EE 456: PSSE Project Report
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Introduction

For our power project, we worked on the Eagle power system that is included in chapter 4 of the Power Systems Analysis Textbook. We used the introduction to PSSE instructions provided to us in order to set up the Eagle Power System. This includes 17 buses, branches to connect all of the buses, assigning the buses as Swing bus, Load bus and Generator buses. We then moved on to performing load flow analysis for 3 different tasks. The first one being a normal condition load flow, second one by adding a 40 MW load to the system and increasing the loads of all the other buses by 40% and then running a load flow analysis for that. The third task was performing different contingencies, N-1 contingency consisted of eliminating the branch between bus 5 and bus 11 and then N-2 contingency included the OWL generator outage.

Task 1

Task 1 for this project required the group to go to the Eagle Power system that is in the textbook set up on PSSE, for this we first calculated the values for R and X in pu instead of ohms as shown in the table in figure 1 below. We went on to fill up details about the load, buses as well as the branches that show the connections between different buses, generators and transformers.

From	To	R (Ω)	X (Ω)	Base MVA	V Base	BMVA	Z base	R (pu)	X (pu)	B (pu)
1	9	3.085	17.47	100	161	3.629	259.21	0.01190	0.06740	0.03629
1	11	4.718	26.7	100	161	5.55	259.21	0.01820	0.10301	0.05550
1	14	3.629	20.53	100	161	4.264	259.21	0.01400	0.07920	0.04264
2	11	2.774	15.66	100	161	3.251	259.21	0.01070	0.06041	0.03251
2	12	2.618	14.78	100	161	3.07	259.21	0.01010	0.05702	0.03070
2	14	3.085	17.47	100	161	3.629	259.21	0.01190	0.06740	0.03629
3	6	3.551	20.09	100	161	4.174	259.21	0.01370	0.07750	0.04174
3	12	3.551	20.09	100	161	4.174	259.21	0.01370	0.07750	0.04174
3	15	3.033	17.16	100	161	3.569	259.21	0.01170	0.06620	0.03569
4	5	1.529	6.3	100	161	1.232	259.21	0.00590	0.02430	0.01232
4	9	2.411	13.69	100	161	2.843	259.21	0.00930	0.05281	0.02843
5	6	1.97	8.09	100	161	1.584	259.21	0.00760	0.03121	0.01584
5	7	1.089	4.48	100	161	0.88	259.21	0.00420	0.01728	0.00880
5	8	1.996	8.17	100	161	1.599	259.21	0.00770	0.03152	0.01599
7	15	1.866	10.63	100	161	2.208	259.21	0.00720	0.04101	0.02208
8	12	1.27	7.13	100	161	1.482	259.21	0.00490	0.02751	0.01482
5	11	2.514	14.18	100	161	2.949	259.21	0.00970	0.05470	0.02949
10	13	3.033	10.15	100	69	0.408	47.61	0.06371	0.21319	0.00408
10	17	3.433	11.49	100	69	0.462	47.61	0.07211	0.24134	0.00462
13	16	4.642	15.54	100	69	0.624	47.61	0.09750	0.15540	5.0000

Figure 1 - Tabular Information : R(pu) and X(pu) Calculations

Bus Number	Section Number	Substation Number	Bus Name	Base kV	Area Num	Area Name	Zone Num	Zone Name	Owner Num	Owner Name	Code	Voltage (pu)	Angle (deg)
1			OWL	161.0	1		2	URBAN	1	EAGLE	3	1.0000	0.00
2			SWIFT	161.0	1		2	URBAN	1	EAGLE	-2	1.0439	14.91
3			PARROT	161.0	1		2	URBAN	1	EAGLE	-2	1.0453	17.36
4			LARK	161.0	1		1	RURAL	1	EAGLE	1	0.9821	5.69
5			JAY	161.0	1		1	RURAL	1	EAGLE	1	0.9896	7.79
6			RAVEN	161.0	1		1	RURAL	1	EAGLE	1	0.9982	9.65
7			WREN	161.0	1		1	RURAL	1	EAGLE	1	0.9899	8.32
8			ROBIN	161.0	1		1	RURAL	1	EAGLE	1	0.9998	9.31
9			SISKIN	161.0	1		2	URBAN	1	EAGLE	1	0.9835	2.94
10			JUNCO	69.0	1		2	URBAN	1	EAGLE	1	0.9294	2.30
11			QUAIL	161.0	1		2	URBAN	1	EAGLE	1	1.0005	7.89
12		1	HERON	161.0	1		2	URBAN	1	EAGLE	1	1.0226	13.09
13			EGRET	69.0	1		2	URBAN	1	EAGLE	1	0.9299	3.81
14			GULL	161.0	1		2	URBAN	1	EAGLE	1	1.0107	7.53
15			CROW	161.0	1		2	URBAN	1	EAGLE	1	0.9998	10.51
16			CROW 69	69.0	1		2	URBAN	1	EAGLE	1	0.9852	7.27
17			SISKIN 69	69.0	1		2	URBAN	1	EAGLE	1	0.9658	2.52

Figure 2 - Bus Data (Task 1)

Bus Number	Bus Name	Id	Term Node Num	Term Node Name	Code	Area Num	Area Name	Zone Num	Zone Name	Owner Num	Owner Name	In Service	Scalable	Interruptible	Pload (MW)	Qload (Mvar)
4 LARK 161.00		1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	60.0000	10.0000
5 JAY 161.00		1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	100.0000	30.0000
6 RAVEN 161.00		1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	80.0000	15.0000
7 WREN 161.00		1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	90.0000	20.0000
8 ROBIN 161.00		1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	40.0000	5.0000
9 SISKIN 161.00		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	10.0000	5.0000
10 JUNCO 69.000		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	15.0000	10.0000
11 QUAIL 161.00		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	75.0000	15.0000
12 HERON 161.00		1	5	STATION_1_1_5	1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	40.0000	15.0000
13 EGRET 69.000		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	30.0000	10.0000
14 GULL 161.00		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	35.0000	10.0000
15 CROW 161.00		1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	10.0000	0.0000
												☑	☑ Yes	☐ Yes		

Figure 3 - Load Data (Task 1)

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Name	Term Node Num (From)	Term Node Name (From)	Term Node Num (To)	Term Node Name (To)	Line R (pu)	Line X (pu)	Charging B (pu)
1	OWL 161.00	9	SISKIN 161.00	1						0.011900	0.067400	0.036290
1	OWL 161.00	11	QUAIL 161.00	1						0.018200	0.103010	0.055500
1	OWL 161.00	14	GULL 161.00	1						0.014000	0.079200	0.042640
2	SWIFT 161.00	11	QUAIL 161.00	1						0.010700	0.060410	0.032510
2	SWIFT 161.00	12	HERON 161.00	1				2	STATION_1_1_2	0.010100	0.057020	0.030700
2	SWIFT 161.00	14	GULL 161.00	1						0.011900	0.067400	0.036290
3	PARROT 161.00	6	RAVEN 161.00	1						0.013700	0.077500	0.041740
3	PARROT 161.00	12	HERON 161.00	1				3	STATION_1_1_3	0.013700	0.077500	0.041740
3	PARROT 161.00	15	CROW 161.00	1						0.011700	0.066200	0.035690
4	LARK 161.00	5	JAY 161.00	1						0.005900	0.024300	0.012320
4	LARK 161.00	9	SISKIN 161.00	1						0.009300	0.052810	0.028430
5	JAY 161.00	6	RAVEN 161.00	1						0.007600	0.031210	0.015840
5	JAY 161.00	7	WREN 161.00	1						0.004200	0.017280	0.008800
5	JAY 161.00	8	ROBIN 161.00	1						0.007700	0.031520	0.015990
5	JAY 161.00	11	QUAIL 161.00	1						0.007200	0.041010	0.022080
7	WREN 161.00	15	CROW 161.00	1						0.004900	0.027510	0.014820
8	ROBIN 161.00	12	HERON 161.00	1				4	STATION_1_1_4	0.009700	0.054700	0.029490
10	JUNCO 69.000	13	EGRET 69.000	1						0.063710	0.213190	0.004080
10	JUNCO 69.000	17	SISKIN 69 69.000	1						0.072110	0.241340	0.004620
13	EGRET 69.000	16	CROW 69 69.000	1						0.097500	0.155400	0.006240

Figure 4 - Branch Data (Task 1)

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Name	Term Node	Term Node Name (From)	Term Node Num (To)	Term Node Name (To)	In Service
9	SISKIN 161.00	17	SISKIN 69 69.000	T1	TRANS1					☑
15	CROW 161.00	16	CROW 69 69.000	T2	TRANS2					☑
										☑

Figure 5 - Transformer Data (Task 1)

Task 2

Design Exercise D10.1-Phase I Power Flow Study-Case 3

       For this part of the project we added a new load of 40 MW called Steel Mill load. With that the base loads were also increased by 30%, with this change we ended up getting voltages outside the regulatory limits. This led us to change the connections in a way that our Steel Mill load which was at bus 18 to be connected to the two generators as well as the 161 kV sides of the two transformers in our model, bus 9 and 15. To be precise we were getting a result of less 0.96 for bus 10 and 13 and our goal was to increase that which we accomplished by doing the above changes. By having the steel mill connect bus 9 and 15 to the generators in bus 2 and 3, we were able to get the voltage in bus 10 and 13 to get above 0.96 pu.

%MVA FOR TRANSFORMERS
% I FOR NON-TRANSFORMER BRANCHES

BUS#-SCT	X-- NAME --X	BASKV	AREA ZONE	VOLT PU/KV	ANGLE	GEN MW/MVAR	LOAD MW/MVAR	SHUNT MW/MVAR	BUS#-SCT	X-- NAME --X	BASKV	AREA	CKT	MW	MVAR	RATIO	ANGLE	% SET
1	OWL	161.00	1	1.0000	0.0	-127.1	0.0	0.0										
			2	161.00		-50.0L	0.0	-0.0	9	SISKIN	161.00	1	1	-100.1	-28.2			
									11	QUAIL	161.00	1	1	-1.8	-9.8			
									14	GULL	161.00	1	1	-25.3	-11.9			
2	SWIFT	161.00	1	1.0317	3.6	490.0	0.0	0.0										
			2	166.10		100.0L	0.0	-0.0	11	QUAIL	161.00	1	1	110.7	23.1			
									12	HERON	161.00	1	1	64.3	11.6			
									14	GULL	161.00	1	1	71.5	17.9			
									18	STEEL MILL	161.00	1	1	243.5	47.4			
3	PARROT	161.00	1	1.0317	3.6	490.0	0.0	0.0										
			2	166.10		100.0L	0.0	-0.0	6	RAVEN	161.00	1	1	95.7	18.0			
									12	HERON	161.00	1	1	47.3	7.6			
									15	CROW	161.00	1	1	0.0	-1.9			
									18	STEEL MILL	161.00	1	1	347.0	76.3			
4	LARK	161.00	1	1.0107	0.3	0.0	78.0	0.0										
			1	162.73		0.0	10.0	-0.0	5	JAY	161.00	1	1	37.9	7.9			
									9	SISKIN	161.00	1	1	-115.9	-17.9			
5	JAY	161.00	1	1.0065	-0.2	0.0	130.0	0.0										
			1	162.04		0.0	30.0	-0.0	4	LARK	161.00	1	1	-37.8	-8.8			
									6	RAVEN	161.00	1	1	9.5	-2.0			
									7	WREN	161.00	1	1	-85.0	-11.6			
									8	ROBIN	161.00	1	1	-6.6	-5.6			
									11	QUAIL	161.00	1	1	-10.1	-2.1			
6	RAVEN	161.00	1	1.0061	-0.4	0.0	104.0	0.0										
			1	161.99		0.0	15.0	-0.0	3	PARROT	161.00	1	1	-94.5	-15.4			
									5	JAY	161.00	1	1	-9.5	0.4			
7	WREN	161.00	1	1.0120	0.6	0.0	117.0	0.0										
			1	162.94		0.0	20.0	-0.0	5	JAY	161.00	1	1	85.3	11.9			
									15	CROW	161.00	1	1	-202.3	-31.9			
8	ROBIN	161.00	1	1.0085	-0.1	0.0	52.0	0.0										
			1	162.37		0.0	5.0	-0.0	5	JAY	161.00	1	1	6.6	4.0			
									12	HERON	161.00	1	1	-58.6	-9.0			
9	SISKIN	161.00	1	1.0317	3.6	0.0	13.0	0.0										
			2	166.10		0.0	5.0	-0.0	1	OWL	161.00	1	1	101.3	31.7			
									4	LARK	161.00	1	1	117.2	22.1			
									17	SISKIN 69	69.000	1	T1	24.4	12.8	1.000LK		
									18	STEEL MILL	161.00	1	1	-255.9	-71.5			
10	JUNCO	69.000	1	0.9709	-1.1	0.0	19.5	0.0										
			2	66.996		0.0	10.0	-0.0	13	EGRET	69.000	1	1	4.4	0.5			
									17	SISKIN 69	69.000	1	1	-23.9	-10.5			
11	QUAIL	161.00	1	1.0076	0.0	0.0	97.5	0.0										
			2	162.22		0.0	15.0	-0.0	1	OWL	161.00	1	1	1.8	4.3			
									2	SWIFT	161.00	1	1	-109.4	-19.2			
									5	JAY	161.00	1	1	10.1	-0.1			
12	HERON	161.00	1	1.0186	1.6	0.0	52.0	0.0										
			2	164.00		0.0	15.0	-0.0	2	SWIFT	161.00	1	1	-63.9	-12.6			
									3	PARROT	161.00	1	1	-47.0	-10.2			
									8	ROBIN	161.00	1	1	58.9	7.8			
13	EGRET	69.000	1	0.9665	-1.7	0.0	39.0	0.0										
			2	66.688		0.0	10.0	-0.0	10	JUNCO	69.000	1	1	-4.4	-0.9			
									16	CROW 69	69.000	1	1	-34.6	-9.1			
14	GULL	161.00	1	1.0115	1.1	0.0	45.5	0.0										
			2	162.85		0.0	10.0	-0.0	1	OWL	161.00	1	1	25.4	8.2			
									2	SWIFT	161.00	1	1	-70.9	-18.2			
15	CROW	161.00	1	1.0317	3.6	0.0	13.0	0.0										
			2	166.10		0.0	0.0	-0.0	3	PARROT	161.00	1	1	0.0	-1.9			
									7	WREN	161.00	1	1	204.3	41.6			
									16	CROW 69	69.000	1	T2	35.9	12.4	1.000LK		
									18	STEEL MILL	161.00	1	1	-253.2	-52.2			
16	CROW 69	69.000	1	1.0167	1.0	0.0	0.0	0.0										
			2	70.150		0.0	0.0	-0.0	13	EGRET	69.000	1	1	35.9	10.6			
									15	CROW	161.00	1	T2	-35.9	-10.6	1.000UN		
17	SISKIN 69	69.000	1	1.0157	1.8	0.0	0.0	0.0										
			2	70.082		0.0	0.0	-0.0	9	SISKIN	161.00	1	T1	-24.4	-11.8	1.000UN		
									10	JUNCO	69.000	1	1	24.4	11.8			
18	STEEL MILL	161.00	1	1.0317	3.6	0.0	81.3	0.0										
			2	166.10		0.0	0.0	-0.0	2	SWIFT	161.00	1	1	-243.5	-47.4			
									3	PARROT	161.00	1	1	-347.0	-76.3			
									9	SISKIN	161.00	1	1	255.9	71.5			
									15	CROW	161.00	1	1	253.2	52.2			

Figure 6 - Load Flow for Task 2

Bus Number	Section Number	Substation Number	Bus Name	Base kV	Area Num	Area Name	Zone Num	Zone Name	Owner Num	Owner Name	Code	Voltage (pu)	Angle (deg)
1			OWL	161.0	1		2	URBAN	1	EAGLE	3	1.0000	0.00
2			SWIFT	161.0	1		2	URBAN	1	EAGLE	-2	1.0317	3.57
3			PARROT	161.0	1		2	URBAN	1	EAGLE	-2	1.0317	3.57
4			LARK	161.0	1		1	RURAL	1	EAGLE	1	1.0107	0.29
5			JAY	161.0	1		1	RURAL	1	EAGLE	1	1.0065	-0.20
6			RAVEN	161.0	1		1	RURAL	1	EAGLE	1	1.0061	-0.37
7			WREN	161.0	1		1	RURAL	1	EAGLE	1	1.0120	0.60
8			ROBIN	161.0	1		1	RURAL	1	EAGLE	1	1.0085	-0.10
9			SISKIN	161.0	1		2	URBAN	1	EAGLE	1	1.0317	3.57
10			JUNCO	69.0	1		2	URBAN	1	EAGLE	1	0.9709	-1.13
11			QUAIL	161.0	1		2	URBAN	1	EAGLE	1	1.0076	0.03
12		1	HERON	161.0	1		2	URBAN	1	EAGLE	1	1.0186	1.65
13			EGRET	69.0	1		2	URBAN	1	EAGLE	1	0.9665	-1.68
14			GULL	161.0	1		2	URBAN	1	EAGLE	1	1.0115	1.06
15			CROW	161.0	1		2	URBAN	1	EAGLE	1	1.0317	3.57
16			CROW 69	69.0	1		2	URBAN	1	EAGLE	1	1.0167	0.96
17			SISKIN 69	69.0	1		2	URBAN	1	EAGLE	1	1.0157	1.79
18			STEEL MILL	161.0	1		2	URBAN	1	EAGLE	1	1.0317	3.57

Figure 7 - Bus Data (Task 2)

Bus Number	Bus Name	Id	Term Node Num	Term Node Name	Area Num	Area Name	Zone Num	Zone Name	Code	VSched (pu)	Regulated Bus Number	In Service	PGen (MW)	PMax (MW)	PMin (MW)	QGen (Mvar)	QMax (Mvar)	QMin (Mvar)
1	OWL 161.00	1					2	URBAN	3	1.0000	1	☑	-127.1364	9999.0000	-9999.0000	-49.9639	250.0000	100.0000
2	SWIFT 161.00	1					2	URBAN	-2	1.0000	2	☑	490.0000	9999.0000	-9999.0000	100.0000	250.0000	100.0000
3	PARROT 161.00	1					2	URBAN	-2	1.0000	3	☑	490.0000	9999.0000	-9999.0000	100.0000	250.0000	100.0000

Figure 8 - Generator Data (Task 2)

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Name	Term Node Num (From)	Term Node Name (From)	Term Node Num (To)	Term Node Name (To)	Line R (pu)	Line X (pu)	Charging B (pu)
1	OWL 161.00	9	SISKIN 161.00	1						0.011900	0.067400	0.036290
1	OWL 161.00	11	QUAIL 161.00	1						0.018200	0.103010	0.055500
1	OWL 161.00	14	GULL 161.00	1						0.014000	0.079200	0.042640
2	SWIFT 161.00	11	QUAIL 161.00	1						0.010700	0.060410	0.032510
2	SWIFT 161.00	12	HERON 161.00	1				2	STATION_1_1_2	0.010100	0.057020	0.030700
2	SWIFT 161.00	14	GULL 161.00	1						0.011900	0.067400	0.036290
2	SWIFT 161.00	18	STEEL MILL 161.00	1						0.000000	0.000100	0.000000
3	PARROT 161.00	6	RAVEN 161.00	1						0.013700	0.077500	0.041740
3	PARROT 161.00	12	HERON 161.00	1				3	STATION_1_1_3	0.013700	0.077500	0.041740
3	PARROT 161.00	15	CROW 161.00	1						0.011700	0.066200	0.035690
3	PARROT 161.00	18	STEEL MILL 161.00	1						0.000000	0.000100	0.000000
4	LARK 161.00	5	JAY 161.00	1						0.005900	0.024300	0.012320
4	LARK 161.00	9	SISKIN 161.00	1						0.009300	0.052810	0.028430
5	JAY 161.00	6	RAVEN 161.00	1						0.007600	0.031210	0.015840
5	JAY 161.00	7	WREN 161.00	1						0.004200	0.017280	0.008800
5	JAY 161.00	8	ROBIN 161.00	1						0.007700	0.031520	0.015990
5	JAY 161.00	11	QUAIL 161.00	1						0.007200	0.041010	0.022080
7	WREN 161.00	15	CROW 161.00	1						0.004900	0.027510	0.014820
8	ROBIN 161.00	12	HERON 161.00	1				4	STATION_1_1_4	0.009700	0.054700	0.029490
9	SISKIN 161.00	18	STEEL MILL 161.00	1						0.000000	0.000100	0.000000
10	JUNCO 69.000	13	EGRET 69.000	1						0.063710	0.213190	0.004080
10	JUNCO 69.000	17	SISKIN 69 69.000	1						0.072110	0.241340	0.004620
13	EGRET 69.000	16	CROW 69 69.000	1						0.097500	0.155400	0.006240
15	CROW 161.00	18	STEEL MILL 161.00	1						0.000000	0.000100	0.000000

Figure 9 - Branch Data (Task 2)

Bus Number	Bus Name	Id	Term Node Num	Term Node Name	Code	Area Num	Area Name	Zone Num	Zone Name	Owner Num	Owner Name	In Service	Scalable	Interruptible	Pload (MW)	Qload (Mvar)
4	LARK 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	78.0000	10.0000
5	JAY 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	130.0000	30.0000
6	RAVEN 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	104.0000	15.0000
7	WREN 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	117.0000	20.0000
8	ROBIN 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	52.0000	5.0000
9	SISKIN 161.00	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	13.0000	5.0000
10	JUNCO 69.000	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	19.5000	10.0000
11	QUAIL 161.00	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	97.5000	15.0000
12	HERON 161.00	1	5	STATION_1_1_5	1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	52.0000	15.0000
13	EGRET 69.000	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	39.0000	10.0000
14	GULL 161.00	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	45.5000	10.0000
15	CROW 161.00	1			1	1		2	URBAN	1	EAGLE	☑	☑ Yes	☐ Yes	13.0000	0.0000
18	STEEL MILL 161.00	1			1	1		1	RURAL	1	EAGLE	☑	☑ Yes	☐ Yes	40.0000	0.0000

Figure 10- Load Data (Task 2)

Task 3

For this task we performed two contingencies, N-1 and N-2 both with increase in the loads by 30%. For N-1 contingency we removed the line 5-11 to resolve the power flow.Then with the same conditions we also had to consider the OWL generator outage We then were required to figure out which bus had the most change in voltage magnitude and which line had the most change in MW line flow between both N-1 and N-2 contingency.

Comparing the two N-1 and N-2 contingencies to identify the voltage magnitude and the MW line flow that changes the most, we find that bus 13 changes its voltage magnitude the most and line 2-18 has the highest MW line flow. In bus 13, the voltage in pu changes from 0.9652 to 0.9320 giving it a total change of 0.0332. In line 2-18, the MW line flow changes from 250.9 to 181.5 giving it a total change of 69.4 MW.

```
                                                                     %MVA FOR TRANSFORMERS
                                                                     % I  FOR NON-TRANSFORMER BRANCHES

X--------- FROM BUS -------X AREA  VOLT          GEN    LOAD   SHUNT  X----------- TO BUS -----------X                    TRANSFORMER      RATING
 BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE MW/MVAR MW/MVAR MW/MVAR  BUS#-SCT X-- NAME --X BASKV AREA CKT      MW     MVAR    RATIO  ANGLE   %  SET

     1     OWL        161.00   1 1.0000   0.0 -127.1    0.0    0.0 --------------------------------------------------------------------------
                             2 161.00          -47.4L   0.0   -0.0      9      SISKIN     161.00   1 1    -98.1   -26.8
                                                                       11      QUAIL      161.00   1 1     -4.7    -9.3
                                                                       14      GULL       161.00   1 1    -24.4   -11.3
     2     SWIFT      161.00   1 1.0305   3.5  490.0    0.0    0.0 --------------------------------------------------------------------------
                             2 165.90          100.0L   0.0   -0.0     11      QUAIL      161.00   1 1    103.3    21.8
                                                                       12      HERON      161.00   1 1     65.3    12.0
                                                                       14      GULL       161.00   1 1     70.5    17.1
                                                                       18      STEEL MILL 161.00   1 1    250.9    49.1
     3     PARROT     161.00   1 1.0305   3.5  490.0    0.0    0.0 --------------------------------------------------------------------------
                             2 165.90          100.0L   0.0   -0.0      6      RAVEN      161.00   1 1     97.5    18.7
                                                                       12      HERON      161.00   1 1     48.0     7.8
                                                                       15      CROW       161.00   1 1      0.0    -1.9
                                                                       18      STEEL MILL 161.00   1 1    344.4    75.3
     4     LARK       161.00   1 1.0088   0.2    0.0   78.0    0.0 --------------------------------------------------------------------------
                             1 162.42            0.0   10.0   -0.0      5      JAY        161.00   1 1     40.4     8.5
                                                                        9      SISKIN     161.00   1 1   -118.4   -18.5
     5     JAY        161.00   1 1.0043  -0.4    0.0  130.0    0.0 --------------------------------------------------------------------------
                             1 161.70            0.0   30.0   -0.0      4      LARK       161.00   1 1    -40.3    -9.3
                                                                        6      RAVEN      161.00   1 1      7.8    -2.4
                                                                        7      WREN       161.00   1 1    -89.2   -12.4
                                                                        8      ROBIN      161.00   1 1     -8.2    -5.9
     6     RAVEN      161.00   1 1.0042  -0.5    0.0  104.0    0.0 --------------------------------------------------------------------------
                             1 161.68            0.0   15.0   -0.0      3      PARROT     161.00   1 1    -96.2   -15.8
                                                                        5      JAY        161.00   1 1     -7.8     0.8
     7     WREN       161.00   1 1.0102   0.5    0.0  117.0    0.0 --------------------------------------------------------------------------
                             1 162.65            0.0   20.0   -0.0      5      JAY        161.00   1 1     89.6    12.9
                                                                       15      CROW       161.00   1 1   -206.6   -32.9
     8     ROBIN      161.00   1 1.0066  -0.2    0.0   52.0    0.0 --------------------------------------------------------------------------
                             1 162.06            0.0    5.0   -0.0      5      JAY        161.00   1 1      8.2     4.3
                                                                       12      HERON      161.00   1 1    -60.2    -9.3
     9     SISKIN     161.00   1 1.0305   3.5    0.0   13.0    0.0 --------------------------------------------------------------------------
                             2 165.90            0.0    5.0   -0.0      1      OWL        161.00   1 1     99.3    30.0
                                                                        4      LARK       161.00   1 1    119.7    23.0
                                                                       17      SISKIN 69  69.000   1 T1    24.4    12.8  1.000LK
                                                                       18      STEEL MILL 161.00   1 1   -256.4   -70.7


    10     JUNCO      69.000   1 0.9696  -1.2    0.0   19.5    0.0 --------------------------------------------------------------------------
                             2 66.904            0.0   10.0   -0.0     13      EGRET      69.000   1 1      4.4     0.5
                                                                       17      SISKIN 69  69.000   1 1    -23.9   -10.5
    11     QUAIL      161.00   1 1.0076   0.2    0.0   97.5    0.0 --------------------------------------------------------------------------
                             2 162.22            0.0   15.0   -0.0      1      OWL        161.00   1 1      4.7     3.8
                                                                        2      SWIFT      161.00   1 1   -102.2   -18.8
    12     HERON      161.00   1 1.0171   1.6    0.0   52.0    0.0 --------------------------------------------------------------------------
                             2 163.75            0.0   15.0   -0.0      2      SWIFT      161.00   1 1    -64.9   -12.8
                                                                        3      PARROT     161.00   1 1    -47.7   -10.4
                                                                        8      ROBIN      161.00   1 1     60.6     8.3
    13     EGRET      69.000   1 0.9652  -1.8    0.0   39.0    0.0 --------------------------------------------------------------------------
                             2 66.596            0.0   10.0   -0.0     10      JUNCO      69.000   1 1     -4.4    -0.9
                                                                       16      CROW 69    69.000   1 1    -34.6    -9.1
    14     GULL       161.00   1 1.0108   1.0    0.0   45.5    0.0 --------------------------------------------------------------------------
                             2 162.74            0.0   10.0   -0.0      1      OWL        161.00   1 1     24.4     7.5
                                                                        2      SWIFT      161.00   1 1    -70.0   -17.5
    15     CROW       161.00   1 1.0305   3.5    0.0   13.0    0.0 --------------------------------------------------------------------------
                             2 165.90            0.0    0.0   -0.0      3      PARROT     161.00   1 1      0.0    -1.9
                                                                        7      WREN       161.00   1 1    208.7    43.1
                                                                       16      CROW 69    69.000   1 T2    35.9    12.5  1.000LK
                                                                       18      STEEL MILL 161.00   1 1   -257.6   -53.7
    16     CROW 69    69.000   1 1.0154   0.9    0.0    0.0    0.0 --------------------------------------------------------------------------
                             2 70.063            0.0    0.0   -0.0     13      EGRET      69.000   1 1     35.9    10.6
                                                                       15      CROW       161.00   1 T2   -35.9   -10.6  1.000UN
    17     SISKIN 69  69.000   1 1.0144   1.7    0.0    0.0    0.0 --------------------------------------------------------------------------
                             2 69.995            0.0    0.0   -0.0      9      SISKIN     161.00   1 T1   -24.4   -11.8  1.000UN
                                                                       10      JUNCO      69.000   1 1     24.4    11.8
    18     STEEL MILL 161.00   1 1.0305   3.5    0.0   81.2    0.0 --------------------------------------------------------------------------
                             2 165.90            0.0    0.0   -0.0      2      SWIFT      161.00   1 1   -250.9   -49.1
                                                                        3      PARROT     161.00   1 1   -344.4   -75.3
                                                                        9      SISKIN     161.00   1 1    256.4    70.7
                                                                       15      CROW       161.00   1 1    257.6    53.7
```

Figure 11 - Load Flow for N-1 contingency (Task 3)

```
                                                                %MVA FOR TRANSFORMERS
                                                                %  I  FOR NON-TRANSFORMER BRANCHES

X--------- FROM BUS --------X AREA  VOLT         GEN    LOAD   SHUNT  X----------- TO BUS -----------X              TRANSFORMER    RATING
 BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE MW/MVAR MW/MVAR MW/MVAR  BUS#-SCT X-- NAME --X BASKV AREA CKT    MW     MVAR   RATIO  ANGLE  %  SET

      1    OWL         161.00  1 0.9957   2.3    0.0    0.0    0.0  --------------------------------------------------------------------------------
                                2 160.31          0.0    0.0   -0.0      9       SISKIN      161.00   1  1   -30.6    -2.4
                                                                         11       QUAIL       161.00   1  1    23.7     1.9
                                                                         14       GULL        161.00   1  1     6.9     0.5
      2    SWIFT       161.00  1 1.0000   3.5  360.2    0.0    0.0  --------------------------------------------------------------------------------
                                2 161.00         46.3L    0.0   -0.0     11       QUAIL       161.00   1  1    74.6     8.5
                                                                         12       HERON       161.00   1  1    65.3    12.6
                                                                         14       GULL        161.00   1  1    38.8     2.7
                                                                         18       STEEL MILL  161.00   1  1   181.5    22.5
      3    PARROT      161.00  1 1.0000   3.5  490.0    0.0    0.0  --------------------------------------------------------------------------------
                                2 161.00        100.0L    0.0   -0.0      6       RAVEN       161.00   1  1    97.6    19.5
                                                                         12       HERON       161.00   1  1    48.1     8.3
                                                                         15       CROW        161.00   1  1     0.0    -1.8
                                                                         18       STEEL MILL  161.00   1  1   344.3    74.0
      4    LARK        161.00  1 0.9775  -0.1    0.0   78.0    0.0  --------------------------------------------------------------------------------
                                1 157.37          0.0   10.0   -0.0      5       JAY         161.00   1  1    40.4     8.6
                                                                          9       SISKIN      161.00   1  1  -118.4   -18.6
      5    JAY         161.00  1 0.9728  -0.6    0.0  130.0    0.0  --------------------------------------------------------------------------------
                                1 156.62          0.0   30.0   -0.0      4       LARK        161.00   1  1   -40.3    -9.4
                                                                          6       RAVEN       161.00   1  1     7.8    -2.2
                                                                          7       WREN        161.00   1  1   -89.3   -12.6
                                                                          8       ROBIN       161.00   1  1    -8.2    -5.8
      6    RAVEN       161.00  1 0.9727  -0.8    0.0  104.0    0.0  --------------------------------------------------------------------------------
                                1 156.60          0.0   15.0   -0.0      3       PARROT      161.00   1  1   -96.2   -15.8
                                                                          5       JAY         161.00   1  1    -7.8     0.8
      7    WREN        161.00  1 0.9789   0.3    0.0  117.0    0.0  --------------------------------------------------------------------------------
                                1 157.61          0.0   20.0   -0.0      5       JAY         161.00   1  1    89.6    13.3
                                                                         15       CROW        161.00   1  1  -206.6   -33.3
      8    ROBIN       161.00  1 0.9751  -0.5    0.0   52.0    0.0  --------------------------------------------------------------------------------
                                1 156.98          0.0    5.0   -0.0      5       JAY         161.00   1  1     8.2     4.3
                                                                         12       HERON       161.00   1  1   -60.2    -9.3
      9    SISKIN      161.00  1 1.0000   3.5    0.0   13.0    0.0  --------------------------------------------------------------------------------
                                2 161.00          0.0    5.0   -0.0      1       OWL         161.00   1  1    30.7    -0.6
                                                                          4       LARK        161.00   1  1   119.8    23.8
                                                                         17       SISKIN 69   69.000   1 T1    24.5    13.0  1.000LK
                                                                         18       STEEL MILL  161.00   1  1  -188.0   -41.2
     10    JUNCO        69.000  1 0.9366  -1.5    0.0   19.5    0.0  --------------------------------------------------------------------------------
                                2 64.627          0.0   10.0   -0.0     13       EGRET       69.000   1  1     4.4     0.6
                                                                         17       SISKIN 69   69.000   1  1   -23.9   -10.6



     11    QUAIL       161.00  1 0.9869   1.0    0.0   97.5    0.0  --------------------------------------------------------------------------------
                                2 158.89          0.0   15.0   -0.0      1       OWL         161.00   1  1   -23.5    -6.7
                                                                          2       SWIFT       161.00   1  1   -74.0    -8.3
     12    HERON       161.00  1 0.9860   1.4    0.0   52.0    0.0  --------------------------------------------------------------------------------
                                2 158.75          0.0   15.0   -0.0      2       SWIFT       161.00   1  1   -64.9   -13.0
                                                                          3       PARROT      161.00   1  1   -47.7   -10.5
                                                                          8       ROBIN       161.00   1  1    60.6     8.6
     13    EGRET        69.000  1 0.9320  -2.1    0.0   39.0    0.0  --------------------------------------------------------------------------------
                                2 64.307          0.0   10.0   -0.0     10       JUNCO       69.000   1  1    -4.4    -0.9
                                                                         16       CROW 69     69.000   1  1   -34.6    -9.1
     14    GULL        161.00  1 0.9927   2.0    0.0   45.5    0.0  --------------------------------------------------------------------------------
                                2 159.82          0.0   10.0   -0.0      1       OWL         161.00   1  1    -6.9    -4.7
                                                                          2       SWIFT       161.00   1  1   -38.6    -5.3
     15    CROW        161.00  1 1.0000   3.5    0.0   13.0    0.0  --------------------------------------------------------------------------------
                                2 161.00          0.0    0.0   -0.0      3       PARROT      161.00   1  1     0.0    -1.8
                                                                          7       WREN        161.00   1  1   208.9    44.4
                                                                         16       CROW 69     69.000   1 T2    36.0    12.8  1.000LK
                                                                         18       STEEL MILL  161.00   1  1  -257.9   -55.4
     16    CROW 69      69.000  1 0.9841   0.7    0.0    0.0    0.0  --------------------------------------------------------------------------------
                                2 67.905          0.0    0.0   -0.0     13       EGRET       69.000   1  1    36.0    10.8
                                                                         15       CROW        161.00   1 T2   -36.0   -10.8  1.000UN
     17    SISKIN 69    69.000  1 0.9832   1.6    0.0    0.0    0.0  --------------------------------------------------------------------------------
                                2 67.839          0.0    0.0   -0.0      9       SISKIN      161.00   1 T1   -24.5   -12.0  1.000UN
                                                                         10       JUNCO       69.000   1  1    24.5    12.0
     18    STEEL MILL  161.00  1 1.0000   3.5    0.0   80.0    0.0  --------------------------------------------------------------------------------
                                2 161.00          0.0    0.0   -0.0      2       SWIFT       161.00   1  1  -181.5   -22.5
                                                                          3       PARROT      161.00   1  1  -344.3   -74.0
                                                                          9       SISKIN      161.00   1  1   188.0    41.2
                                                                         15       CROW        161.00   1  1   257.9    55.4
```

Figure 12 - Load Flow for N-2 contingency (Task 3)