IEEE 14 Bus Simulation

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Useful Links for Downloading Additional Power System Analysis Resources:

(All necessary data for completing this simulation was obtained from the resources listed below. Full credit goes to the original creators, and special thanks to the open-source communities and contributors, without whom this project would not have been possible.)

1. https://tweckesser.wordpress.com/power-system-data-and-test-cases/?utm_source=chatgpt.com

2. https://icseg.iti.illinois.edu/power-cases/

3. https://www.kios.ucy.ac.cy/testsystems/

4. https://webhomes.maths.ed.ac.uk/OptEnergy/NetworkData/

5. https://labs.ece.uw.edu/pstca/

This project was undertaken to gain a deeper understanding of power system modeling and simulation. For the sake of simplicity and clarity, the IEEE 14-bus system was used as the test case.

The following studies were conducted on this system :

1. Loadflow
2. Short Circuit Analysis
3. Motor Starting
4. Harmonic Analysis
5. Dynamic/Transient Analysis

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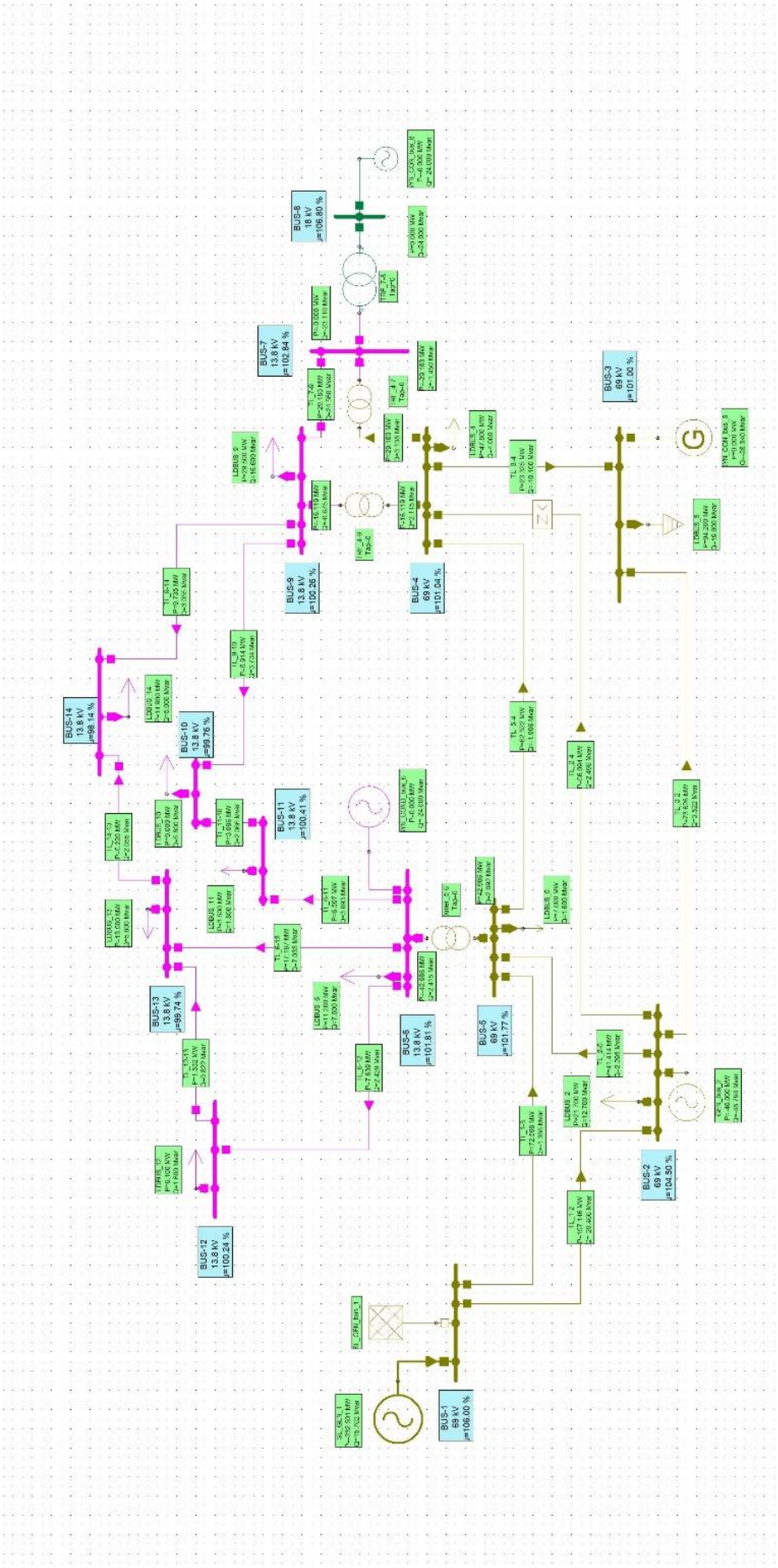
Loadflow Study:



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Loadflow Results:

From Area/Zone	To Area/Zone	P Loss (MW)	Q Loss (MVAr)	P Imp (MW)	Q Imp (MVAr)	P Gen (MW)	Q Gen (MVAr)	P Load (MW)	Q Load (MVAr)	Gen. Cost (Curr. Units)	Qc Shunt (MVAr)	Ql Shunt (MVAr)	Q Comp (MVAr)	Iron Losses (MW)
Network		13.501	27.972	232.501	-15.762	272.501	33.032	259	5.06	0	0	0	0	0
Area 1		13.501	27.972	0	0	272.501	33.032	259	5.06	0	0	0	0	0
Zone 1		13.501	27.972	0	0	272.501	33.032	259	5.06	0	0	0	0	0

Voltage (kV)	P Loss Li (MW)	Q Loss Li (MVAr)	P Loss L (MW)	Q Loss L (MVAr)	P Loss T (MW)	Q Loss T (MVAr)
7.8	0.588	2.721	0	0	0	0
13.8	0	0	0	0	0	0
18	0	0	0	0	0.89	0
69	12.913	16.727	0	0	7.635	0

ID	Name	U (kV)	u (%)	U ang (°)	P Load (MW)	Q Load (MVAr)	P Gen (MW)	Q Gen (MVAr)
174092	BUS-1	73.14	106	0	15.762	0	232.501	0
174077	BUS-10	13.767	99.76	-15.5	5.9	5.8	0	0
174074	BUS-11	13.857	100.41	-15.3	5.3	1.8	0	0
174075	BUS-12	13.833	100.24	-15.7	5.7	1.6	0	0
174061	BUS-13	13.764	99.96	-15.7	13.5	5.8	0	0
174063	BUS-14	13.545	98.14	-16.6	14.9	5	0	0
174062	BUS-15	72.105	104.5	-12.7	12.7	4	0	48.794
174096	BUS-3	69.696	101.12	-12.8	94.2	19	0	28.34
174095	BUS-4	69.715	101.04	-12.1	0	0	0	0
174090	BUS-5	70.222	101.77	-8.7	2.6	1.6	0	24
174093	BUS-6	45.01	101.1	-14.7	1.2	0.5	0	0
174082	BUS-7	14.192	102.84	-13.4	3.5	0	0	0
174081	BUS-8	13.804	100.6	-15.3	2	0	0	0
174071	BUS-9	13.837	100.26	-15.3	29.5	16.6	0	0

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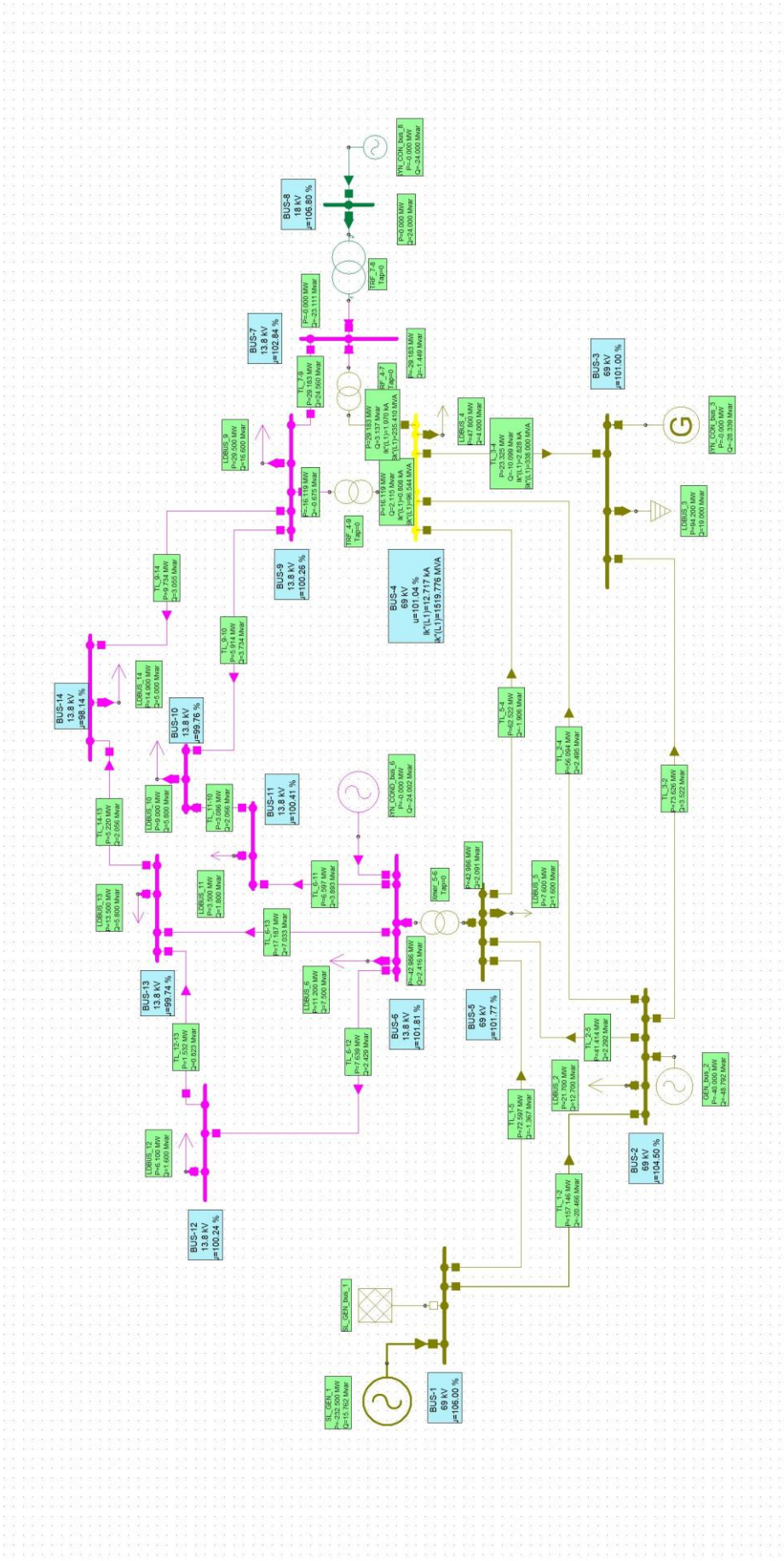
Short Circuit Analysis :



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Short Circuit Analysis Results:

Fault Current																				
ID	Fault Location From	To Node	Distance from fault	Element Name	Type	Un (kV)	UL-E (kV)	AU L-E (°)	Ik'' (kA)	AIk'' (°)	Fault Type	Method	Maximum	Network Type	CB Delay Time (s)	SC Duration (s)	SC Duration (s)	Zone	Area	Partial Network
174086	BUS-4	Faulted	0	—	—	69	43.82	180	12.717	-81.38	3phase	IEC6090	☑	MESHED	0.02	1	0.02	Zone 1	Area 1	1
174351	BUS-4	BUS-3	—	TL_3-4	Line	—	2.828	103.55	—	—	—	—	☐	—	—	—	—	Zone 1	Area 1	1
174366	BUS-4	BUS-5	—	TL_5-4	Line	—	4.573	97.52	—	—	—	—	☐	—	—	—	—	Zone 1	Area 1	1
174371	BUS-4	BUS-2	—	TL_2-4	Line	—	2.563	100.69	—	—	—	—	☐	—	—	—	—	Zone 1	Area 1	1
174230	BUS-4	BUS-9	—	TRF_4-9	2W Transfo	—	0.808	95.12	—	—	—	—	☐	—	—	—	—	Zone 1	Area 1	1
174271	BUS-4	BUS-7	—	TRF_4-7	2W Transfo	—	1.97	92.84	—	—	—	—	☐	—	—	—	—	Zone 1	Area 1	1

Current at fault locations															
ID	Fault Location	Un (kV)	Ik''(kA)	AIk'' (°)	Fault Type	Method	Maximum	Network Type	CB Delay Time (s)	SC Duration (s)	SC Duration (s)	Description	Zone	Area	Partial Network
174086	BUS-4	69	12.71	-81.38	3phase fault	IEC60909	☑	MESHED	0.02	1	0.02	—	Zone 1	Area 1	1

Node Voltages																		
ID	Name	Faulted	Un (kV)	U L-E (kV)	AU L-E (°)	U L-L (kV)	AU L-L (°)	U (012) (kV)	AU (012) (°)	U0 (kV)	AU0 (°)	Fault Type	Method	Maximum	Description	Zone	Area	Partial Network
174086	BUS-4	☑	69	43.821	180	75.9	330	43.821	180	0	-90	3phase fault	IEC60909	☑	—	Zone 1	Area 1	1

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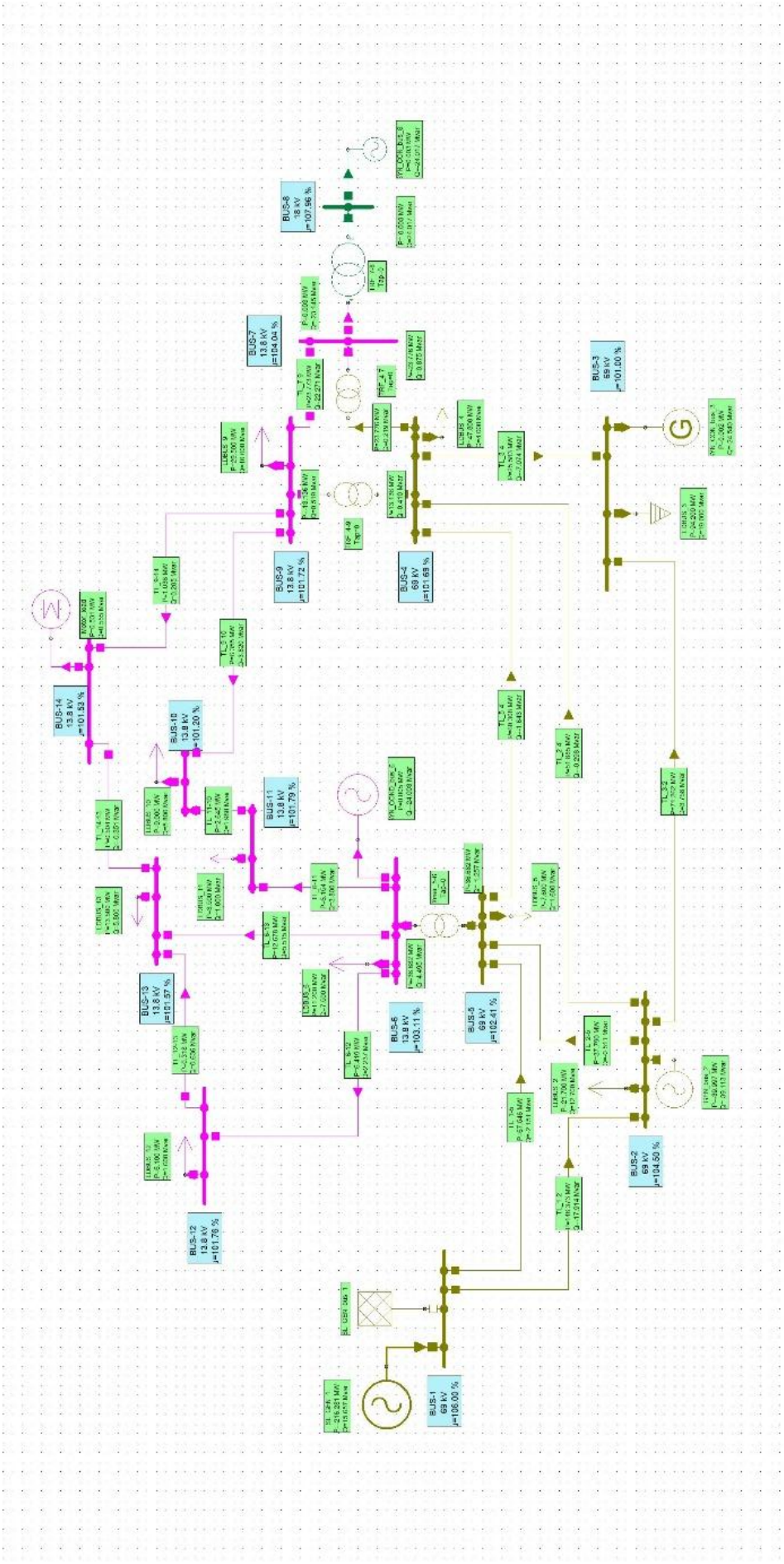
Motor Starting Anlaysis:



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		t (s)	U (kV)	I (kA)	P (MW)	Q (Mvar)	Me (Nm)	MI (Nm)	s	n/nr
174648	Motor_load	0	14.012	0.032	0.537	0.556	3391.549	3354.714	0.0024	1.0077

174141	GEN_bus_2	0		0.448	-39.998	-39.114				
		0.01		0.448	-39.998	-39.114				

174486	SL_GEN_1	0		1.712	-216.281	15.657
		0.01		1.712	-216.281	15.657

174175	SYN_CON_bus_3	0		0.203	0.001	-24.54
		0.01		0.203	0.001	-24.54

174185	SYN_CON_bus_8	0		0.714	0.002	-24.018
		0.01		0.714	0.002	-24.017

174151	SYN_COND_bus_6	0		0.974	0.003	-24.003
		0.01		0.974	0.004	-24.003

174336	TL_1-2	0		1.164	146.373	-17.914
		0.01		1.164	146.373	-17.914

174361	TL_1-5	0		0.552	-67.546	2.151
		0.01		0.552	-67.546	2.151

174308	TL_11-10	0		0.137	-2.646	-1.98
		0.01		0.137	-2.646	-1.98

174293	TL_12-13	0		0.029	-0.319	-0.636
		0.01		0.029	-0.319	-0.636

174323	TL_14-13	0		0.025	-0.502	0.352
		0.01		0.025	-0.503	0.351

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174371	TL_2-4	0		0.415	51.885	-0.298
		0.01		0.415	51.885	-0.298
174283	TL_2-5	0		0.303	37.79	-0.511
		0.01		0.303	37.79	-0.511
174346	TL_3-2	0		0.571	71.262	3.758
		0.01		0.571	71.262	3.758
174351	TL_3-4	0		0.218	25.583	-7.074
		0.01		0.218	25.583	-7.074
174366	TL_5-4	0		0.493	60.309	-1.643
		0.01		0.493	60.308	-1.643
174303	TL_6-11	0		0.297	-6.154	-3.8
		0.01		0.297	-6.154	-3.8
174288	TL_6-12	0		0.279	-6.42	-2.237
		0.01		0.279	-6.42	-2.237
174298	TL_6-13	0		0.57	-12.68	-5.516
		0.01		0.57	-12.679	-5.515
174331	TL_7-9	0		1.31	23.775	22.272
		0.01		1.31	23.774	22.271
174313	TL_9-10	0		0.307	-6.354	-3.82
		0.01		0.307	-6.354	-3.82
174318	TL_9-14	0		0.044	-1.039	-0.206
		0.01		0.044	-1.038	-0.205
174271	TRF_4-7	0		0.957	-23.777	0.874
		0.01		0.957	-23.777	0.874
174230	TRF_4-9	0		0.541	-13.137	0.519
		0.01		0.541	-13.137	0.519

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174257	TRF_7-8	0		0.931	0.002	-23.146
		0.01		0.931	0.002	-23.146

174216	Xmer_5-6	0		1.5	-36.682	4.495
		0.01		1.499	-36.682	4.495

174092	BUS-1	0	73.14			
		0.01	73.14			

174077	BUS-10	0	13.966
		0.01	13.966

174074	BUS-11	0	14.047
		0.01	14.047

174065	BUS-12	0	14.043
		0.01	14.043

174062	BUS-13	0	14.017
		0.01	14.017

174068	BUS-14	0	14.012
		0.01	14.012

174095	BUS-2	0	72.105
		0.01	72.105

174098	BUS-3	0	69.69
		0.01	69.69

174086	BUS-4	0	70.166
		0.01	70.166

174089	BUS-5	0	70.659
		0.01	70.66

174080	BUS-6	0	14.229
		0.01	14.229

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174101	BUS-7	0	14.358
		0.01	14.358

174083	BUS-8	0	19.433
		0.01	19.433

174071	BUS-9	0	14.037
		0.01	14.037

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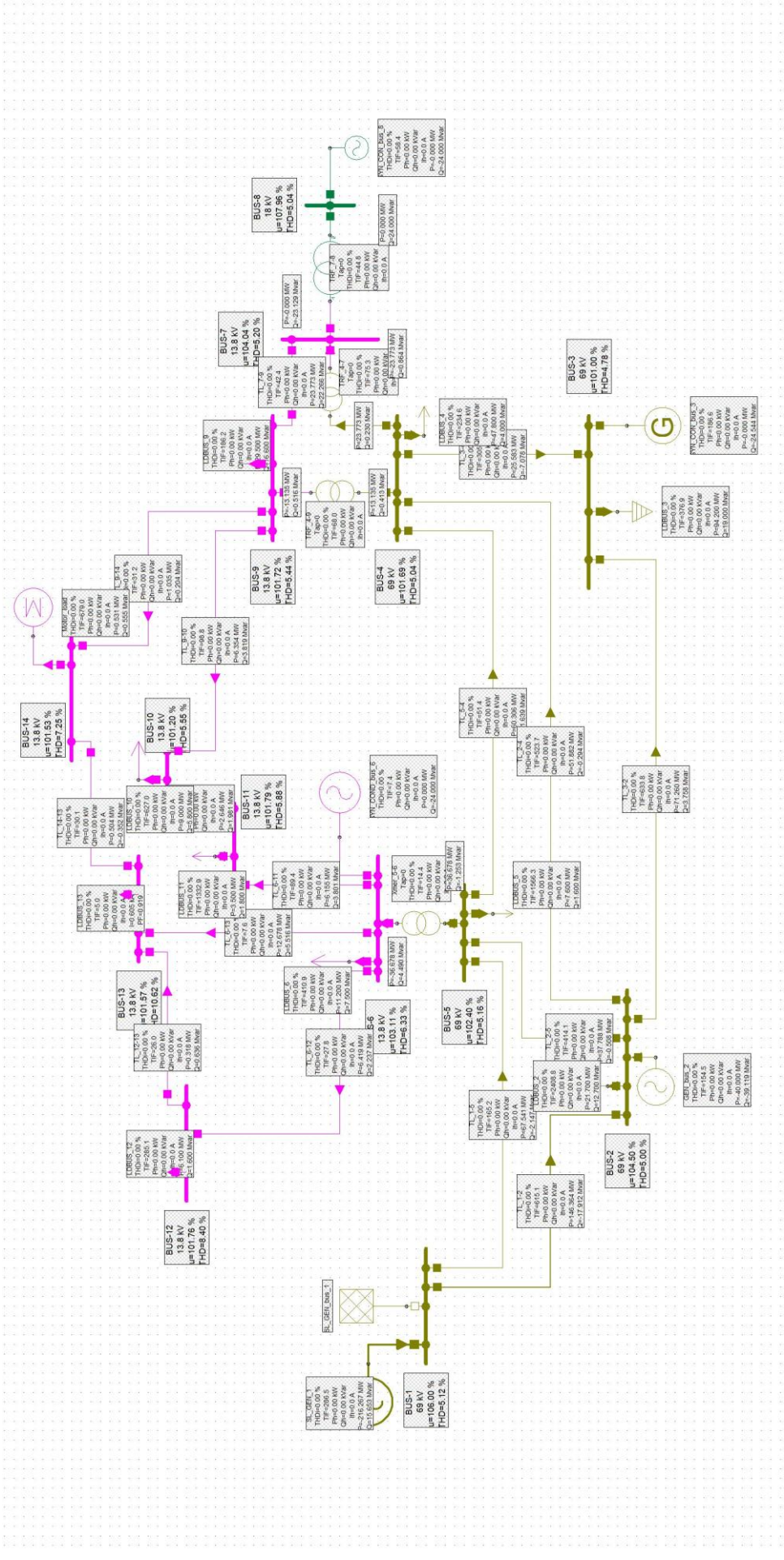
Harmonic Analysis:



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ID	Name	THD (%)	f (Hz)	U (V)	U (%)	U ang	Descripti	Zone	Area	Network
174092	BUS-1	5.12	150	3200.753	4.64	269.89		Zone 1	Area 1	1
			250	0.1741	0	-20.49				
			350	544.599	0.79	71.8				
			550	0.1605	0	-15.86				
			650	480.416	0.7	-82.55				
			850	0.339	0	-20.43				
			950	304.556	0.44	265.91				
			1050	1268.149	1.84	265.16				
174077	BUS-10	5.55	150	566.906	4.11	-89.76		Zone 1	Area 1	1
			250	25.23	0.18	82.34				
			350	239.452	1.74	82.66				
			550	35.36	0.26	85.98				
			650	103.853	0.75	87.3				
			850	37.932	0.27	86.02				
			950	174.849	1.27	88.7				
			1050	403.884	2.93	85.33				
174074	BUS-11	5.88	150	540.383	3.92	-89.6		Zone 1	Area 1	1
			250	12.978	0.09	76.62				
			350	279.974	2.03	84.32				
			550	17.918	0.13	83.3				
			650	143.165	1.04	87.84				
			850	19.181	0.14	84.33				
			950	219.688	1.59	88.95				
			1050	468.015	3.39	85.88				
174065	BUS-12	8.4	150	445.977	3.23	-88.4		Zone 1	Area 1	1
			250	112.433	0.81	84.88				
			350	528.434	3.83	85.72				
			550	157.73	1.14	87.53				
			650	334.772	2.43	88				
			850	162.365	1.18	88.35				
			950	459.19	3.33	88.83				
			1050	690.991	5.01	86.95				
174062	BUS-13	10.62	150	393.834	2.85	-85.83		Zone 1	Area 1	1
			250	205.633	1.49	82.94				
			350	709.02	5.14	85.23				
			550	288.565	2.09	86.73				
			650	466.671	3.38	87.65				
			850	297.178	2.15	87.85				
			950	629.405	4.56	88.56				
			1050	813.543	5.9	87.03				
174068	BUS-14	7.25	150	497.518	3.61	-88.47		Zone 1	Area 1	1
			250	105.734	0.77	83.22				
			350	430.159	3.12	84.35				
			550	148.435	1.08	86.78				
			650	249.881	1.81	87.58				
			850	153.909	1.12	87.65				
			950	358.623	2.6	88.61				
			1050	567.042	4.11	86.29				

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174095	BUS-2	5	150	3186.101	4.62	269.89		Zone 1	Area 1	1
			250	0.3064	0	-13.95				
			350	527.853	0.77	71.18				
			550	0.2506	0	-12.93				
			650	428.265	0.62	-82.99				
			850	0.39	0	-18.81				
			950	236.465	0.34	266.27				
			1050	1103.431	1.6	265.1				
174098	BUS-3	4.78	150	3180.275	4.61	269.84		Zone 1	Area 1	1
			250	0.1897	0	-12.47				
			350	350.622	0.51	65.18				
			550	0.149	0	-12.02				
			650	236.122	0.34	-87.78				
			850	0.206	0	-18.02				
			950	75.259	0.11	265.77				
			1050	774.837	1.12	266.12				
174086	BUS-4	5.04	150	2983.885	4.32	-89.73		Zone 1	Area 1	1
			250	24.52	0.04	72.85				
			350	716.16	1.04	70.11				
			550	38.229	0.06	76.15				
			650	212.179	0.31	-82.01				
			850	68.084	0.1	71.27				
			950	151.402	0.22	81.53				
			1050	1606.727	2.33	84.18				
174089	BUS-5	5.16	150	2931.281	4.25	-89.57		Zone 1	Area 1	1
			250	15.998	0.02	68.08				
			350	800.623	1.16	73.12				
			550	27.107	0.04	73.85				
			650	230.12	0.33	-77.74				
			850	61.362	0.09	69.82				
			950	173.895	0.25	84.8				
			1050	1827.706	2.65	84.61				
174080	BUS-6	6.33	150	512.886	3.72	-89.37		Zone 1	Area 1	1
			250	2.495	0.02	0.17				
			350	326.737	2.37	85.69				
			550	1.602	0.01	-0.06				
			650	186.301	1.35	88.18				
			850	1.079	0.01	-0.36				
			950	269.861	1.96	89.16				
			1050	534.472	3.87	86.29				
174101	BUS-7	5.2	150	597.896	4.33	-89.76		Zone 1	Area 1	1
			250	15.64	0.11	82.7				
			350	158.85	1.15	78.86				
			550	22.167	0.16	85.64				
			650	34.794	0.25	83.16				
			850	25.072	0.18	84.34				
			950	91.808	0.67	87.92				
			1050	346.887	2.51	84.53				
174083	BUS-8	5.04	150	779.865	4.33	-89.76		Zone 1	Area 1	1
			250	0.139	0	-6.91				
			350	83.957	0.47	78.62				
			550	0.0895	0	-4.18				
			650	18.389	0.1	83.03				
			850	0.0655	0	-5.54				
			950	48.523	0.27	87.83				
			1050	452.461	2.51	84.53				
174071	BUS-9	5.44	150	578.559	4.19	-89.81		Zone 1	Area 1	1
			250	31.04	0.22	83.66				
			350	225.588	1.63	81.88				
			550	43.623	0.32	86.59				
			650	88.283	0.64	86.97				
			850	46.815	0.34	86.41				
			950	158.032	1.15	88.59				
			1050	375.691	2.72	85.02				

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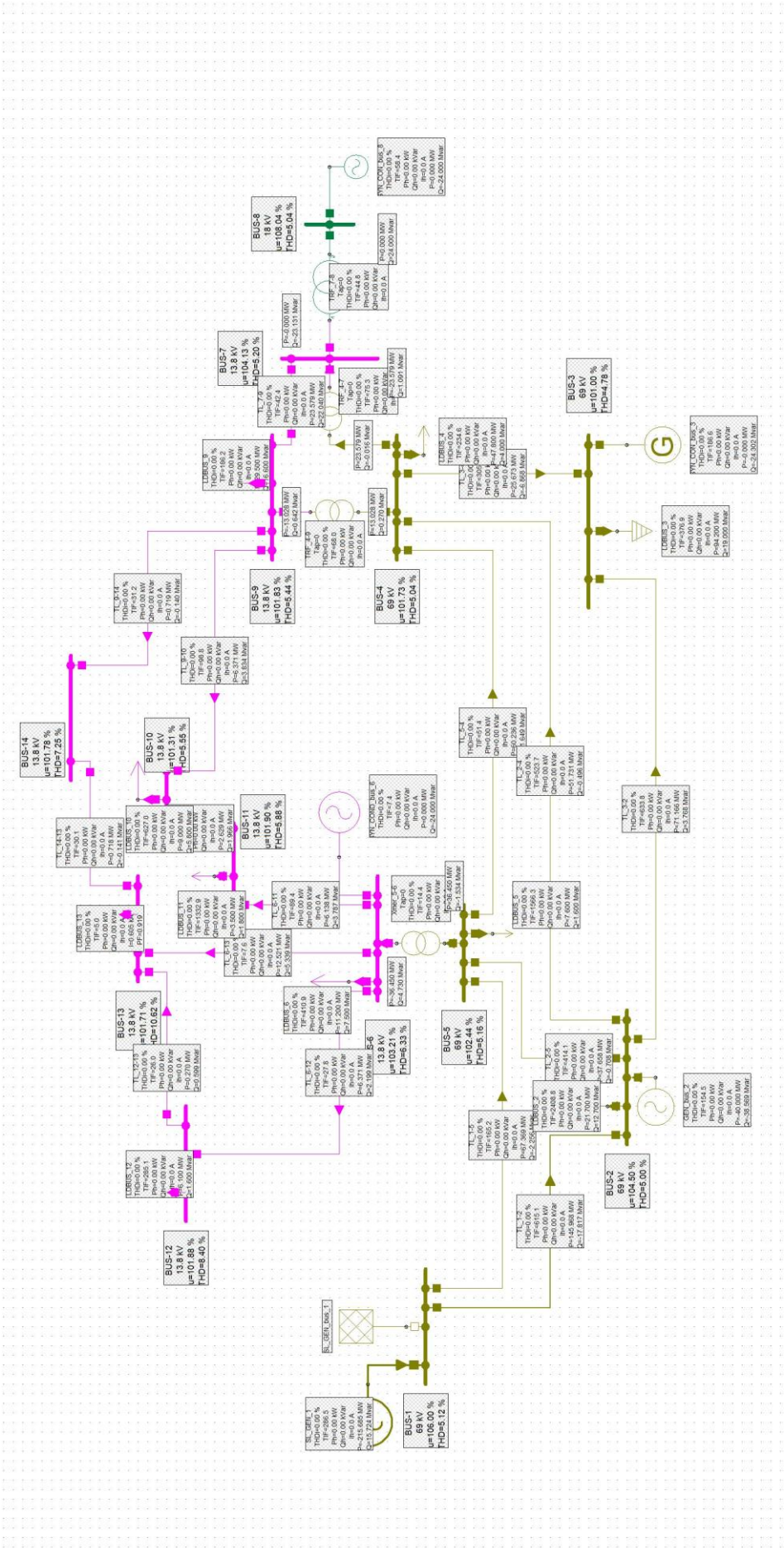
Dynamic/Transient Simulation



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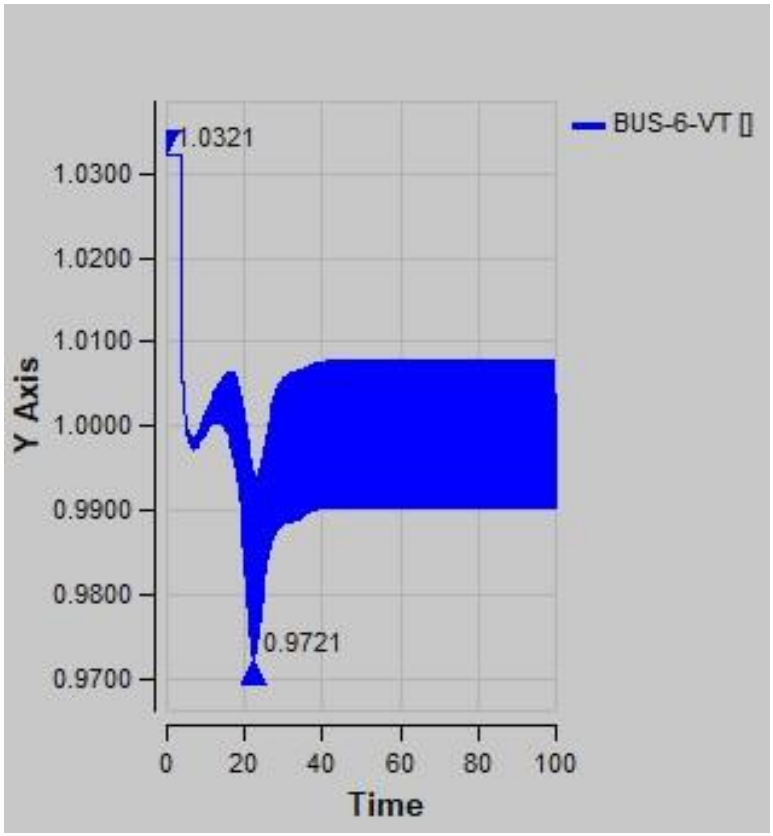

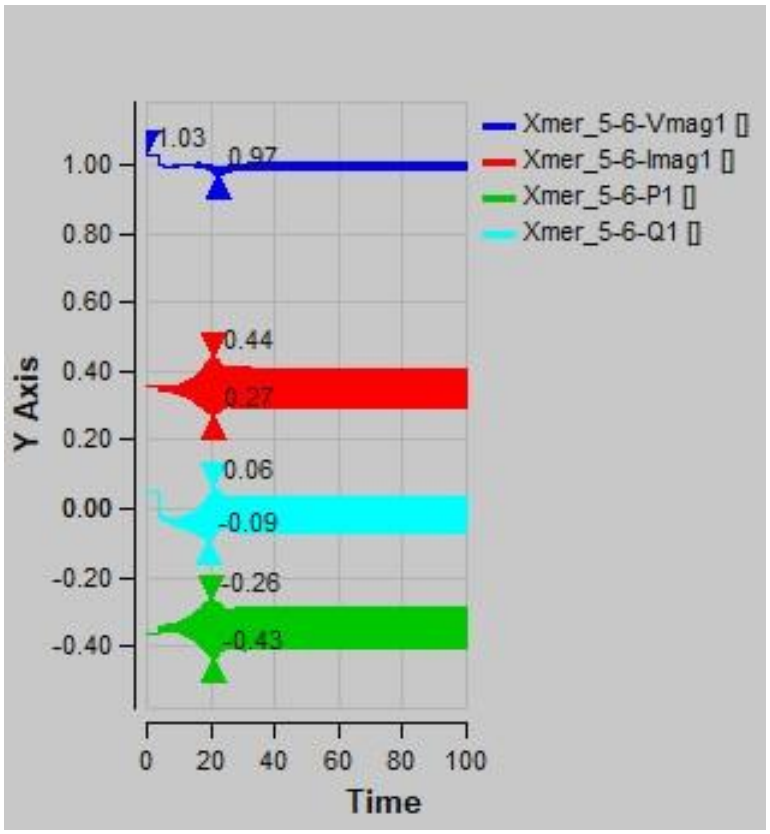

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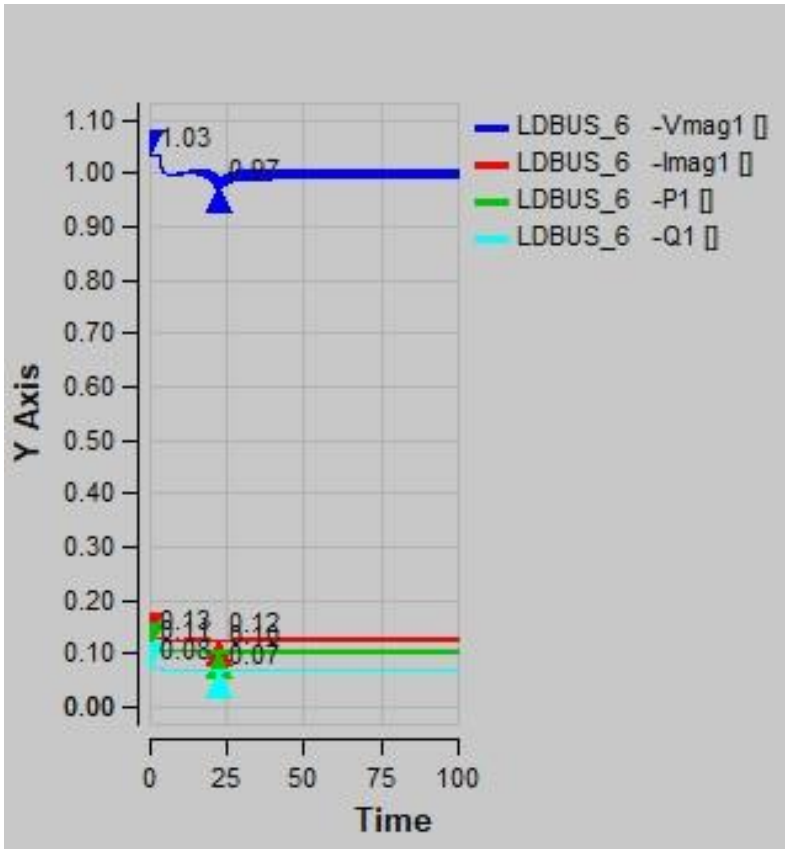

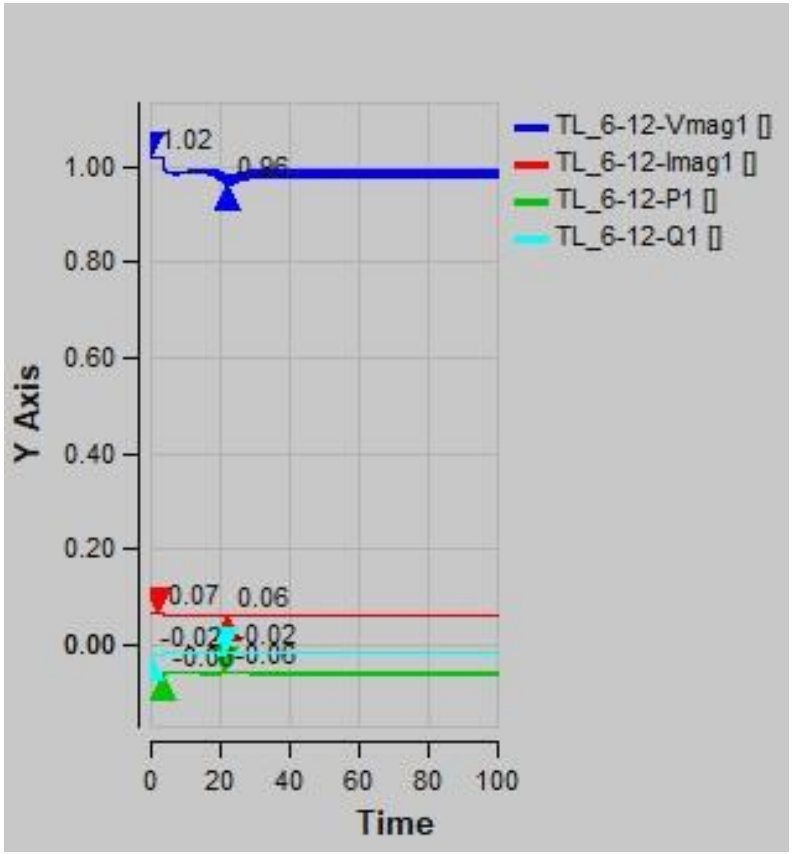

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