4.5 Power System Analysis

4.5.1 Purpose

A 370 MW combined cycle generating facility, which is scheduled to begin operation in 2008, is to be added to the Tashkent Thermal Power Plant. The purpose of the power system analysis is carrying out the calculation in order to examine the influence due to the introduction of this facility under normal condition and emergency condition. The power system analysis will be examined issues such as power flow, short-circuit current, stability, and frequency fluctuation.

4.5.2 Examined Case

Ideally, the power system of year 2008 would be simulated for the calculations, but accurate data is not available with regard to demand forecast, generation development plan, and power transmission system development plan for future years. Therefore, the analysis will be carried out based on the actual year 2002 data for the power system to which the new 370MW generator of the Tashkent Thermal Power Plant will be connected.

The calculations are carried out about the two cases that are the summer peak and winter peak representing the different aspects of the power flow.

4.5.3 Simulated System

Because the electrical power system in Uzbekistan retains the transmission system that was constructed during the time of the former Soviet Union, there are international connection lines between Uzbekistan and four other countries (Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan). The five countries including Uzbekistan make up the Central Asia Power System. The trunk transmission lines of the Central Asia Power System are 500 kV and 220 kV lines. For the purposes of these calculations, almost all of the 500 kV and 220 kV transmission lines and substations of the system were simulated except some radial power system. Major power plants with capacities of 600 MW or more were simulated accurately unit by unit. Namely, the simulated 8 power plants are as follows.

Uzbekistan	Syrdariya	3000 MW	Thermal power plant
	Novo Angren	2100 MW	Thermal power plant

	Tashkent	1860 MW	Thermal power plant
	Navoi	1250 MW	Thermal power plant
	Charvac	620 MW	Hydro power plant
Kyrgyzstan	Toktogul	1200 MW	Hydro power plant
	Kurpsai	800 MW	Hydro power plant
Tajikistan	Nurek	3000 MW	Hydro power plant

The 500 kV bus of the Almaty substation in Kazakhstan was taken as the slack bus. (Figure 4.5-1)

4.5.4 Calculation Software

Calculations were carried out by using " CRIEPI's Power System Analysis Tools" developed by the Central Research Institute of the Electric Power Industry (CRIEPI) in Japan. This software is currently used by all the electric power companies in Japan. SJSC "Uzbekenergo" is using the calculation software named "Mustang" which was made in former Soviet Union.

4.5.5 Winter Peak Calculation Results

(1) Power Flow

The results of the power flow calculation after the new 370 MW generator is connected to the Tashkent Thermal Power Plant are shown in Figure 4.5-2.

The power flow through each transmission line is as shown in Table 4.5-1. For all the transmission lines, the calculated flow was within the allowable current capacity.

The power flow calculations when one circuit of 500kV transmission line is tripped were also carried out and the result is as shown in Table 4.5-1. For all the 500 kV transmission lines and most 220kV transmission lines, the calculated flow was within the allowable current capacity.

(2) Voltage

For the purposes of maintaining the proper voltage, the static condensers with required capacity were inserted into the several substations.

The voltage values for the 500 kV and 220 kV buses at each substation were as shown in Figure 4.5-2 and Table 4.5-2. The 500kV bus voltage of each substations was within the range of 535 kV (107.1 %) and 500 kV (100.0 %). And the 220 kV bus voltage of each substations was within the range of 229 kV (104.0 %) and 201 KV (91.4 %). In all cases, the voltage was found to fall within the target range of ±10 %.

(3) Short-circuit Current

The 3-phase short-circuit current values for the 500 kV and 220 kV buses for each substation were as shown in Table 4.5-3. The maximum short-circuit current was 13.1 kA for a 500 kV bus and 27.5 kA for a 220 kV bus. In all cases, the current was within the rated current capacity for the equipment of 40 kA.

The influence of introduction of 370 MW combined cycle power plant on the network system was +0.4 kA for a 500kV bus and +2.8 kA for a 220kV bus of Tashkent Thermal Power Plant. However, in these calculations, only principal power plants were simulated, so the values were slightly lower than the actual short-circuit current values.

According to NDC (National Dispatch Center) calculations, the present 3-phase short-circuit current value of Tashkent Thermal Power Plant 220kV bus is close to 40kA and according to the kind of faults it may be over 40kA. Therefore when the power system development plan is decided, the more exact short-circuit current calculation should be carried out about 2008year stage when the new 370 MW generator is put into operation. And if necessary, either of the countermeasures should be taken. Since it seems that it is sufficiently possible to replace 220kV circuit breakers from designing to installation for two years, it will be possible to carry out it after the detailed study by SJSC "Uzbekenergo".

a. One more 500/220kV transformer is constructed and 220kV bus bar is operated separately.
b. Next replaced generators are connected to 500kV bus directly.
c. As the next replaced generator's step-up transformers, high impedance ones are adopted.
d. All 220kV circuit breakers are replaced to the rated current capacity 50kA or 63kA.

(4) Static Stability

Static stability calculations were carried out for the purpose of assessing whether or not stability can be maintained in the power system when a slight disturbance such as a circuit-breaker opening occurs somewhere in the system. The result of this calculation, which is provided in Figure 4.5-3, indicates that the system is stable.

(5) Dynamic Stability

Dynamic stability calculations were performed assuming the case that a 2LG-O(Line Ground fault - Open) fault occurred at the nearest point of the 370 MW generator of the Tashkent Thermal Power Plant.

Failure sequence:

500kV Transmission line, Transformer:

Circuit breaker opens 120 ms after the failure occurs.

220kV Transmission line:

Circuit breaker opens 200 ms after the failure occurs.

Case 1: 500kV Tashkent GRES - Shimkent

Case 2: 500kV Tashkent GRES - TashkentSS

Case 3: 220kV Tashkent GRES - Uksak

Case 4: Tashkent GRES 500/220 kV main transformer

The results of the calculations for each case are as shown in Figures 4.5-4, 4.5-5, 4.5-6, and 4.5-7. The fluctuation in the phase angle of the power plant is converged, so power system stability is stable.

(6) Frequency Fluctuation

The unit with the largest capacity in the Central Asia Power System is the 800 MW generator at the Tarimaljan Power Plant (expected to begin operation in 2003). The frequency drop was calculated for the case when the Tarimaljan 800 MW generator dropped out of the system, and the frequency rise was calculated in the cases of 5 % and 10 % load reductions of the whole system. The results of the calculations are shown in Figures 4.5-8, 4.5-9, and 4.5-10. The frequency drop of the case of the Tarimaljan 800 MW generator dropped out is 0.1Hz, the frequency rise of the case of 5% load reduction is 0.05Hz and the frequency rise of the case of 10% load reduction is 0.1Hz. The range of permitted frequency is 48.5Hz - 51.5Hz in the electric power companies of Japan, so this frequency fluctuation values are within the range.

The standard gas turbine of a certain manufacturer for commercial use is designed so as to be able to continuously operate under load within the range of the network frequency of 47.5 Hz to 51.5 Hz. Such allowable range is specified to avoid that the natural frequencies of rotating blades of the turbine and compressor will be resonant with the harmonics of the rotating speed.

Therefore, if the network frequency exceeds the said range, the generator breaker shall be forced to open or the gas turbine shall be forced to trip with the time delayed frequency relay. In case of the gas turbine mentioned above, the time delayed frequency relays have such functions as shown below:

a. Under Frequency Relay

47.0 Hz < F <= 47.5 Hz	The generator breaker opens after 15 seconds.
F = 47.0 Hz	The gas turbine trips after 0.1 second.
F < 47.0 Hz	The gas turbine immediately trips.

b. Over Frequency Relay

F = 51.5 Hz	The gas turbine trips after 0.1 second.
F > 51.5 Hz	The gas turbine immediately trips.

The allowable range where the gas turbine can be continuously operated under load is changeable depending upon the design concept of the gas turbine manufacturer. So that we will recommend that SJSC "Uzbekenergo" should discuss with the EPC contractor as to how to pre-set the frequency relays.

4.5.6 Summer Peak Calculation Results

(1) Power Flow

The results of the power flow calculation after the new 370 MW generator is connected to the Tashkent Thermal Power Plant are shown in Figure 4.5-11.

The power flow through each transmission line is as shown in Table 4.5-1. For all the transmission lines, the calculated flow was within the allowable current capacity.

(2) Voltage

For the purposes of maintaining the proper voltage, the static condensers with required capacity were inserted into the several substations.

The voltage values for the 500 kV and 220 kV buses at each substation were as shown in Figure 4.5-11 and Table 4.5-2. The 500kV bus voltage of each substations was within the range of 543 kV (108.7 %) and 500 kV (100.0 %). And the 220 kV bus voltage of each substations was within the range of 241 kV (109.6 %) and 210 KV (95.5 %). In all cases, the voltage was found to fall within the target range of ±10 %.

(3) Short-circuit Current

Same as winter peak calculation result.

(4) Static Stability

Static stability calculations were carried out for the purpose of assessing whether or not stability can be maintained in the power system when a slight disturbance such as a circuit-breaker opening occurs somewhere in the system. The results of these calculations, which are provided in Figure 4.5-12, indicate that the system is stable.

(5) Dynamic Stability

Dynamic stability calculations were performed assuming the case that a 2LG-O fault occurred at the nearest point of the 370 MW generator of the Tashkent Thermal Power Plant.

Failure sequence:

500kV Transmission line, Transformer:

Circuit breaker opens 120 ms after the failure occurs.

220kV Transmission line:

Circuit breaker opens 200 ms after the failure occurs.

Case 1: 500kV Tashkent GRES - Shimkent

Case 2: 500kV Tashkent GRES - TashkentSS

Case 3: 220kV Tashkent GRES - Uksak

Case 4: Tashkent GRES 500/220 kV main transformer

The results of the calculations for each case are as shown in Figures 4.5-13, 4.5-14, 4.5-15, and 4.5-16. The fluctuation in the phase angle of the power plant is converged, so power system stability is stable.

(6) Frequency Fluctuation

Same as winter peak calculation result.

4.5.7 Conclusion and Observations

(1) Conclusion

The analysis revealed that there will be no problems of power flow, voltage, short-circuit current, stability and frequency fluctuation caused by connecting the new 370 MW generator of the Tashkent Thermal Power Plant to the existing power system.

This analysis study was carried out using the data in 2002 not 2008 when the new C/C will be putting into operation. For the exact power system development plan, it is necessary to carry out the analysis study at the stage of 2008 and of future year. Therefore it is necessary to clarify the problem of power system regarding power flow, voltage, short-circuit current, stability and frequency fluctuation based on more precise analysis study taking into account demand forecast, power generation development plan and power transmission development plan by SJSC "Uzbekenergo". It seems that SJSC "Uzbekenergo" holds the technical skill of power system analysis. NDC is mainly carrying out power system analysis in Uzbekistan system and UDC is mainly carrying out in whole Central Asia system.

(2) Observations

However, an examination of the system as a whole revealed a problem of dynamic stability. The power flow is heavy from the east side to the west side of the power system, making the system a very weak one in terms of system stability. In particular, the dynamic stability would become unstable if the faults were to occur on the 500 kV transmission lines between Tashkent and Syrdarinskaya, between Syrdarinskaya and Guzar, or from Frunzenskaya to Toktogulskaya to Lochin. Therefore the dynamic stability calculations were performed assuming the case that 3LG-O fault of these each 500kV transmission lines occurred.

* Tashkent - Syrdarinskaya
Unstable at 3LG-O (Figure 4.5-20)
Stable at 1LG-O-C (Figure 4.5-21)
When the 800 MW generator of the Tarimaljan Power Plant will be connected to the system, the westward power flow will be alleviated, and the level of dynamic stability will become stable (Figure 4.5-22).

* Syrdarinskaya - Guzar
When the 800 MW generator of the Tarimaljan Power Plant joins the system, the westward power flow will be alleviated, but the level of dynamic stability will be still unstable (Figure 4.5-23). It will be necessary to install the power system stabilizer to divide the system into east part and west part and the both system to be stable or the new 500kV transmission line from Syrdarinskaya to Guzar to keep the system stable when the transmission line is an accident.

* Frunzenskaya - Toktogulskaya - Lochin.
Stable at 3LG-O (Figure 4.5-24, 4.5-25)

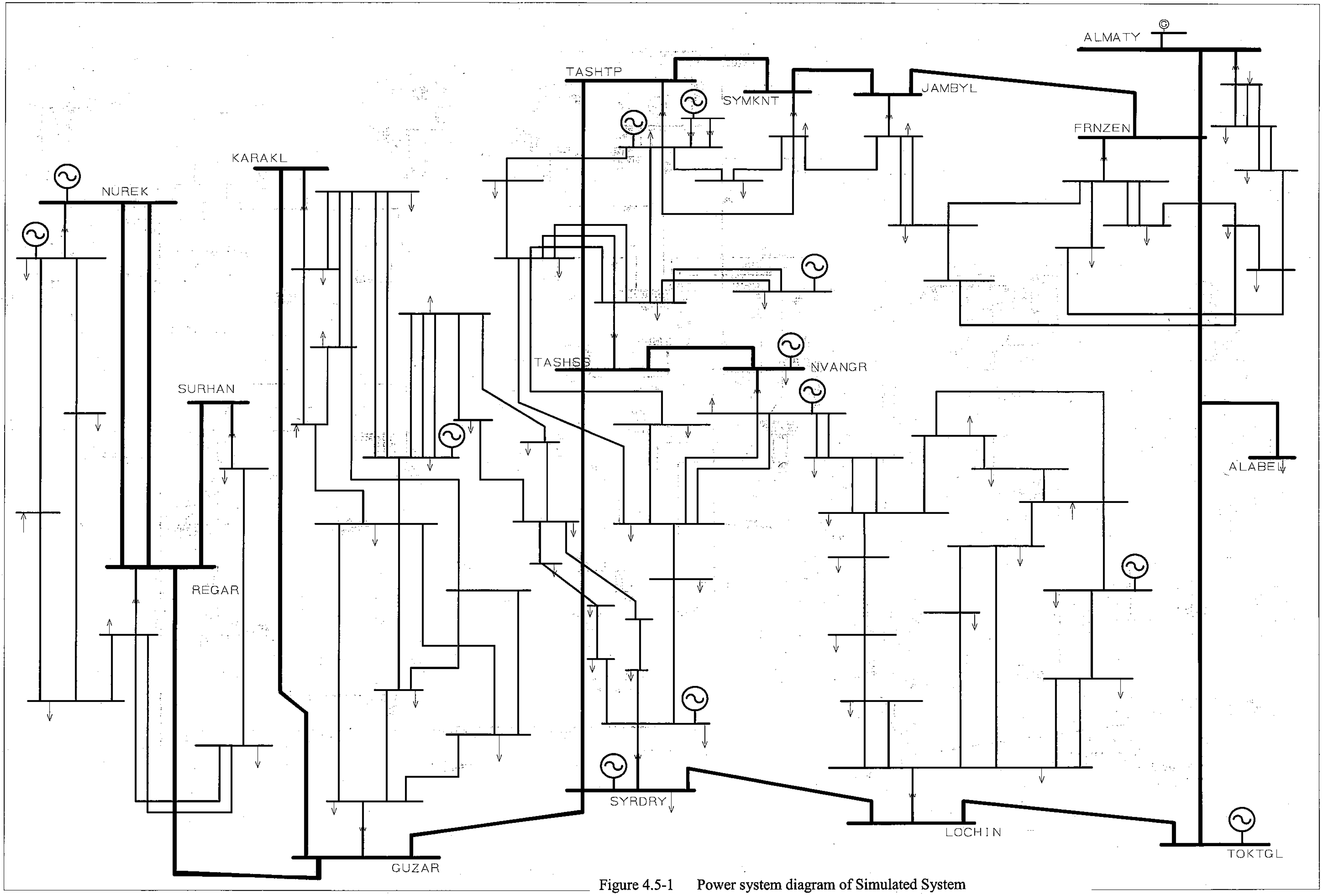
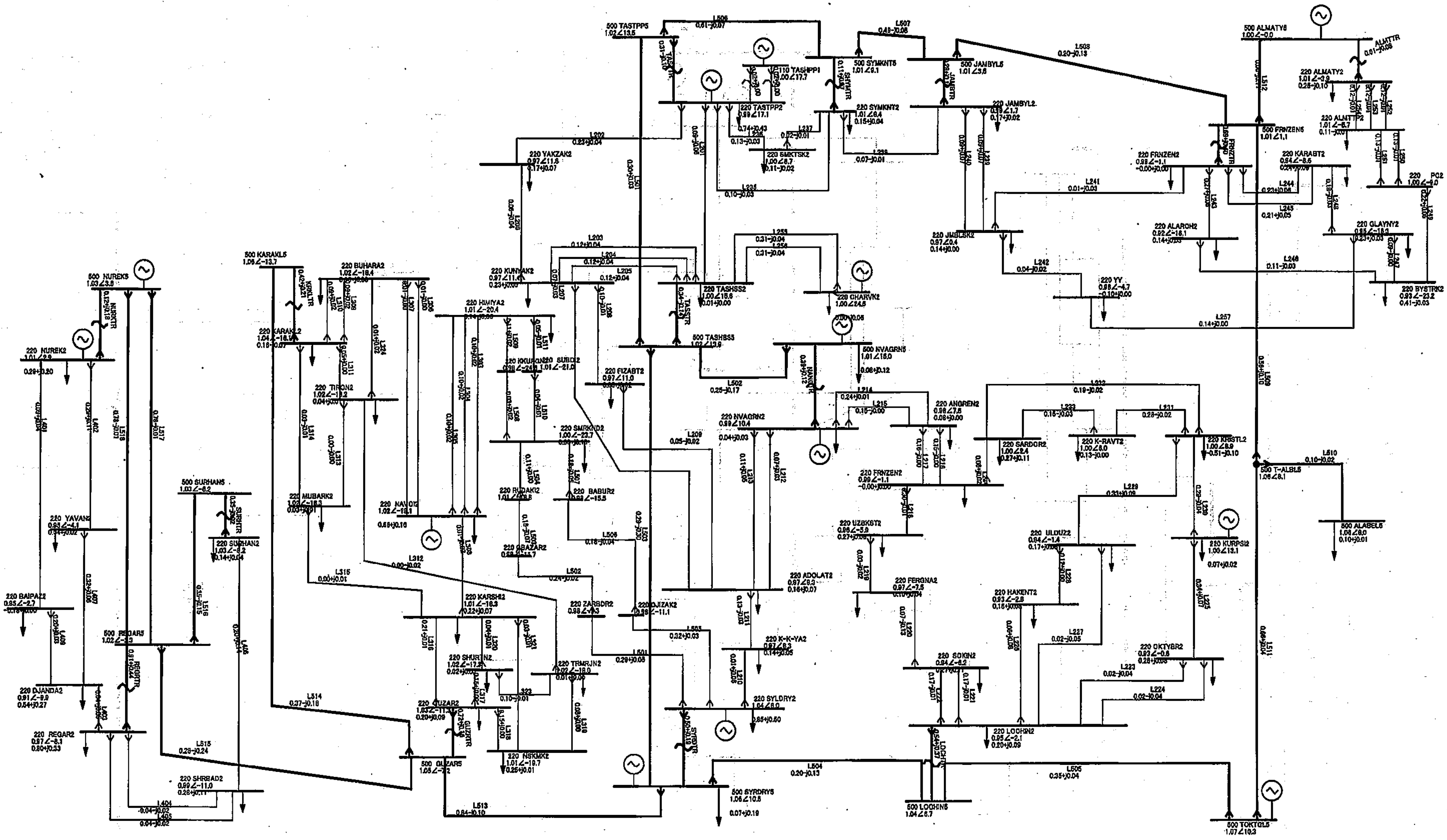


Figure 4.5-1 Power system diagram of Simulated System



注：母線電圧および線路潮流は p.u.値
（ベース電圧 500kV, 220kV　ベース容量 1000MVA）

Figure 4.5-2　Power Flow Diagram of Winter Peak Demand

Table 4.5-1 Power Flow Calculation Result (power flow of each TL)

from		to	voltage	capacity T/L		capacity FACILITIES		normal condition(summer)		normal condition(winter)		1 circuit tripped of 500kV T/L: TashTP - TashSS	TashSS - NvAngr	TashSS - Syrdry	Syrdry - Lochin	Lochin - Toktgl	TashTP - Symknt	Symknt - Jambyl	Jambyl - Frnzen	Frnzen - Toktgl	Guzar - Karakl	Regar - Nurek
			kV	A	MVA	A	MVA	MVA	%	MVA	%	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA	MVA
TASTPP5	-	TASHSS5	500	2475	2143	2000	1732	133	7.7%	301	17.4%	-	246	429	418	29	142	112	212	938	263	268
TASHSS5	-	NVAGRN5	500	2475	2143	2000	1732	185	10.7%	308	17.6%	287	-	155	274	259	243	250	274	545	297	306
TASHSS5	-	SYRDRY5	500	2475	2143	2000	1732	639	36.9%	423	24.4%	460	349	-	320	616	584	605	508	329	417	424
SYRDRY5	-	LOCHIN5	500	2070	1793	2000	1732	209	12.1%	266	15.4%	307	254	216	-	555	425	454	345	497	234	256
LOCHIN5	-	TOKTGL5	500	2115	1832	2000	1732	470	27.1%	395	22.8%	341	380	499	582	-	241	229	295	1020	430	407
TASTPP5	-	SYMKNT5	500	2475	2143	2000	1732	291	16.8%	611	35.2%	511	585	712	716	301	-	333	491	1267	577	599
SYMKNT5	-	JAMBYL5	500	2000	1732	2000	1732	262	15.1%	497	28.7%	437	479	601	605	183	255	-	391	1105	463	485
JAMBYL5	-	FRNZEN5	500	2000	1732	2000	1732	143	8.3%	244	14.1%	197	224	356	348	183	166	207	-	778	215	234
FRNZEN5	-	T-ALBL5	500	2000	1732	2000	1732	270	15.6%	594	34.3%	653	607	505	479	910	823	872	719	-	564	584
T-ALBL5	-	ALABEL5	500	2000	1732	2000	1732	57	3.3%	99	5.7%	99	100	99	99	98	99	99	99	-	99	100
T-ALBL5	-	TOKTGL5	500	2000	1732	2000	1732	100	5.7%	659	38.1%	729	677	537	522	1009	918	967	800	-	625	647
FRNZEN5	-	ALMATY5	500	2475	2143	2000	1732	393	22.7%	180	10.4%	170	186	156	155	160	175	212	184	535	180	178
SYRDRY5	-	GUZAR5	500	2475	2143	2000	1732	493	28.4%	846	48.9%	846	845	843	848	847	846	846	846	856	799	858
GUZAR5	-	KARAKL5	500	2475	2143	2000	1732	483	27.9%	413	23.9%	413	413	412	414	414	414	414	414	405	-	416
GUZAR5	-	REGAR5	500	2475	2143	2000	1732	783	45.2%	368	21.2%	368	369	373	364	358	366	365	366	438	318	379
REGAR5	-	SURHAN5	500	2475	2143	2000	1732	361	20.8%	381	22.0%	381	381	382	381	381	381	381	381	390	373	365
REGAR5	-	NUREK5	500	2475	2143	2000	1732	904	52.2%	778	44.9%	778	778	778	778	778	778	778	778	790	784	-
REGAR5	-	NUREK5	500	2475	2143	2000	1732	904	52.2%	778	44.9%	778	778	778	778	778	778	778	778	790	784	1519
TASTPP2	-	TASHSS2	220	925	352	1000	381	169	48.0%	111	31.4%	90	115	88	98	134	53	123	117	118	111	111
TASTPP2	-	YAKZAK2	220	945	360	1000	381	232	64.5%	237	65.7%	172	191	259	238	263	206	254	246	190	240	238
TASHSS2	-	KUNYAK2	220	945	360	1000	381	104	28.9%	123	34.0%	133	92	138	126	131	133	128	125	113	124	123
TASHSS2	-	KUNYAK2	220	945	360	1000	381	104	28.9%	123	34.0%	133	92	138	126	131	133	128	125	113	124	123
TASHSS2	-	KUNYAK2	220	945	360	1000	381	104	28.9%	123	34.0%	133	92	138	126	131	133	128	125	113	124	123
KUNYAK2	-	YAKZAK2	220	945	360	1000	381	105	29.0%	68	19.0%	36	29	80	65	87	44	81	75	56	70	69
KUNYAK2	-	ADOLAT2	220	825	314	1000	381	110	35.0%	79	25.2%	60	19	119	83	104	80	98	88	35	82	80
KUNYAK2	-	FIZABT2	220	825	314	1000	381	155	49.2%	99	31.3%	85	37	127	102	118	99	113	105	65	101	99
ADOLAT2	-	FIZABT2	220	690	263	828	316	70	26.5%	52	19.8%	39	19	81	54	69	53	66	59	23	54	53
SYLDRY2	-	K-K-YA2	220	825	314	990	377	123	39.0%	73	23.1%	72	97	151	80	82	77	80	76	76	65	72
K-K-YA2	-	ADOLAT2	220	945	360	1000	381	205	56.9%	134	37.3%	131	188	257	104	159	148	156	144	90	147	137
NVAGRN2	-	ADOLAT2	220	945	360	1000	381	76	21.2%	71	19.8%	81	141	89	58	62	74	67	70	84	75	72
NVAGRN2	-	ADOLAT2	220	945	360	1000	381	132	36.6%	124	34.3%	139	245	154	100	106	129	116	120	145	130	125
NVAGRN2	-	ANGREN2	220	945	360	1000	381	276	76.7%	244	67.7%	251	272	277	292	304	277	284	262	155	242	243
NVAGRN2	-	ANGREN2	220	945	360	1000	381	166	46.2%	147	40.8%	151	164	167	176	183	167	171	158	94	146	147
ANGREN2	-	OBHYAT2	220	825	314	990	377	184	58.5%	148	47.2%	154	170	174	185	194	174	179	162	83	147	148
ANGREN2	-	OBHYAT2	220	825	314	990	377	194	61.8%	157	49.9%	163	180	183	195	205	184	189	171	87	155	156
OBHYAT2	-	UZBKST2	220	945	360	1000	381	230	63.8%	299	83.0%	305	320	323	334	344	324	329	312	231	298	299
UZBKST2	-	FERGNA2	220	945	360	1000	381	63	17.4%	37	10.4%	42	59	62	65	70	60	65	50	71	36	37
FERGNA2	-	SOKIN2	220	945	360	1000	381	156	43.2%	152	42.3%	148	132	128	125	118	132	128	141	218	152	152
SOKIN2	-	LOCHIN2	220	945	360	1000	381	200	55.7%	175	48.5%	172	164	163	157	154	162	160	168	215	175	175
SOKIN2	-	LOCHIN2	220	945	360	1000	381	200	55.7%	175	48.5%	172	164	163	157	154	162	160	168	215	175	175
LOCHIN2	-	OKTYBR2	220	945	360		0	39	10.9%	43	12.1%	44	46	47	38	33	45	45	44	78	42	43
LOCHIN2	-	OKTYBR2	220	945	360		0	39	10.9%	43	12.1%	44	46	47	38	33	45	45	44	78	42	43
OKTYBR2	-	KURPSI2	220	945	360		0	128	35.5%	344	95.4%	346	353	354	367	382	355	358	350	308	344	344
LOCHIN2	-	HAKENT2	220	945	360	1000	381	135	37.6%	101	27.9%	100	99	99	89	80	97	96	98	142	100	100
LOCHIN2	-	ULDUZ2	220	945	360	1000	381	78	21.6%	52	14.4%	53	57	58	49	42	56	57	54	85	51	52
HAKENT2	-	ULDUZ2	220	925	352	1000	381	25	7.0%	124	35.3%	126	131	132	134	136	132	133	128	111	124	124
ULDUZ2	-	KRISTL2	220	825	314	1000	381	115	36.6%	340	108.2%	344	354	356	370	383	357	361	350	285	340	340
KRISTL2	-	KURPSI2	220	945	360		0	257	71.3%	292	81.2%	290	283	281	276	277	281	279	286	367	292	292
KRISTL2	-	K-RAVT2	220	1380	526	1000	381	176	46.2%	282	73.9%	279	270	267	263	259	268	265	274	320	282	282
KRISTL2	-	SARDOR2	220	825	314	1000	381	107	34.2%	186	59.3%	184	175	173	169	166	174	171	180	222	187	187
K-RAVT2	-	SARDOR2	220	1380	526	1656	631	87	16.5%	149	28.4%	146	137	135	129	126	135	132	142	190	150	149
OBHYAT2	-	SARDOR2	220	825	314	990	377	44	14.1%	68	21.7%	64	59	59	52	50	56	55	61	129	69	68
TASTPP2	-	SYMKNT2	220	945	360		0	86	23.9%	107	29.7%	123	110	112	114	82	271	94	96	166	104	106
TASTPP2	-	SMKTSK2	220	945	360		0	108	29.9%	137	38.0%	154	140	143	145	109	314	124	125	200	134	136
SYMKNT2	-	SMKTSK2	220	945	360		0	20	5.6%	22	6.0%	37	26	25	28	15	184	7	7	101	19	21
SYMKNT2	-	JAMBYL2	220	945	360		0	44	12.3%	76	21.0%	70	74	89	89	36	63	265	67	150	71	74
JAMBYL2	-	JMBLSK2	220	945	360		0	116	32.3%	115	32.0%	112	115	117	119	104	100	98	144	151	113	115
JAMBYL2	-	JMBLSK2	220	945	360		0	116	32.3%	115	32.0%	112	115	117	119	104	100	98	144	151	113	115
JMBLSK2	-	FRNZEN2	220	945	360		0	32	8.9%	29	8.0%	27	28	34	33	25	28	31	64	60	28	28
JMBLSK2	-	YY	220	945	360		0	43	12.0%	46	12.9%	44	46	49	49	35	36	37	66	75	45	46
YY	-	GLAYNY2	220	945	360		0	46	12.8%	144	39.9%	141	143	147	147	131	132	133	167	169	141	143
FRNZEN2	-	ALARCH2	220	945	360		0	122	34.0%	274	76.1%	274	274	273	272	274	272	272	269	282	270	273
FRNZEN2	-	KARABT2	220	945	360		0	122	33.9%	234	64.9%	235	234	233	232	237	236	237	227	229	232	233
FRNZEN2	-	KARABT2	220	945	360		0	113	31.4%	217	60.1%	217	217	215	215	219	219	219	211	212	215	216
ALARCH2	-	BYSTRK2	220	945	360		0	37	10.2%	114	31.8%	114	115	113	113	114	112	111	108	122	111	113
BYSTRK2	-	GLAYNY2	220	945	360		0	29	8.2%	88	24.4%	86	88	87	87	81	78	78	93	118	83	86
GLAYNY2	-	KARABT2	220	945	360		0	121	33.6%	187	51.9%	188	187	183	183	192	186	186	169	187	184	186
BYSTRK2	-	PC2	220	945	360		0	152	42.3%	227	63.1%	229	226	232	231	235	245	251	235	184	235	230
PC2	-	ALMTTP2	220	945	360		0	102	28.4%	127	35.2%	127	127	128	128	131	134	135	128	116	131	128
PC2	-	ALMTTP2	220	945	360		0	102	28.4%	127	35.2%	127	127	128	128	131	134	135	128	116	131	128
ALMATY2	-	ALMTTP2	220	945	360		0	104	28.9%	122	33.9%	123	122	123	123	125	127	128	123	114	125	123
ALMATY2	-	ALMTTP2	220	945	360		0	104	28.9%	122	33.9%	123	122	123	123	125	127	128	123	114	125	123
ALMATY2	-	ALMTTP2	220	945	360		0	104	28.9%	122	33.9%	123	122	123	123	125	127	128	123	114	125	123
TASHSS2	-	CHARVK2	220	945	360		0	314	87.1%	311	86.5%	312	313	309	311	311	311	310	311	325	311	311
TASHSS2	-	CHARVK2	220	945	360		0	314	87.1%	311	86.5%	312	313	309	311	311	311	310	311	325	311	311
SYLDRY2	-	ZARBDR2	220	690	263	828	316	240	91.2%	293	111.4%	293	293	294	293	294	293	293	293	287	370	298
ZARBDR2	-	CBAZAR2	220	690	263	828	316	171	64.9%	245	93.0%	245	245	246	244	245	245	245	245	242	291	248
CBAZAR2	-	RUDAKI2	220	690	263	828	316	153	58.1%	180	68.4%	180	180	181	180	180	180	180	180	177	214	182
RUDAKI2	-	SMRKND2	220	690	263	828	316	95	36.0%	115	43.7%	115	115	116	115	115	115	115	115	112	156	118
SYLDRY2	-	DJIZAK2	220	825	314	990	377	214	68.0%	318	101.1%	318	319	319	318	319	318	318	318	311	407	324
DJIZAK2	-	BABUR2	220	825	314	990	377	176	56.1%	188	59.9%	188	189	189	188	189	188	189	188	184	237	192
BABUR2	-	SMRKND2	220	825	314	1000	381	175	55.8%	187	59.6%	187	188	188	187	188	188	188	187	183	239	191
SMRKND2	-	KKURGN2	220	945	360	600	229	82	35.7%	40	17.7%	40	40	41	39	38	40	40	40	49	81	41
KKURGN2	-	HIMIYA2	220	945	360	1000	381	96	26.6%	112	31.1%	112	112	111	113	113	112	112	112	113	109	109
SMRKND2	-	SUBDI2	220	945	360	1000	381	47	13.0%	42	11.6%	42	41	41	42	42	42	42	42	48	63	40
SUBDI2	-	HIMIYA2	220	945	360	1000	381	53	14.9%	49	13.7%	49	49	48	49	49	49	49	49	56	54	46
HIMIYA2	-	NAVOI2	220	945	360	1000	381	100	27.6%	103	28.6%	103	103	102	103	103	103	103	103	103	98	101
HIMIYA2	-	NAVOI2	220	945	360	1000	381	100	27.6%	103	28.6%	103	103	102	103	103	103	103	103	103	98	101
HIMIYA2	-	NAVOI2	220	945	360	1000	381	100	27.6%	103	28.6%	103	103	102	103	103	103	103	103	103	98	101
NAVOI2	-	BUHARA2	220	945	360	600	229	48	20.8%	14	6.1%	14	13	13	14	15	14	14	14	28	82	19
NAVOI2	-	BUHARA2	220	945	360	600	229	48	20.8%	14	6.1%	14	13	13	14	15	14	14	14	28	82	19
NAVOI2	-	KARSHI2	220	825	314	990	377	54	17.3%	18	5.8%	18	18	16	19	20	19	19	18	33	109	28
KARAKL2	-	BUHARA2	220	825	314	990	377	100	31.8%	91	28.9%	91	91	91	91	90	91	91	91	97	15	88
KARAKL2	-	BUHARA2	220	825	314	990	377	100	31.8%	91	28.9%	91	91	91	91	90	91	91	91	97	15	88
KARAKL2	-	TIRON2	220	825	314	990	377	46	14.6%	54	17.1%	54	54	54	54	54	54	54	54	54	48	53
TIRON2	-	TRMRJN2	220	610	232	732	279	19	8.1%	18	7.7%	18	18	18	18	18	18	18	18	15	91	20
TIRON2	-	MUBARK2	220	690	263	828	316	23	8.8%	7	2.6%	7	7	7	7	8	7	7	7	10	72	10
KARAKL2	-	MUBARK2	220	825	314	990	377	22	6.9%	32	10.2%	32	32	32	32	32	32	32	32	32	55	32
KARSHI2	-	MUBARK2	220	825	314	990	377	17	5.3%	22	7.1%	22	22	22	23	23	23	23	22	16	147	25
GUZAR2	-	KARSHI2	220	945	360	945	360	221	61.3%	207	57.6%	207	207	207	207	207	207	207	207	211	355	205
GUZAR2	-	SHURTN2	220	945	360		0	178	49.4%	165	45.7%	165	164	164	165	164	164	164	164	167	275	163
GUZAR2	-	NSKMK2	220	825	314	1000	381	171	54.4%	148	47.1%	148	148	148	148	148	148	148	148	150	215	147
NSKMK2	-	TRMRJN2	220	825	314	990	377	109	34.7%	80	25.4%	80	80	80	80	80	80	80	80	79	49	80
KARSHI2	-	SHURTN2	220	945	360		0	44	12.2%	43	11.8%	43	43	43	43	42	43	43	43	45	79	41
KARSHI2	-	NSKMK2	220	825	314	1000	381	54	17.2%	32	10.2%	32	32	32	32	32	32	32	32	33	14	33
KARSHI2	-	TRMRJN2	220	825	314	990	377	18	5.6%	15	4.7%	15	15	15	15	15	15	15	15	19	27	13
TRMRJN2	-	SHURTN2	220	945	360		0	127	35.1%	102	28.2%	102	102	101	102	102	102	102	102	103	168	101
BUHARA2	-	TIRON2	220	825	314	990	377	52	16.6%	26	8.3%	26	26	27	25	24	26	26	26	43	78	18
NUREK2	-	BAIPAZ2	220	945	360		0	68	19.0%	101	27.9%	100	100	100	101	101	101	101	101	97	104	123
NUREK2	-	YAVAN2	220	945	360		0	214	59.6%	308	85.5%	308	308	308	308	309	308	308	308	299	318	364
REGAR2	-	DJANDA2	220	945	360		0	95	26.5%	68	19.0%	69	69	69	68	68	68	68	68	77	60	59
REGAR2	-	SHRBAD2	220	945	360		0	49	13.7%	46	12.8%	46	46	46	46	46	46	46	46	47	45	46
REGAR2	-	SHRBAD2	220	945	360		0	50	13.8%	46	12.8%	46	46	46	46	46	46	46	46	48	45	46
SURHAN2	-	SHRBAD2	220	945	360		0	189	52.5%	245	68.1%	245	245	245	245	245	245	245	245	247	243	239
DJANDA2	-	YAVAN2	220	945	360		0	224	62.3%	321	89.2%	321	321	321	322	322	321	321	321	317	326	363
YAVAN2	-	BAIPAZ2	220	945	360		0	81	22.4%	76	21.2%	76	76	76	76	76	76	76	76	76	76	74
DJANDA2	-	BAIPAZ2	220	945	360		0	151	42.0%	199	55.2%	199	199	199	199	199	199	199	199	197	201	219

Table 4.5-2 Power Flow Calculation Result (Voltage value of each SS)

		node voltage (normal condition)			
		summer		winter	
base_V	NAME	(kV)	(%)	(kV)	(%)
500	TASTPP5	513.34	102.7%	507.90	101.6%
500	TASHSS5	513.34	102.7%	508.69	101.7%
500	NVAGRN5	507.66	101.5%	503.98	100.8%
500	SYRDRY5	534.89	107.0%	529.03	105.8%
500	LOCHIN5	531.66	106.3%	520.58	104.1%
500	SYMKNT5	517.20	103.4%	507.22	101.4%
500	JAMBYL5	519.94	104.0%	505.42	101.1%
500	FRNZEN5	522.98	104.6%	506.58	101.3%
500	T-ALBL5	542.53	108.5%	531.79	106.4%
500	ALABEL5	543.01	108.6%	531.76	106.4%
500	TOKTGL5	542.24	108.4%	535.43	107.1%
500	ALMATY5	500.12	100.0%	500.10	100.0%
500	GUZAR5	542.84	108.6%	524.28	104.9%
500	KARAKL5	543.38	108.7%	528.33	105.7%
500	REGAR5	518.07	103.6%	508.56	101.7%
500	SURHAN5	519.67	103.9%	514.03	102.8%
500	NUREK5	519.76	104.0%	513.97	102.8%
220	TASTPP2	219.82	99.9%	218.54	99.3%
220	TASHSS2	222.12	101.0%	220.87	100.4%
220	KUNYAK2	214.32	97.4%	213.24	96.9%
220	YAKZAK2	213.15	96.9%	212.46	96.6%
220	NVAGRN2	216.82	98.6%	216.88	98.6%
220	ANGREN2	214.87	97.7%	215.59	98.0%
220	OBHYAT2	211.27	96.0%	212.04	96.4%
220	UZBKST2	213.80	97.2%	210.48	95.7%
220	FERGNA2	219.19	99.6%	213.23	96.9%
220	SOKIN2	213.41	97.0%	206.32	93.8%
220	LOCHIN2	218.67	99.4%	209.61	95.3%
220	OKTYBR2	214.55	97.5%	205.16	93.3%
220	HAKENT2	213.80	97.2%	204.89	93.1%
220	ULDUZ2	213.19	96.9%	205.74	93.5%
220	KRISTL2	213.08	96.9%	220.46	100.2%
220	K-RAVT2	210.73	95.8%	219.53	99.8%
220	SARDOR2	213.22	96.9%	219.56	99.8%
220	KURPSI2	219.58	99.8%	220.49	100.2%
220	SYLDRY2	234.01	106.4%	229.09	104.1%
220	K-K-YA2	212.83	96.7%	214.35	97.4%
220	ADOLAT2	213.80	97.2%	214.34	97.4%
220	FIZABT2	213.53	97.1%	213.04	96.8%
220	SYMKNT2	225.48	102.5%	221.62	100.7%
220	SMKTSK2	225.57	102.5%	221.03	100.5%
220	JAMBYL2	224.82	102.2%	218.59	99.4%
220	JMBLSK2	218.82	99.5%	213.46	97.0%
220	FRNZEN2	226.43	102.9%	218.31	99.2%
220	ALMATY2	220.18	100.1%	222.59	101.2%
220	ALARCH2	216.31	98.3%	201.88	91.8%
220	BYSTRK2	213.64	97.1%	205.20	93.3%
220	PC2	220.01	100.0%	220.56	100.3%
220	ALMTTP2	219.01	99.6%	221.84	100.8%
220	GLAYNY2	210.01	95.5%	208.53	94.8%
220	KARABT2	219.14	99.6%	207.43	94.3%
220	CHARVK2	220.33	100.2%	219.80	99.9%
220	YY	218.36	99.3%	215.14	97.8%
220	SMRKND2	234.20	106.5%	219.35	99.7%
220	HIMIYA2	225.83	102.7%	221.61	100.7%
220	NAVOI2	227.26	103.3%	223.70	101.7%
220	KARAKL2	237.70	108.0%	228.07	103.7%
220	BUHARA2	231.98	105.4%	223.62	101.6%
220	TIRON2	234.79	106.7%	225.37	102.4%
220	GUZAR2	237.79	108.1%	227.52	103.4%
220	KARSHI2	234.85	106.8%	222.64	101.2%
220	NSKMK2	236.44	107.5%	221.97	100.9%
220	TRMRJN2	236.27	107.4%	223.60	101.6%
220	SHURTN2	236.48	107.5%	224.13	101.9%
220	MUBARK2	235.95	107.3%	225.08	102.3%
220	ZARBDR2	232.08	105.5%	216.62	98.5%
220	CBAZAR2	234.64	106.7%	215.73	98.1%
220	RUDAKI2	241.06	109.6%	222.80	101.3%
220	DJIZAK2	230.46	104.8%	216.04	98.2%
220	BABUR2	231.39	105.2%	216.46	98.4%
220	KKURGN2	226.30	102.9%	216.00	98.2%
220	SUBDI2	227.45	103.4%	221.55	100.7%
220	NUREK2	227.23	103.3%	221.97	100.9%
220	REGAR2	221.68	100.8%	214.36	97.4%
220	SURHAN2	228.25	103.8%	226.80	103.1%
220	SHRBAD2	219.86	99.9%	217.06	98.7%
220	DJANDA2	215.79	98.1%	201.08	91.4%
220	YAVAN2	220.95	100.4%	207.92	94.5%
220	BAIPAZ2	224.37	102.0%	208.91	95.0%

Table 4.5-3 Short Circuit Current Calculation Result

NAME	BASE Voltage (kV)	breaking capacity (kA)	FAULT CURRENT without CC (KA)	FAULT CURRENT with CC (KA)	FAULT CAPACITY without CC (MVA)	FAULT CAPACITY with CC (MVA)
ALMATY5	500	40	40.0	40.0	34,623	34,629
TASTPP5	500	40	10.9	11.3	9,422	9,771
TASHSS5	500	40	11.8	12.2	10,243	10,599
NVAGRN5	500	40	8.9	9.0	7,677	7,831
SYRDRY5	500	40	13.1	13.1	11,308	11,386
LOCHIN5	500	40	5.7	5.8	4,972	4,982
SYMKNT5	500	40	7.1	7.2	6,141	6,268
JAMBYL5	500	40	5.7	5.7	4,924	4,965
FRNZEN5	500	40	7.1	7.2	6,178	6,202
T-ALBL5	500	40	5.7	5.7	4,964	4,973
ALABEL5	500	40	4.8	4.9	4,196	4,203
TOKTGL5	500	40	6.2	6.2	5,358	5,367
GUZAR5	500	40	5.5	5.5	4,748	4,751
KARAKL5	500	40	3.1	3.1	2,717	2,718
REGAR5	500	40	6.4	6.4	5,538	5,539
SURHAN5	500	40	3.3	3.3	2,892	2,892
NUREK5	500	40	7.8	7.8	6,735	6,736
TASTPP2	220	40	24.7	27.5	9,400	10,469
TASHSS2	220	40	21.7	22.4	8,253	8,551
KUNYAK2	220	40	14.2	14.5	5,396	5,524
YAKZAK2	220	40	11.6	11.9	4,434	4,544
NVAGRN2	220	40	17.1	17.3	6,505	6,578
ANGREN2	220	40	10.8	10.8	4,098	4,124
OBHYAT2	220	40	6.1	6.1	2,328	2,334
UZBKST2	220	40	4.6	4.6	1,742	1,744
FERGNA2	220	40	4.7	4.7	1,784	1,786
SOKIN2	220	40	6.0	6.0	2,278	2,280
LOCHIN2	220	40	8.3	8.3	3,175	3,180
OKTYBR2	220	40	5.3	5.3	2,025	2,026
HAKENT2	220	40	6.1	6.1	2,326	2,328
ULDUZ2	220	40	6.2	6.2	2,378	2,380
KRISTL2	220	40	6.3	6.3	2,399	2,401
K-RAVT2	220	40	4.8	4.8	1,837	1,839
SARDOR2	220	40	4.9	4.9	1,853	1,855
KURPSI2	220	40	7.1	7.1	2,702	2,703
SYLDRY2	220	40	24.3	24.4	9,261	9,293
K-K-YA2	220	40	9.9	10.0	3,767	3,794
ADOLAT2	220	40	14.3	14.4	5,436	5,502
FIZABT2	220	40	11.3	11.5	4,295	4,370
SYMKNT2	220	40	11.8	12.0	4,483	4,564
SMKTSK2	220	40	6.9	7.0	2,615	2,650
JAMBYL2	220	40	9.4	9.5	3,589	3,612
JMBLSK2	220	40	7.0	7.0	2,651	2,662
FRNZEN2	220	40	12.7	12.8	4,857	4,871
ALMATY2	220	40	19.8	19.8	7,527	7,528
ALARCH2	220	40	3.5	3.5	1,350	1,351
BYSTRK2	220	40	4.1	4.1	1,550	1,551
PC2	220	40	6.9	6.9	2,634	2,634
ALMTTP2	220	40	12.4	12.4	4,735	4,735
GLAYNY2	220	40	3.8	3.8	1,447	1,448
KARABT2	220	40	6.0	6.0	2,286	2,289
CHARVK2	220	40	11.5	11.6	4,398	4,438
YY	220	40	2.1	2.1	810	811
SMRKND2	220	40	4.5	4.5	1,729	1,729
HIMIYA2	220	40	8.7	8.7	3,298	3,298
NAVOI2	220	40	10.9	10.9	4,141	4,142
KARAKL2	220	40	7.0	7.0	2,672	2,673
BUHARA2	220	40	7.1	7.1	2,698	2,699
TIRON2	220	40	5.6	5.6	2,147	2,148
GUZAR2	220	40	9.1	9.1	3,479	3,481
KARSHI2	220	40	6.4	6.4	2,447	2,447
NSKMK2	220	40	4.7	4.8	1,810	1,810
TRMRJN2	220	40	5.6	5.6	2,116	2,116
SHURTN2	220	40	5.6	5.6	2,125	2,125
MUBARK2	220	40	4.6	4.6	1,764	1,764
ZARBDR2	220	40	3.7	3.7	1,403	1,403
OBAZAR2	220	40	3.0	3.0	1,156	1,156
RUDAKI2	220	40	3.0	3.0	1,139	1,140
DJIZAK2	220	40	3.5	3.5	1,338	1,339
BABUR2	220	40	3.4	3.4	1,278	1,278
KKURGN2	220	40	4.1	4.1	1,549	1,549
SUBDI2	220	40	5.6	5.6	2,135	2,136
NUREK2	220	40	14.4	14.4	5,481	5,481
REGAR2	220	40	9.9	9.9	3,757	3,758
SURHAN2	220	40	6.4	6.4	2,437	2,437
SHRBAD2	220	40	5.4	5.4	2,053	2,053
DJANDA2	220	40	5.3	5.3	2,037	2,037
YAVAN2	220	40	6.2	6.2	2,360	2,360
BAIPAZ2	220	40	5.3	5.3	2,004	2,004

Winter Peak Calculation results

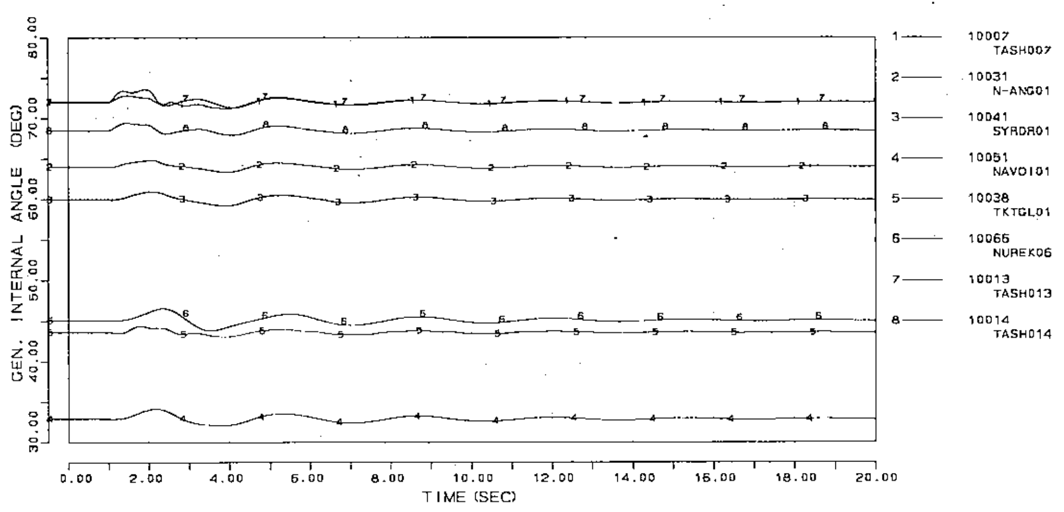


Figure 4.5-3 Static Stability

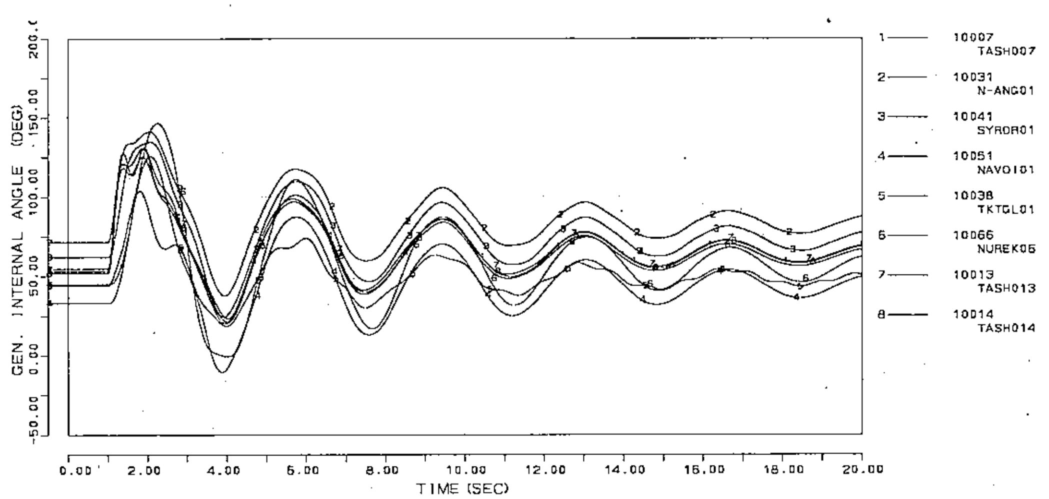


Figure 4.5-4 500kV TL Tashkent TPP-Symkent 2LGO

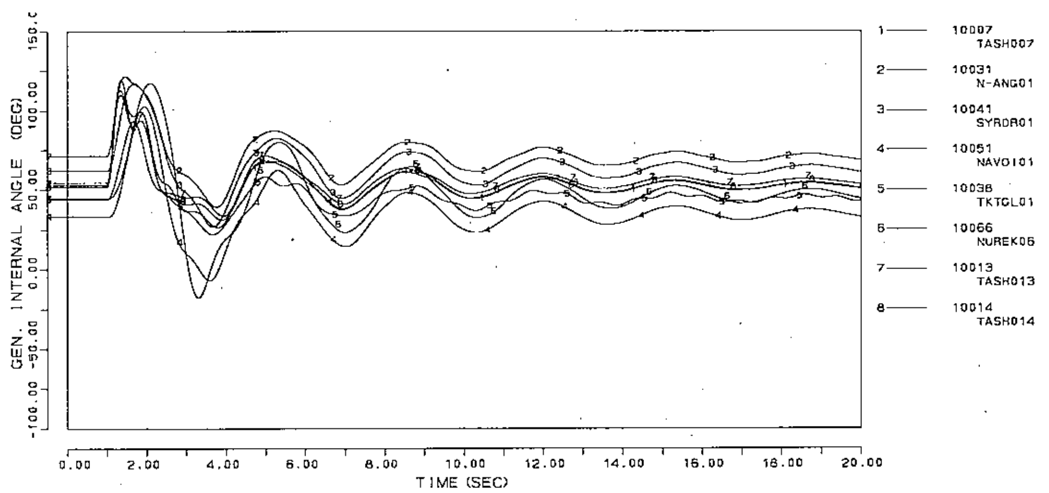


Figure 4.5-5 500kV TL Tashkent TPP-Tashkent SS 2LGO

Winter Peak Calculation results

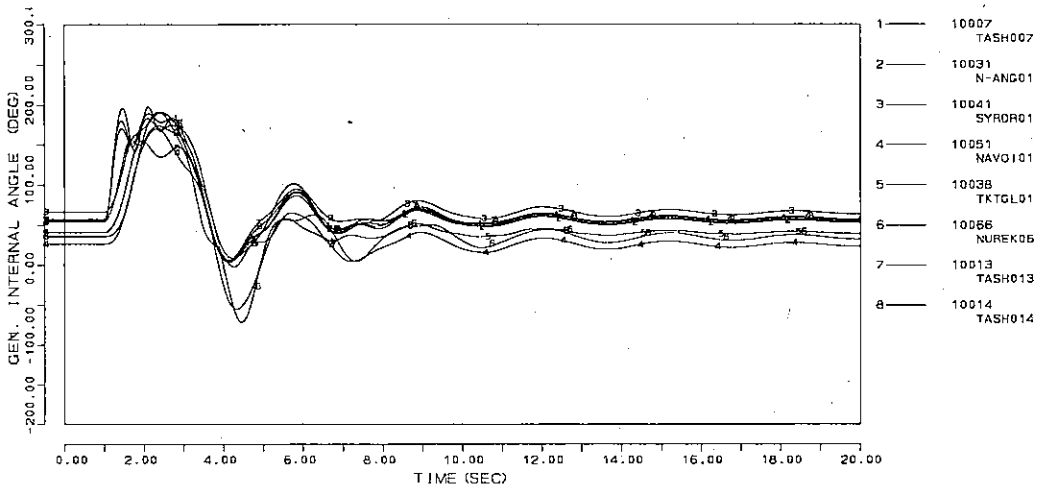


Figure 4.5-6 220kV TL Tashkent TPP-Uksak 2LGO

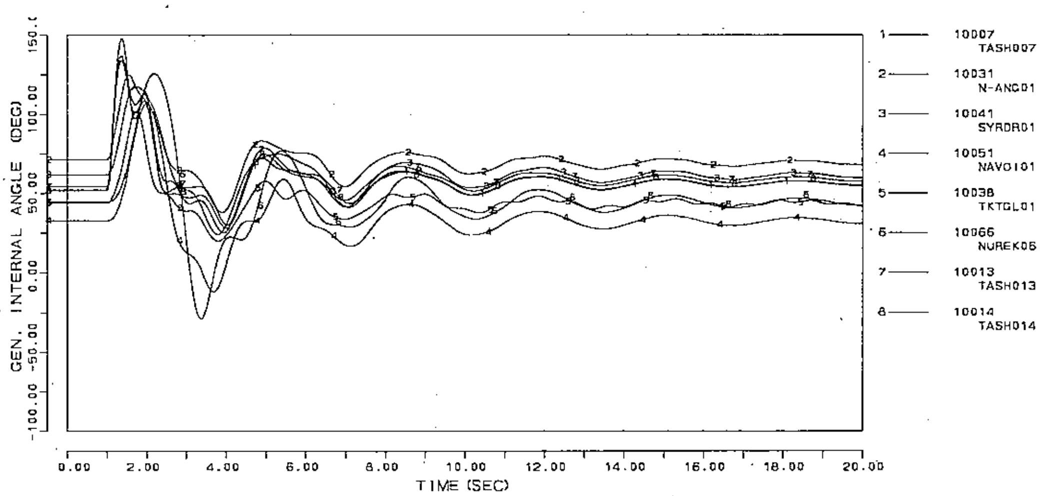


Figure 4.5-7 Tashkent TPP 500/220 Tr 2LGO

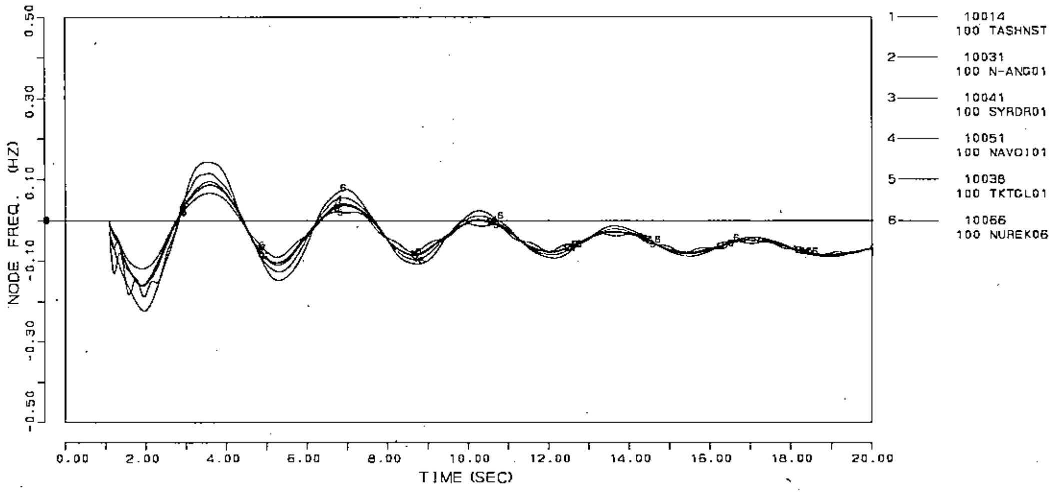


Figure 4.5-8 Tarimaljan 800MW generator drop out (frequency)

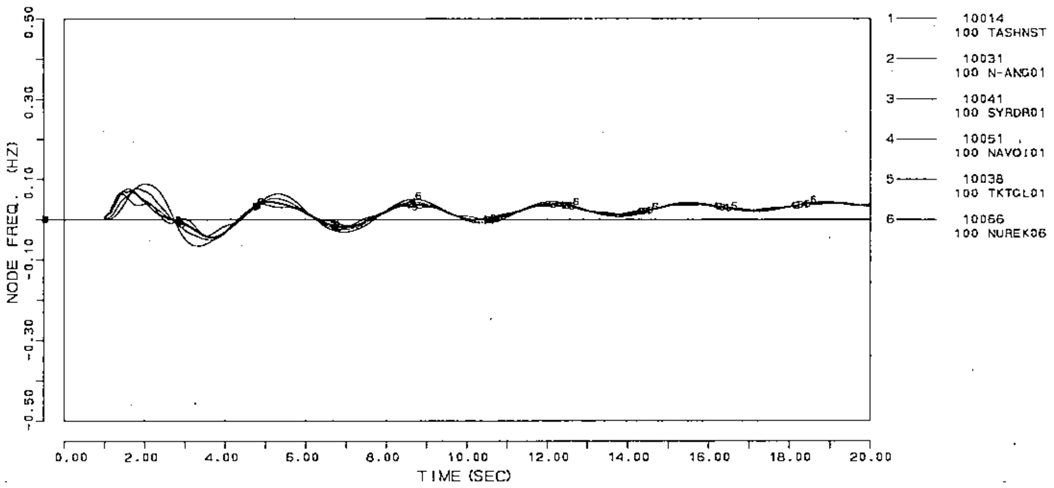


Figure 4.5-9 5% Load reduction (frequency)

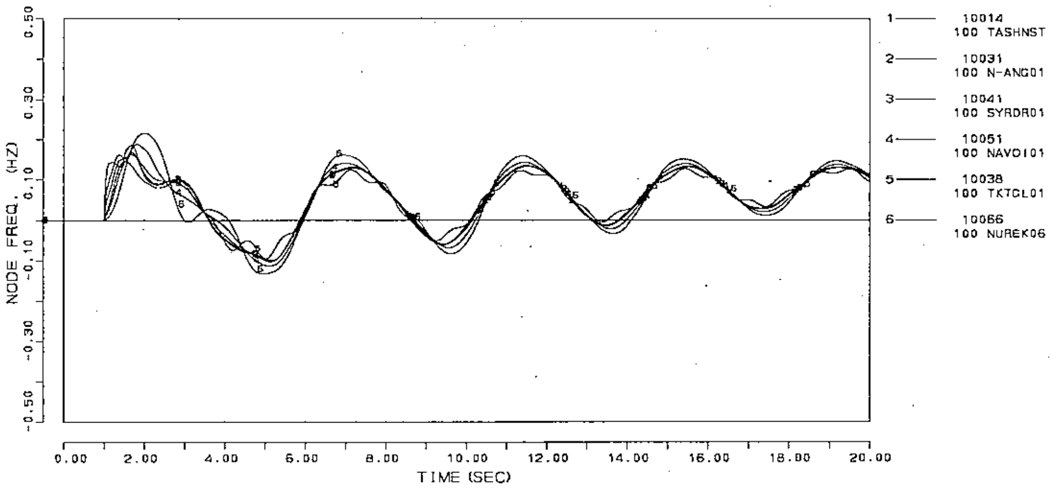
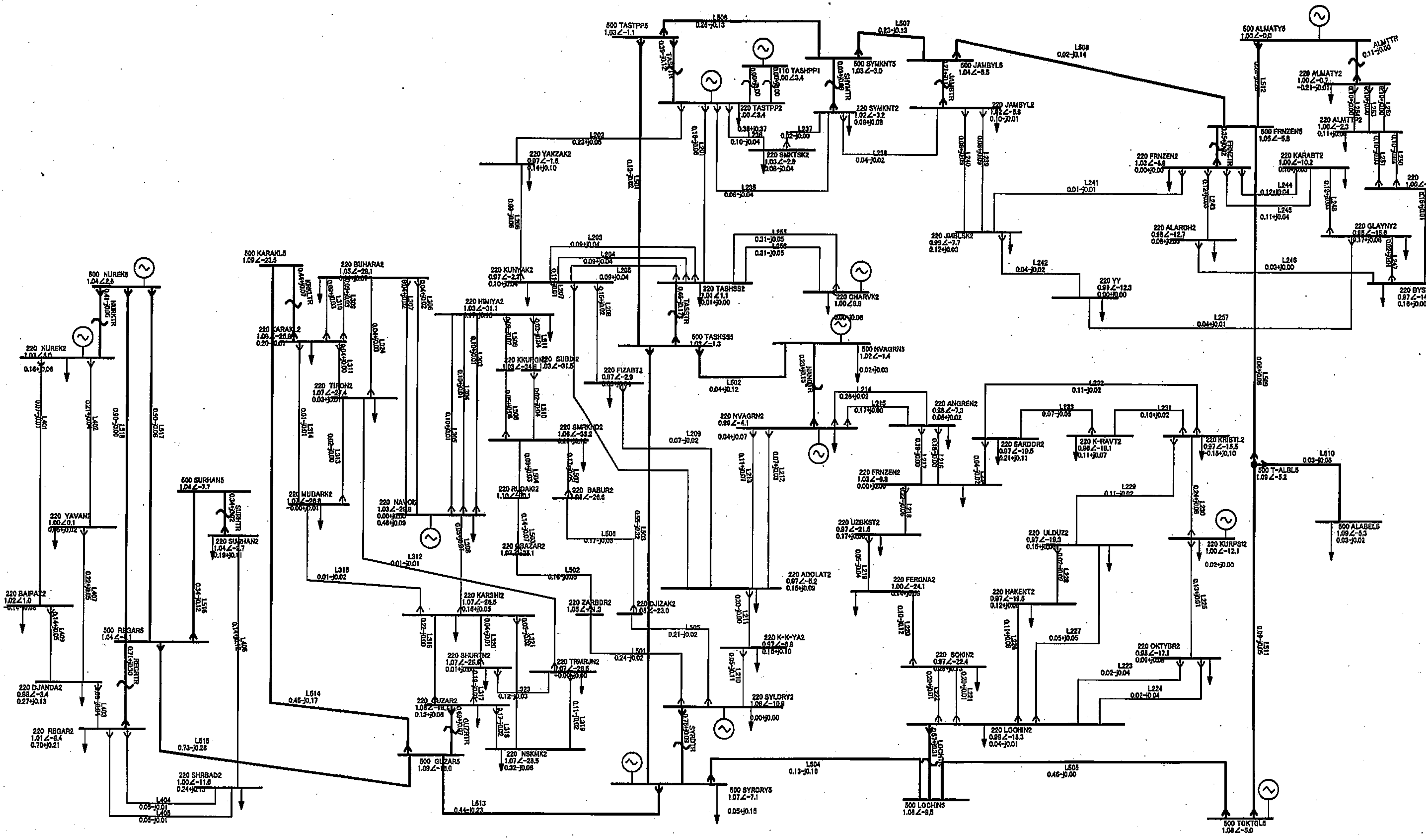


Figure 4.5-10 10% Load reduction (frequency)



注：母線電圧および線路潮流は p.u.値
(ベース電圧 500kV, 220kV　ベース容量 1000MVA)

Figure 4.5-11　Power Flow Diagram of Summer Peak Demand

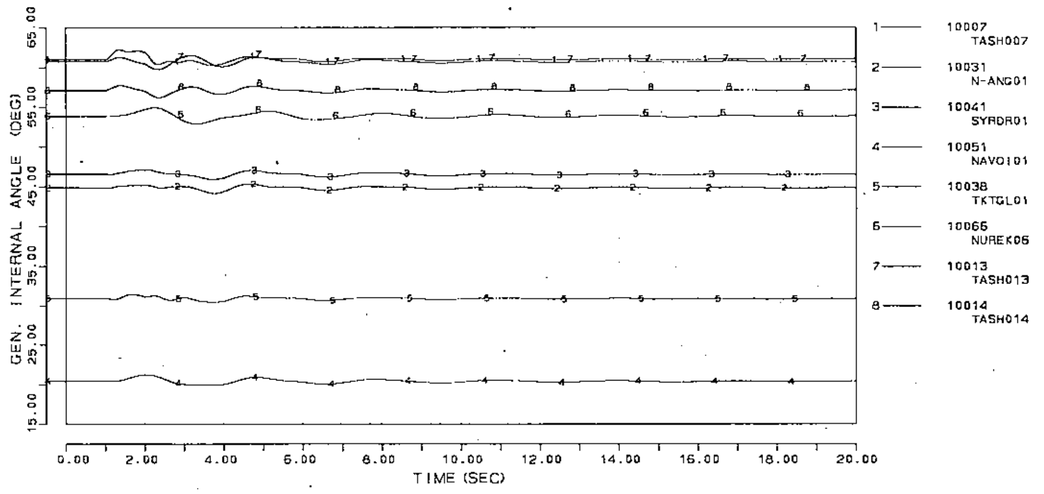


Figure 4.5-12 Static Stability

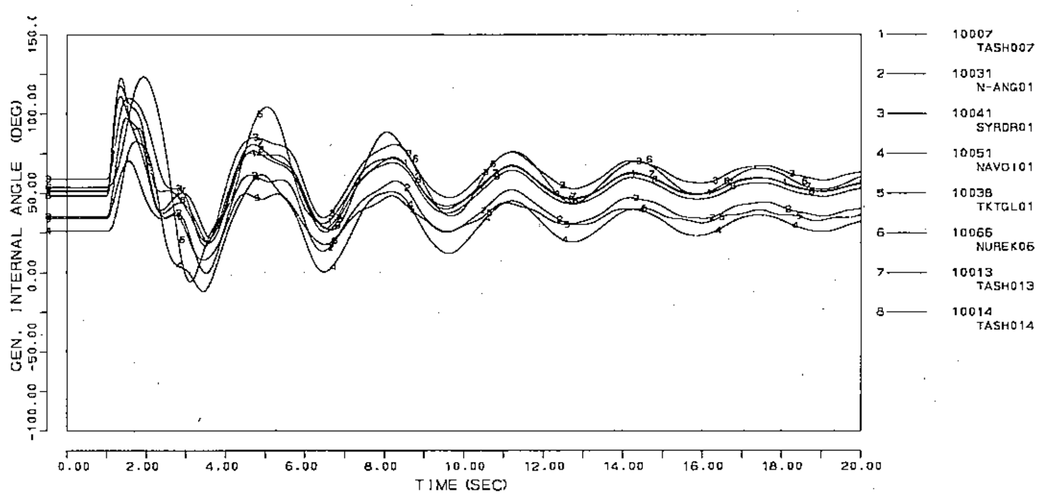


Figure 4.5-13 500kV TL Tashkent TPP-Symkent 2LGO

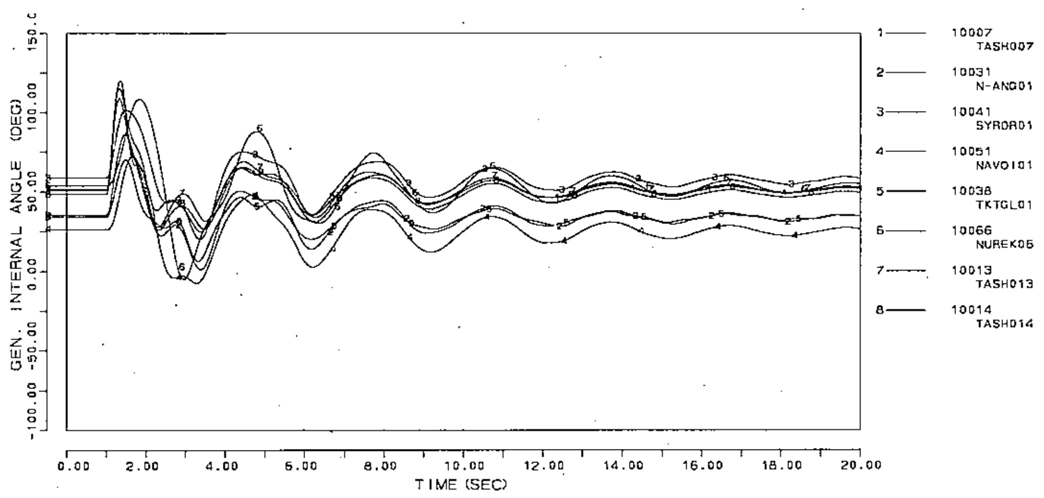


Figure 4.5-14 500kV TL Tashkent TPP-TashkentSS 2LGO

Summer Peak Calculation results

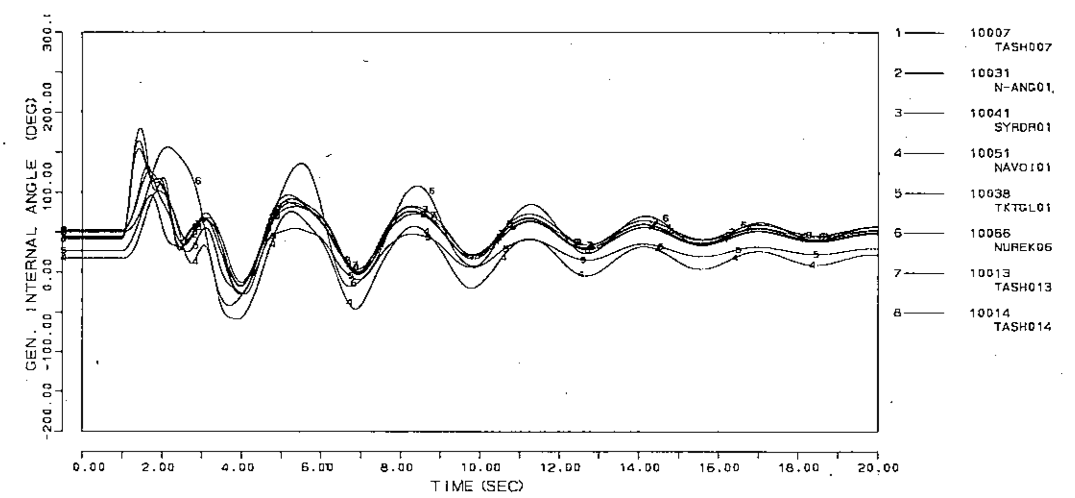


Figure 4.5-15 220kV TL Tashkent TPP-Uksak 2LGO

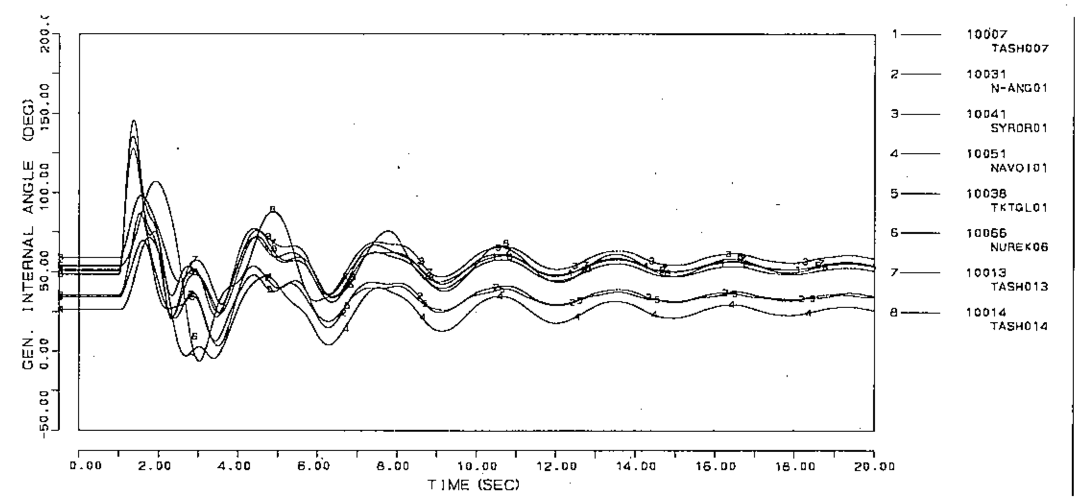


Figure 4.5-16 Tashkent TPP 500/220 Tr 2LGO

Summer Peak Calculation results

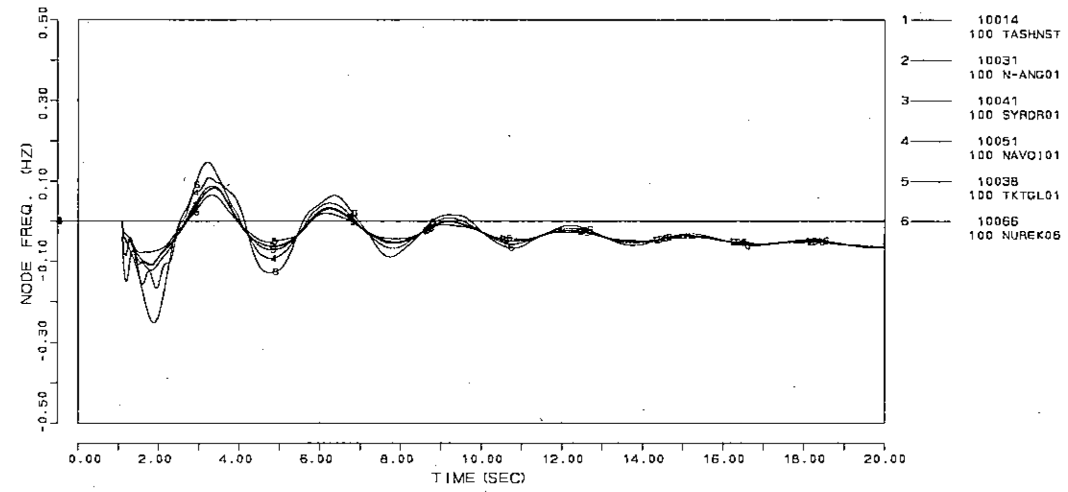


Figure 4.5-17 Tarimaljan 800MW generator drop out (frequency)

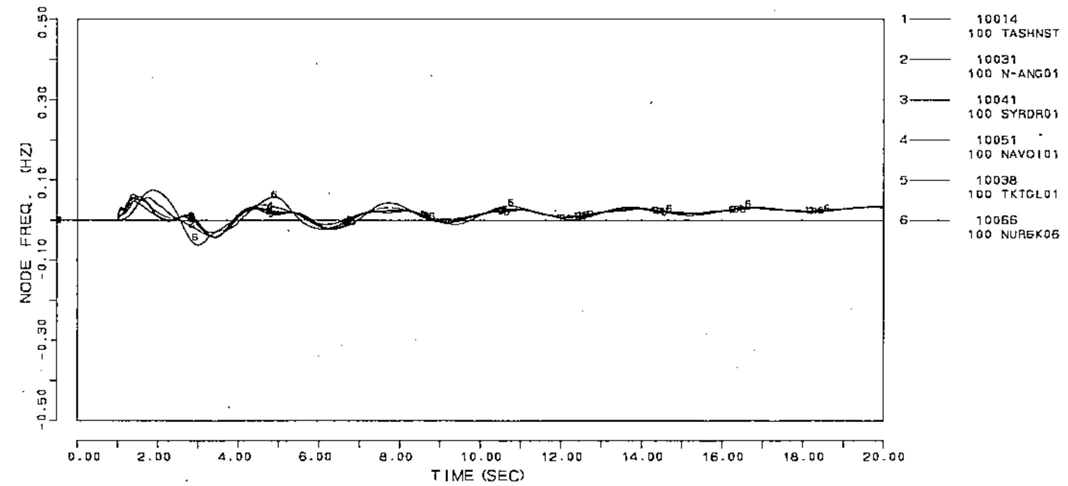


Figure 4.5-18 5% Load reduction (frequency)

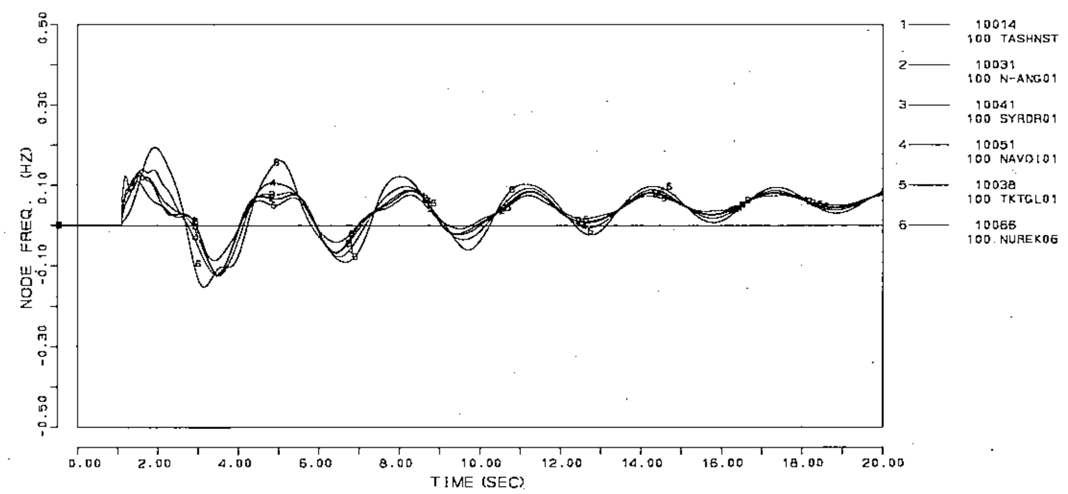


Figure 4.5-19 10% Load reduction (frequency)

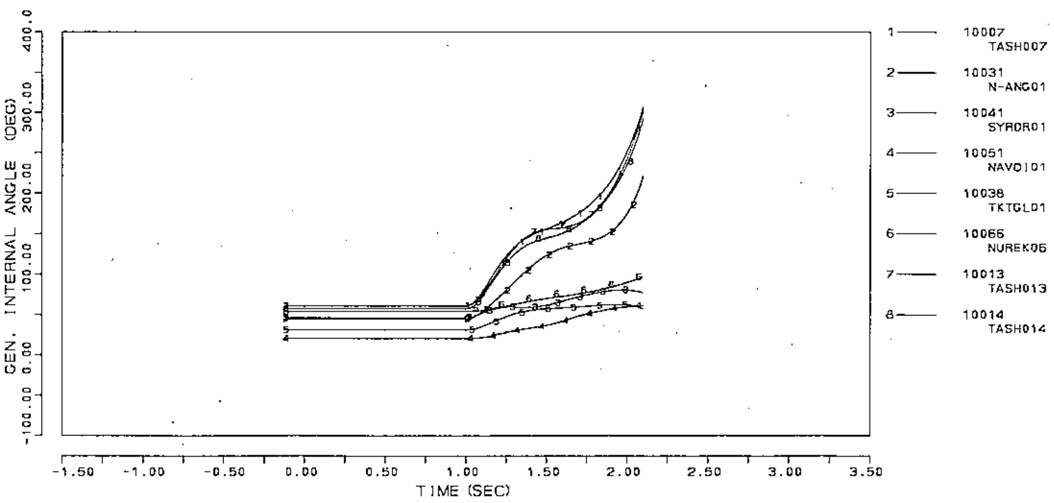


Figure 4.5-20 500kV TL TashkentSS-Syrdariya 3LGO

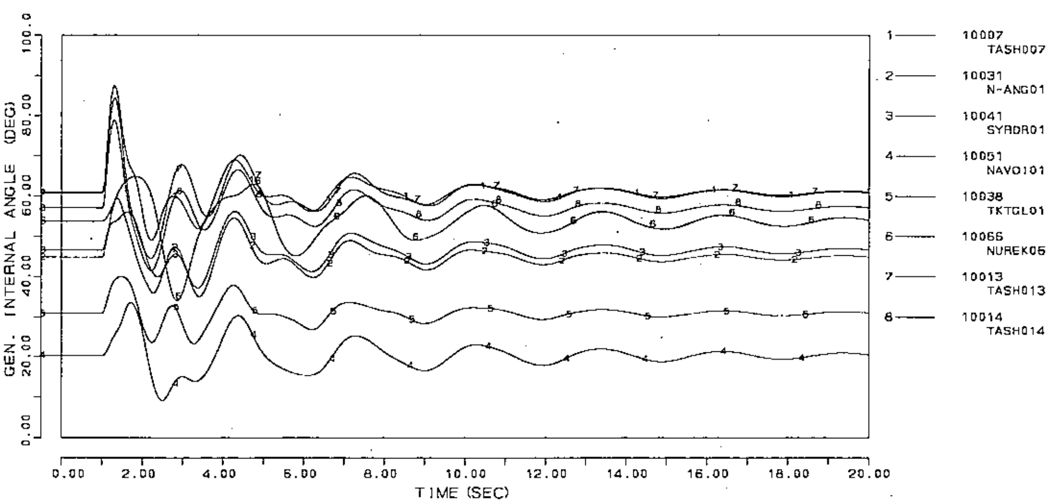


Figure 4.5-21 500kV TL TashkentSS-Syrdariya 1LGOC

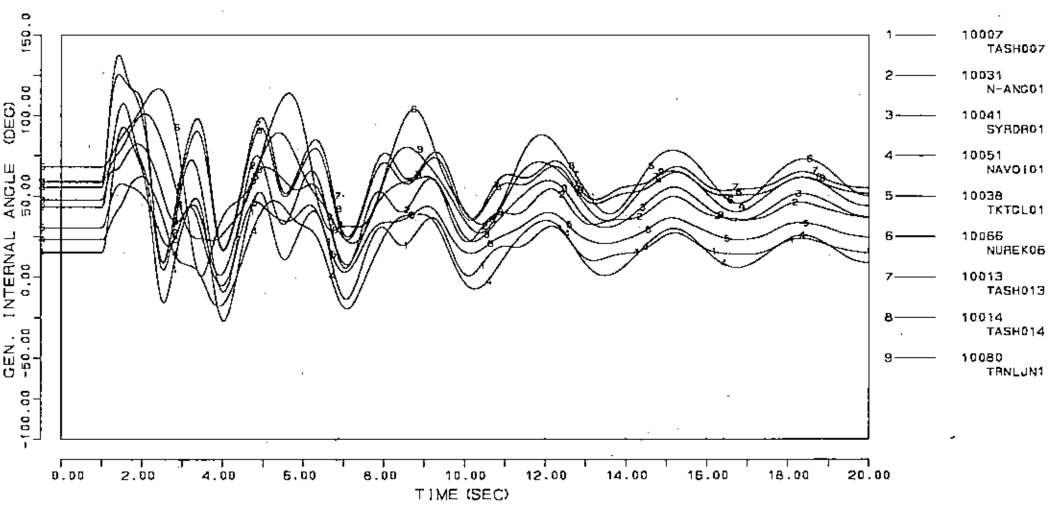


Figure 4.5-22 500kV TL TashkentSS-Syrdariya 3LGO with Tarimaljan

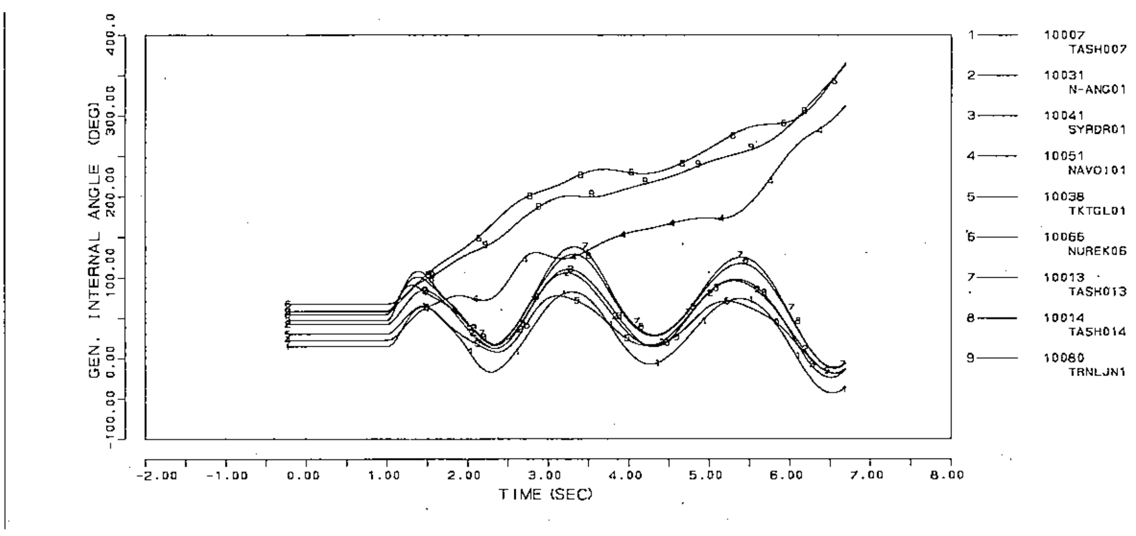


Figure 4.5-23 500kV TL Syrdarya-Guzar 3LGO with Tarimaljan

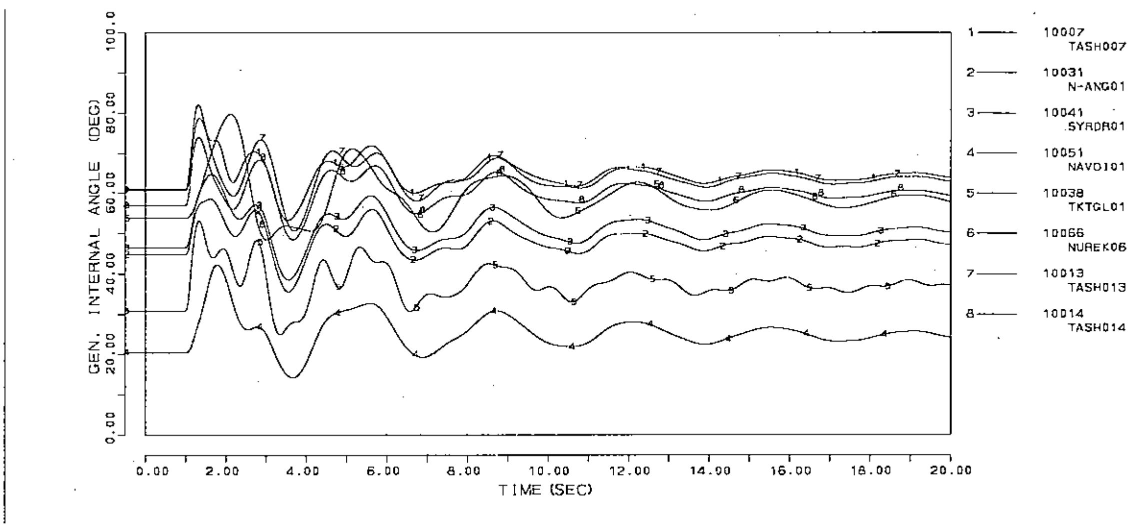


Figure 4.5-24 500kV TL Frunzen-Toktgul 3LGO

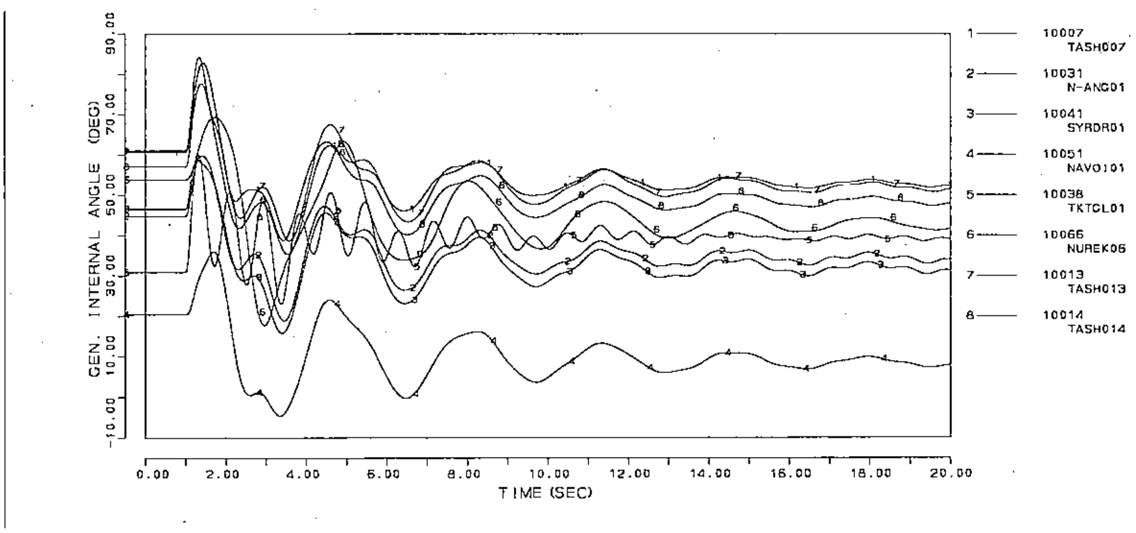


Figure 4.5-25 500kV TL Toktgul-Lochin 3LGO

Chapter 5 Improvement Plan For Tashkent Thermal Power Plant (Dc "Tashtpp")

THE DETAILED DESIGN STUDY FOR

MODERNIZATION OF TASHKENT THERMAL POWER PLANT

IN THE REPUBLIC OF UZBEKISTAN

FINAL REPORT

CONTENTS

LIST OF TABLE

LIST OF PICTURES

LIST OF FIGURES