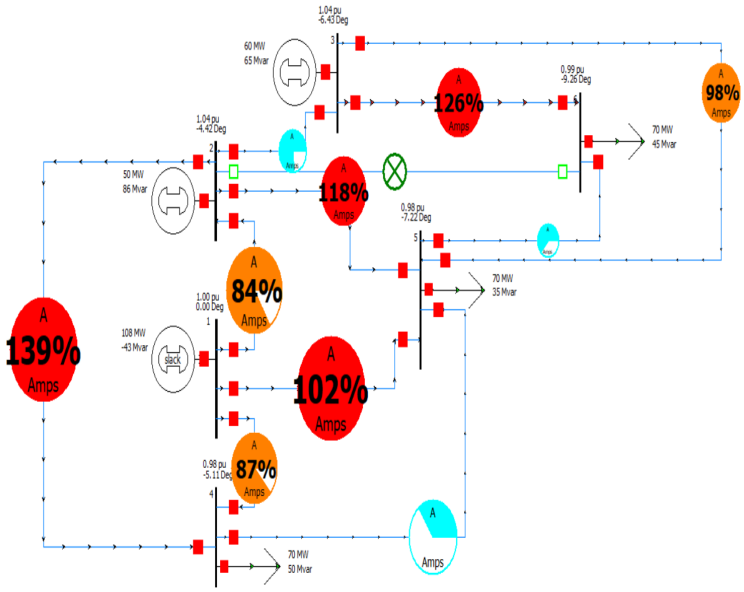

Figure 22: simulation

Table 8: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-43	0	1000	1.0	-100	100
2	Closed	50	86	0	1000	1.04	-100	100
3	Closed	60	65	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98295	226.078	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98447	226.428	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	0.98580	226.734	0.95	1.05	0.90	1.10

Figure 23: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	42.2	50.0	84.4	MVA
2	1	1	4	4	1	YES	Default	43.7	50.0	87.5	MVA
3	1	1	5	5	1	YES	Default	40.9	40.0	102.3	MVA
4	2	2	3	3	1	YES	Default	16.0	20.0	79.8	MVA
5	2	2	4	4	1	YES	Default	58.3	40.0	145.7	MVA
6	2	2	5	5	1	YES	Default	25.4	20.0	127.1	MVA
7	2	2	6	6	1	YES	Default	0.0	30.0	0.0	MVA
8	3	3	5	5	1	YES	Default	23.3	20.0	116.6	MVA
9	3	3	6	6	1	YES	Default	78.8	60.0	131.3	MVA
10	5	5	4	4	1	YES	Default	10.4	20.0	51.8	MVA
11	5	5	6	6	1	YES	Default	12.2	20.0	60.9	MVA

Figure 24: lines

- **Removal of the transmission line connecting between bus 3 and 5:**

Simulation:

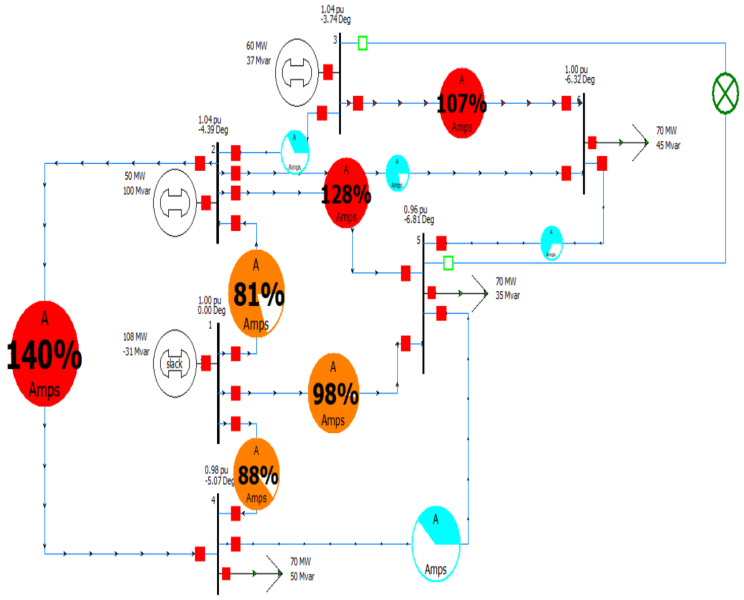

Figure 25: simulation

Table 9: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-31	0	1000	1.0	-100	100
2	Closed	50	100	0	1000	1.04	-100	100
3	Closed	60	37	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.03862	238.883	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.97624	224.536	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.96480	221.903	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	0.99785	229.506	0.95	1.05	0.90	1.10

Figure 26: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	40.5	50.0	81.0	MVA
2	1	1	4	4	1	YES	Default	43.8	50.0	87.7	MVA
3	1	1	5	5	1	YES	Default	39.1	40.0	97.7	MVA
4	2	2	3	3	1	YES	Default	7.1	20.0	35.5	MVA
5	2	2	4	4	1	YES	Default	58.2	40.0	145.4	MVA
6	2	2	5	5	1	YES	Default	27.2	20.0	136.0	MVA
7	2	2	6	6	1	YES	Default	26.4	30.0	88.1	MVA
8	3	3	5	5	1	YES	Default	0.0	20.0	0.0	MVA
9	3	3	6	6	1	YES	Default	66.8	60.0	111.4	MVA
10	5	5	4	4	1	YES	Default	8.1	20.0	40.7	MVA
11	5	5	6	6	1	YES	Default	12.8	20.0	64.2	MVA

Figure 27: lines

• **Removal of the transmission line connecting between bus 3 and 6:**

Simulation:

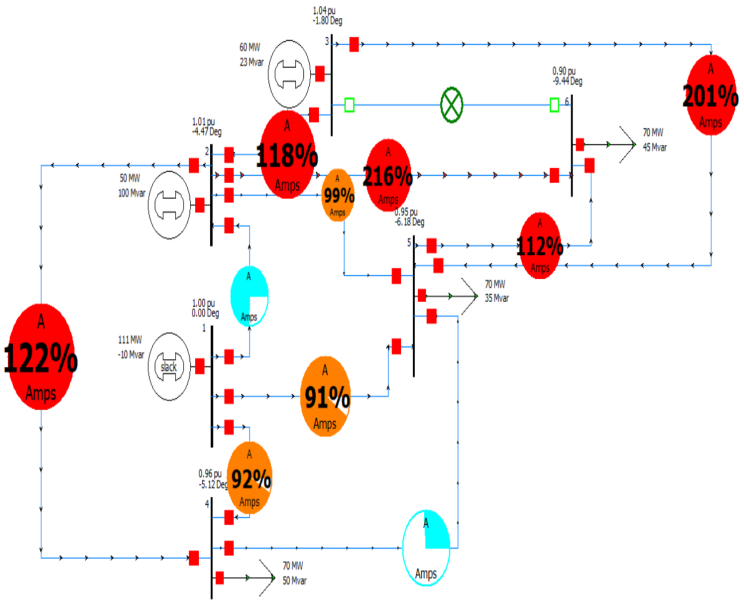

Figure 28: simulation

Table 10: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	111	-10	0	1000	1.0	-100	100
2	Closed	50	100	0	1000	1.04	-100	100
3	Closed	60	23	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.01455	233.348	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.96045	220.903	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.95423	219.472	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	0.90136	207.314	0.95	1.05	0.90	1.10

Figure 29: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	36.9	50.0	73.8	MVA
2	1	1	4	4	1	YES	Default	46.2	50.0	92.4	MVA
3	1	1	5	5	1	YES	Default	36.5	40.0	91.2	MVA
4	2	2	3	3	1	YES	Default	23.8	20.0	119.2	MVA
5	2	2	4	4	1	YES	Default	49.3	40.0	123.3	MVA
6	2	2	5	5	1	YES	Default	21.6	20.0	107.8	MVA
7	2	2	6	6	1	YES	Default	65.7	30.0	219.0	MVA
8	3	3	5	5	1	YES	Default	42.1	20.0	210.5	MVA
9	3	3	6	6	1	YES	Default	0.0	60.0	0.0	MVA
10	5	5	4	4	1	YES	Default	5.8	20.0	28.8	MVA
11	5	5	6	6	1	YES	Default	22.4	20.0	112.2	MVA

Figure 30: lines

As can be seen, the voltage magnitude of bus 6 is equal to 0.90136 pu which violates the lower voltage limit.

• **Removal of the transmission line connecting between bus 4 and 5:**
Simulation:

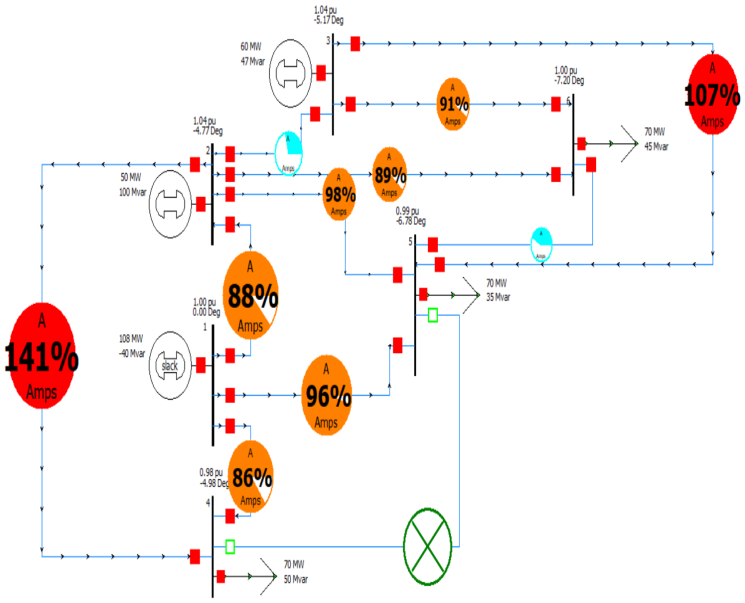

Figure 31: simulation

Table 11: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-40	0	1000	1.0	-100	100
2	Closed	50	100	0	1000	1.04	-100	100
3	Closed	60	47	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04135	239.511	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.97746	224.816	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98585	226.745	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00193	230.443	0.95	1.05	0.90	1.10

Figure 32: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	43.8	50.0	87.6	MVA
2	1	1	4	4	1	YES	Default	43.0	50.0	86.0	MVA
3	1	1	5	5	1	YES	Default	38.4	40.0	96.1	MVA
4	2	2	3	3	1	YES	Default	5.9	20.0	29.7	MVA
5	2	2	4	4	1	YES	Default	58.7	40.0	146.7	MVA
6	2	2	5	5	1	YES	Default	21.8	20.0	109.0	MVA
7	2	2	6	6	1	YES	Default	28.7	30.0	95.7	MVA
8	3	3	5	5	1	YES	Default	24.2	20.0	120.9	MVA
9	3	3	6	6	1	YES	Default	56.9	60.0	94.9	MVA
10	5	5	4	4	1	YES	Default	0.0	20.0	0.0	MVA
11	5	5	6	6	1	YES	Default	8.4	20.0	42.0	MVA

Figure 33: lines

- **Removal of the transmission line connecting between bus 5 and 6:**

Simulation:

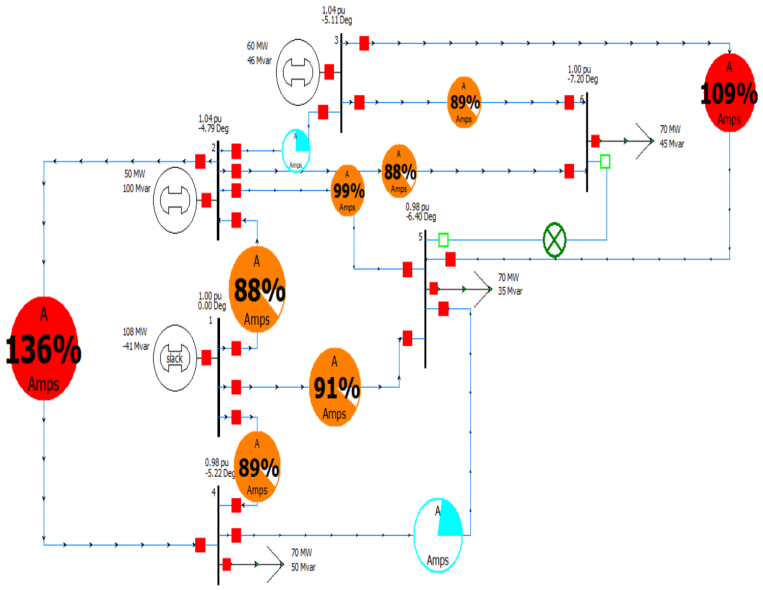

Figure 34: simulation

Table 12: generators

Number of Bus	Status	Gen MW	Gen Mvar	Min MW	Max MW	Set Volt	Min Mvar	Max Mvar
1	Closed	108	-41	0	1000	1.0	-100	100
2	Closed	50	100	0	1000	1.04	-100	100
3	Closed	60	46	0	1000	1.04	-100	100

	Number	Name	Area Name	Monitor	Limit Group	PU Volt	Volt (kV)	Limit Low PU Volt	Limit High PU Volt	Contingency Limit Low PU Volt	Contingency Limit High PU Volt
1	1	1	1	YES	Default	1.00000	230.000	0.95	1.05	0.90	1.10
2	2	2	1	YES	Default	1.04279	239.842	0.95	1.05	0.90	1.10
3	3	3	1	YES	Default	1.04500	240.350	0.95	1.05	0.90	1.10
4	4	4	1	YES	Default	0.98137	225.716	0.95	1.05	0.90	1.10
5	5	5	1	YES	Default	0.98153	225.753	0.95	1.05	0.90	1.10
6	6	6	1	YES	Default	1.00412	230.949	0.95	1.05	0.90	1.10

Figure 35: buses

	From Number	From Name	To Number	To Name	Circuit	Monitor	Limit Group	Limiting Flow Used	Limit Used	% of Limit Used	MVA or Amps?
1	1	1	2	2	1	YES	Default	44.2	50.0	88.5	MVA
2	1	1	4	4	1	YES	Default	44.7	50.0	89.5	MVA
3	1	1	5	5	1	YES	Default	36.4	40.0	90.9	MVA
4	2	2	3	3	1	YES	Default	5.1	20.0	25.5	MVA
5	2	2	4	4	1	YES	Default	56.8	40.0	142.1	MVA
6	2	2	5	5	1	YES	Default	22.4	20.0	112.0	MVA
7	2	2	6	6	1	YES	Default	28.4	30.0	94.8	MVA
8	3	3	5	5	1	YES	Default	24.9	20.0	124.4	MVA
9	3	3	6	6	1	YES	Default	56.0	60.0	93.4	MVA
10	5	5	4	4	1	YES	Default	7.1	20.0	35.3	MVA
11	5	5	6	6	1	YES	Default	0.0	20.0	0.0	MVA

Figure 36: lines