Transmission Service Request:
Operational Stability Performance Study

Tenaska Gateway Partners, LTD's
Gateway, Texas Project

AEP IPP Project #2005

Transmission Planning
November 2001

AEP: America's Energy Partner℠

1. INTRODUCTION

In response to transmission service requests (TSRs) by agents for Tenaska Gateway Partners, LTD (Tenaska), American Electric Power (AEP) has conducted a stability performance study to determine the maximum generation that may be connected and operated into the AEP transmission system at Tenaska's Gateway Generating Plant. The Gateway Plant is connected to AEP's Pirkey-Crockett 345 kV line and is located in Eastern Texas at a point along the line right of way 36.5 miles from Pirkey Station and 67.0 miles from Crockett Station. This report documents the stability performance study and resulting Gateway Plant generation limits.

Per request by Tenaska, a screening study was undertaken to determine if adding series compensation to the Gateway-Crockett-Grimes 345 kV line would improve stability performance of the Gateway Plant, and how much compensation would be required to allow the full capability of the Gateway Plant, 913 MW (winter, net), to be accommodated. The results of this screening study are included here.

2. OVERVIEW OF GENERATION FACILITY

Figure 1 shows the transmission system in the vicinity of the Gateway 345 kV Station indicating the transmission paths to Grimes via Crockett and to Pirkey. Figure 2 shows the arrangement of the Gateway combined cycle generation facility. Each generator is connected through a circuit breaker and step-up transformer into the Gateway 345 kV switchyard which, on the AEP side, is then connected into a three circuit breaker ring bus on the Pirkey-Crockett line as shown in Figure 2.

The Gateway switching configuration is such that the four generators may be connected to either the AEP or ERCOT transmission systems in any combination. For the purposes of the TSR and this study, the generation connected to the AEP transmission system is considered to be dispatched according to the schedule in Table 1 below. These dispatch increments are based on winter MW capability data supplied by Tenaska.

3. TESTING CRITERIA

AEP transient stability criteria for 345 kV connected generation facilities shown in Table 2 below specify the conditions and events for which stable operation is required. In addition, satisfactory damping of generating unit post-disturbance power oscillations is required.

These testing criteria are used in time domain simulations to evaluate the stability performance of a proposed generation facility. For each disturbance, the resulting transmission system response is simulated and then analyzed to assess the impact of the disturbance scenarios on the proposed generators and the surrounding system.

Table 1
Gateway Net MW Dispatch Increments

Machines in Service	Net MW Dispatch per Machine	Total Net MW
1 GT	170 MW	170 MW
1 GT + ST	170 MW + 142 MW	312 MW
2 GTs	1@170 MW, 1@180 MW	350 MW
1 GT + ST *	180 MW + 284 MW	464 MW
3 GTs	2@170 MW, 1@180 MW	520 MW
1 GT + ST **	180 MW + 393 MW	573 MW
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW
2 GTs + ST ***	2@155 MW + 395 MW	705 MW
2 GTs + ST **	1@170 MW, 1@180 MW + 393 MW	743 MW
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW

* ST at 2 GT level presuming second GT dispatched to ERCOT
** ST at 3 GT level presuming other GT(s) dispatched to ERCOT
*** ST at 3 GT level presuming other GT dispatched to ERCOT, summer capability

Table 2
AEP Stability Disturbance Testing Criteria for 345 kV Connected Generation

Prefault System Condition	Fault Disturbance Scenario
All Facilities In Service	**1A.** Permanent phase-to-ground fault with primary breaker failure. Fault cleared by backup breakers. **1B.** Permanent 3-phase fault with unsuccessful HSR where applicable. Fault cleared by primary breakers. **1C.** 3-phase line opening without fault.
One Facility Out of Service	**1D.** Permanent 3-phase fault with unsuccessful HSR where applicable. Fault cleared by primary breakers. **1E.** 3-phase line opening without fault.

4. STUDY SCOPE

Dynamic simulations were conducted for the following limiting disturbance scenario and corresponding post-contingency transmission configurations as follows:

Case 4 – No prior outages. Permanent three phase fault at Gateway 345 kV on line to Pirkey. Fault clearing in 3.5 cycles. Gateway generation remains connected through Crockett and Grimes 138 kV. (Criterion 1B)

Case 4A – Prior outage of Crockett 345/138 kV transformer. Otherwise, same as Case 4. (Criterion 1D)

Case 4B – Prior outage of Grimes-Mt. Zion-Huntsville 138 kV line. Otherwise, same as Case 4. (Criterion 1D)

Case 4C – Prior outage of one of two Grimes 345/138 kV transformers. Otherwise, same as Case 4. (Criterion 1D)

Case 4D – Prior outage of Grimes-Walden-Conroe 138 kV line. Otherwise, same as Case 4. (Criterion 1D)

Case 4E – Prior outage of Grimes-Colstta-Bryan 138 kV line. Otherwise, same as Case 4. (Criterion 1D)

Case 4F – Prior outage of Grimes-Mag And-Navasota 138 kV line. Otherwise, same as Case 4. (Criterion 1D)

Case 4G – Prior outage of Crockett-Grimes 345 kV line. Otherwise, same as Case 4. (Criterion 1D)

The following other disturbance scenarios were considered in this study but were found to result in stability limits that were not as restrictive as the limits established by Case 4 above:

Case 1 – No prior outages. Permanent phase-to-ground fault at Pirkey 345 kV on line to Diana. Fault clearing at Diana end in 3.5 cycles with circuit breaker failure at Pirkey. Backup clearing in 10.5 cycles removing line to Gateway and Pirkey 345/138 kV. Gateway generation remains connected through Crockett 345 kV. (Criterion 1A)

Case 2 – No prior outages. Permanent phase-to-ground fault at Crockett 345 kV on line to Grimes. Fault clearing at Grimes end in 3.5 cycles with circuit breaker failure at Crockett. Backup clearing in 18.5 cycles removing line to Grimes and Crockett 345/138 kV. Gateway generation remains connected through Pirkey 345 kV. (Criterion 1A)

Case 3 – Prior outage of Pirkey-Diana 345 kV. Permanent three phase fault at Gateway 345 kV on line to Crockett. Fault clearing in 3.5 cycles. Gateway generation remains connected through Pirkey 138 kV. (Criterion 1D)

Case 5 – Prior outage of Pirkey-Diana 345 kV. Non-fault initiated tripping of Gateway-Crockett 345 kV. Gateway generation remains connected through Pirkey 138 kV. (Criterion 1E)

Case 6 – Prior outage of one Grimes or Crockett outlet (see Cases 4A-F above). Non-fault initiated tripping of Gateway-Pirkey 345 kV. Gateway generation remains connected through Crockett/Grimes 138 kV. (Criterion 1E)

5. DYNAMICS BASE CASE

A dynamics base case representing Southwest Power Pool 2002 summer peak load conditions was used for this study. Tenaska's Gateway generation project was added to the base case using data and other information provided by Tenaska, and was modeled in this study as shown in Attachment 1. The dynamics data and modeling information as documented in Attachment 1 are assumed to be the final data for the Gateway Plant generating units reflecting equipment commissioning tests and field settings. Power system stabilizers were included on all four of the Tenaska Gateway machines with settings of KS1=30 as noted in Attachment 1. The Tenaska Frontier Project at the Grimes 345 kV Station was represented in this stability study as either off line or at 300 MW (2 GTs at 150 MW each) as noted.

6. STABILITY SIMULATION RESULTS – Operating Study

The stability study results indicating the maximum permissible generation at Gateway are given in Tables 3 through 8 below. Attachment 2 contains plots of Gateway and Frontier machine speeds and selected bus voltages from the simulations on the base conditions that bound the stability limits.

The plots shown in conjunction with Tables 3 through 6 include the cases at the highest stable MW level and the next highest level showing the unstable result. The plots shown in conjunction with Tables 7 and 8 show only selected plots from among the four prior outage conditions at the highest stable MW level and the next highest unstable level. Other plots at lower MW levels (520 and 573) are included as verification that these levels are acceptable considering that different combinations of GT and ST generators are involved and the stability performance was marginal.

Table 3
Gateway Stability Results, Frontier at 0 MW
No Prior Outages

Machines in Service	Net MW Dispatch per Machine	Total Net MW	Result
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Stable
1 GT + ST	180 MW + 393 MW	573 MW	Stable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Stable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

Table 4
Gateway Stability Results, Frontier at 300 MW
No Prior Outages

Machines in Service	**Net MW Dispatch per Machine**	**Total Net MW**	**Result**
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Stable
1 GT + ST	180 MW + 393 MW	573 MW	Stable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Stable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

Table 5
Gateway Stability Results, Frontier at 0 MW
Prior Outage of Crockett 345/138 kV or Grimes-Huntsville 138 kV

Machines in Service	**Net MW Dispatch per Machine**	**Total Net MW**	**Result**
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Unstable *
1 GT + ST	180 MW + 393 MW	573 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Unstable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

* unstable for Crockett 345/138 kV prior outage; post-disturbance power swings too poorly damped for Grimes-Huntsville 138 kV prior outage.

Table 6
Gateway Stability Results, Frontier at 300 MW
Prior Outage of Crockett 345/138 kV or Grimes-Huntsville 138 kV

Machines in Service	**Net MW Dispatch per Machine**	**Total Net MW**	**Result**
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Unstable
1 GT + ST	180 MW + 393 MW	573 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Unstable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

Table 7
Gateway Stability Results, Frontier at 0 MW
Prior Outage of Grimes 345/138 (1), Grimes-Conroe, Grimes-Bryan, or Grimes-Navasota 138 kV

Machines in Service	**Net MW Dispatch per Machine**	**Total Net MW**	**Result**
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Stable
1 GT + ST	180 MW + 393 MW	573 MW	Stable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Stable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

Table 8
Gateway Stability Results, Frontier at 300 MW
Prior Outage of Grimes 345/138 (1), Grimes-Conroe, Grimes-Bryan, or Grimes-Navasota 138 kV

Machines in Service	**Net MW Dispatch per Machine**	**Total Net MW**	**Result**
1 GT	170 MW	170 MW	Stable
1 GT + ST	170 MW + 142 MW	312 MW	Stable
2 GTs	1@170 MW, 1@180 MW	350 MW	Stable
1 GT + ST	180 MW + 284 MW	464 MW	Stable
3 GTs	2@170 MW, 1@180 MW	520 MW	Stable
1 GT + ST	180 MW + 393 MW	573 MW	Stable
2 GTs + ST	1@170 MW, 1@180 MW + 284 MW	634 MW	Unstable
2 GTs + ST	2@155 MW + 395 MW	705 MW	Unstable
2 GTs + ST	1@170 MW, 1@180 MW + 393 MW	743 MW	Unstable
3 GTs + ST	2@170 MW, 1@180 MW + 393 MW	913 MW	Unstable

The prior outage of Crockett-Grimes 345 kV line followed by the outage of Gateway-Pirkey 345 kV line, Case 4G, results operation of Gateway generation through Crockett 138 kV only. The Gateway Plant would need to be curtailed to 150 MW or less whenever the Crockett-Grimes 345 kV line is out in anticipation of the outage of Gateway-Pirkey 345 kV line. Similarly, the Gateway Plant would need to be curtailed to 150 MW or less whenever Gateway-Pirkey 345 kV line is out in anticipation of the outage of Crockett-Grimes 345 kV line.

7. STABILITY SIMULATION RESULTS – Series Compensation

The use of series compensation on the Crockett-Gateway and Crockett-Grimes 345 kV lines was investigated to determine if the maximum Gateway net generation of 913 MW could be accommodated. Increments of 10 percent series compensation with equal percentages on Crockett-Gateway and Crockett-Grimes lines were considered. Both series cap banks were assumed to be located at Crockett. The results of this limited-scope investigation are summarized in Table 9 and plots of the simulations with series compensation are shown in Attachment 3.

Table 9
Gateway Stability Results w/ Series Compensation of
Crockett-Gateway & Crockett-Grimes 345 kV lines, No Prior Outages

% Series Comp	**Gateway Net MW**	**Frontier Net MW**	**Result**
60	913	0	Unstable
70	913	0	Stable
80	913	300	Unstable

8. SUMMARY

- The stability performance of Tenaska's Gateway Generating Plant is acceptable up to 634 MW with all transmission facilities in the vicinity of Gateway (Figure 1) in service and the Frontier Plant at 300 MW or less. Gateway Plant generation into the AEP Transmission System must not exceed 634 MW.

- With outage of one of two Grimes 345/138 kV transformers, or the Grimes-Conroe, Grimes-Bryan, or Grimes-Navasota 138 kV lines, Gateway generation must not exceed 634 MW when Frontier is off-line, or 573 MW when the Frontier Plant is on-line and generating 300 MW or less.

- The Gateway Plant generation must not exceed 464 MW if either the Crockett 345/138 kV transformer or Grimes-Huntsville 138 kV line is out of service and the Frontier Plant is off line, or on line and at 300 MW or less.

- Gateway Plant generation limits with the Frontier Plant at more than 300 MW have not been determined and would probably be lower than the above limts.

- The Gateway Plant must be curtailed to 150 MW or less whenever either the Crockett-Grimes 345 kV line or the Gateway-Pirkey 345 kV line is out of service in anticipation of outage of the other.

- At all times operating power system stabilizers with setting KS1=30, are required on all Gateway Plant generators operated into the AEP transmission system in order to achieve satisfactory damping of post-disturbance power oscillations.

- The dynamics data and modeling information as documented in Attachment 1 is assumed to be the final data for the Gateway Plant generating units reflecting equipment commissioning tests and field settings.

- In order to permit up to 913 MW of generation at Gateway to operate into the AEP Transmission System, a series compensation level of at least 70 percent is required on both Crockett-Gateway and Crockett-Grimes 345 kV lines. Operation of the Frontier Plant would cause series compensation requirements in excess of 80 percent on both lines depending on the Frontier generation dispatch.

- Series compansation is not recommended due to probable severe system impacts. If series compensation of Crockett-Gateway and Crockett-Grimes 345 kV lines is to be further considered, the load flow and short circuit impacts would need to be assessed, as well as sub-synchronous resonance impacts on both Gateway and Frontier Plants, and possibly other nearby generating plants. The use of series compensation would also necessitate the redesign of line relaying systems.

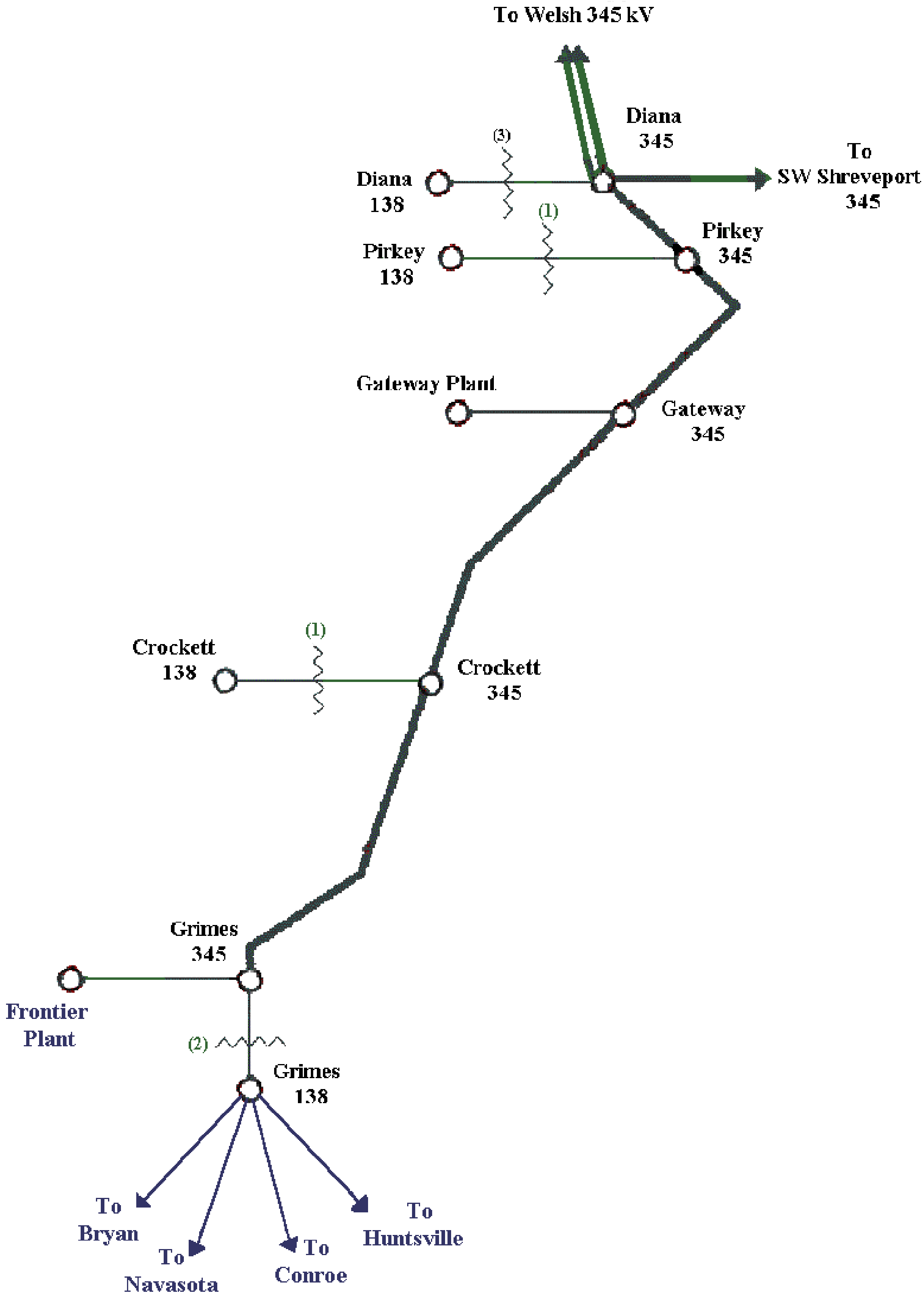


Figure 1 - Transmission System in the Vicinity of Gateway Plant

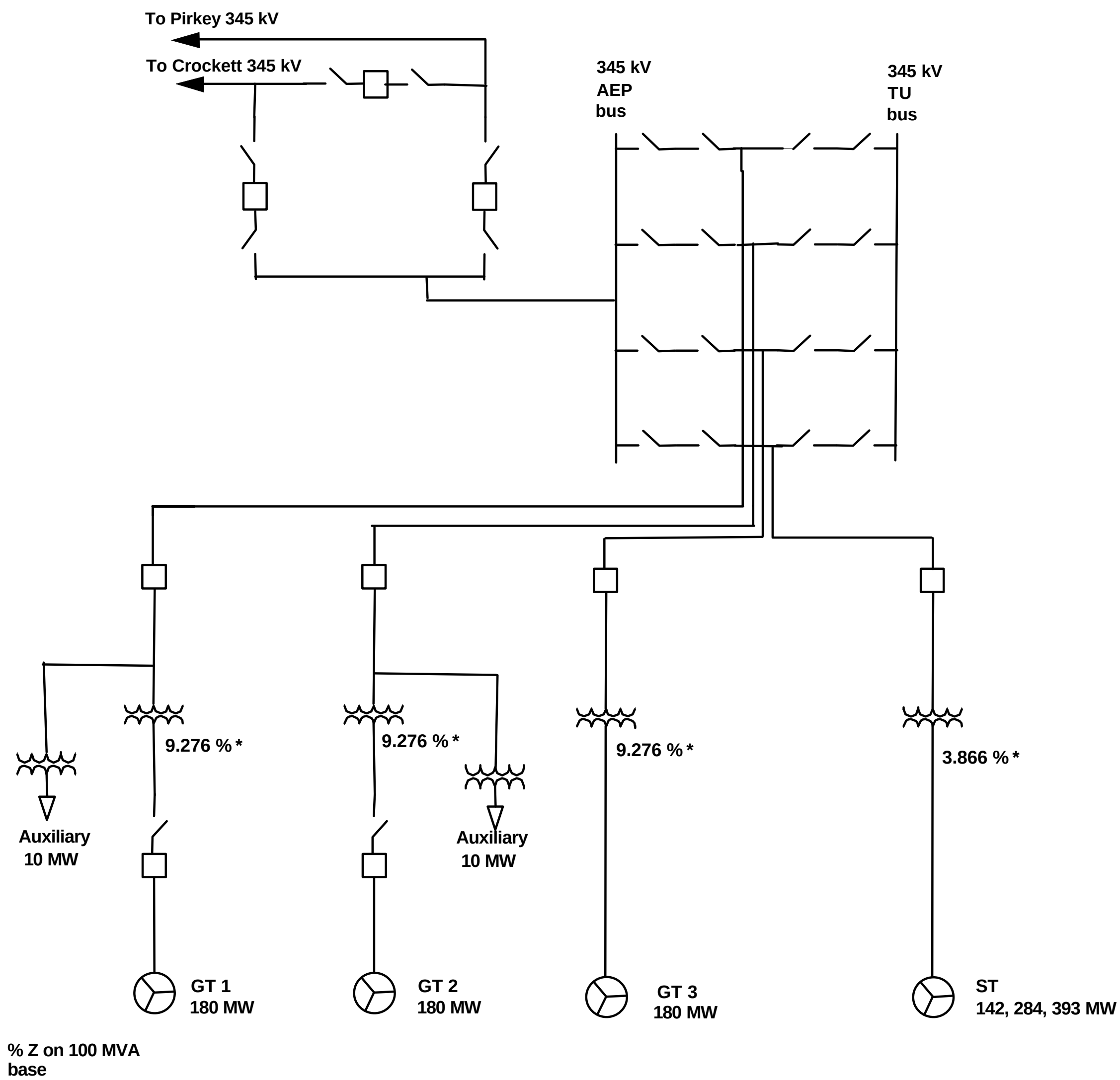


Figure 2 - Tenaska Gateway Generating Plant

Attachment 1

Tenaska Gateway Generation

Dynamics Data

GENROU - GT

Round Rotor Generator Model
(Quadratic Saturation)

Value	Description
198.9	Base MVA
0.003	R_a
4.767	T'_{do} (>0) (sec)
0.033	T''_{do} (>0) (sec)
0.387	T'_{qo} (>0) (sec)
0.075	T''_{qo} (>0) (sec)
5.6	Inertia, H
0	Speed damping, D
1.819	X_d
1.736	X_q
0.276	X'_d
0.449	X'_q
0.195	$X''_d = X''_q$
0.161	X_l
0.05	S(1.0)
0.23	S(1.2)

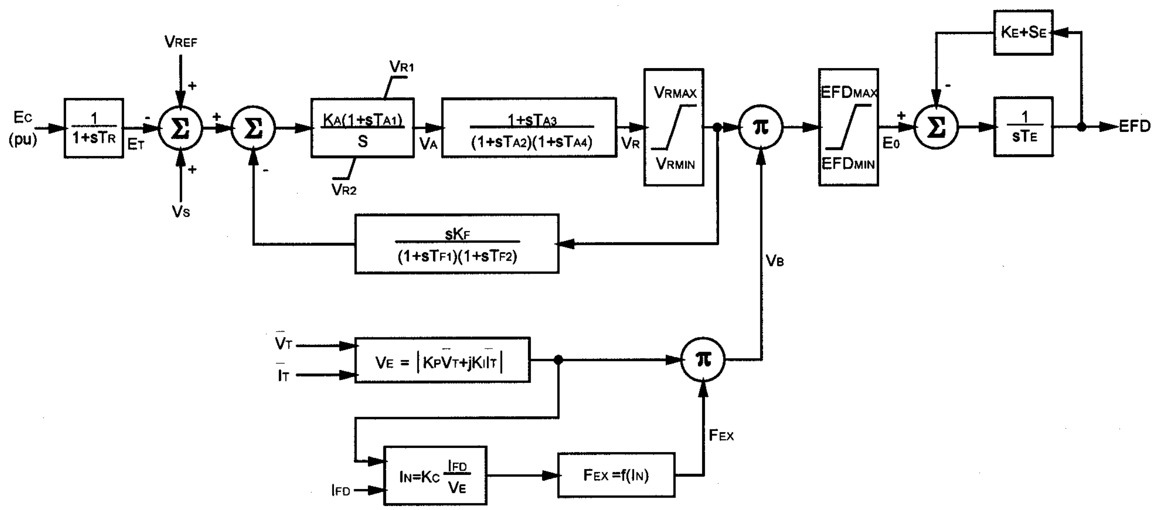
X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu , machine MVA base,
X''_q must be equal to X''_d.

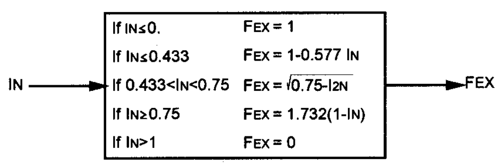
EXPIC1 - GT

Proportional/Integral Excitation System

Value	Description
0	T_R (sec)
3.14	K_A
1.0	T_{A1} (sec)
1.0	V_{R1}
-0.87	V_{R2}
0.01	T_{A2} (sec)
0	T_{A3} (sec)
0	T_{A4} (sec)
1.0	V_{RMAX}
-0.87	V_{RMIN}
0	K_F
1.0	T_{F1} (>0) (sec)
1.0	T_{F2} (sec)
7.96	EFD_{MAX}
0	EFD_{MIN}
0	K_e
0	T_e (sec)
0	E_1
0	SE_1
0	E_2
0	SE_2
6.37	K_P
0	K_I
0.08	K_C

EXPIC1





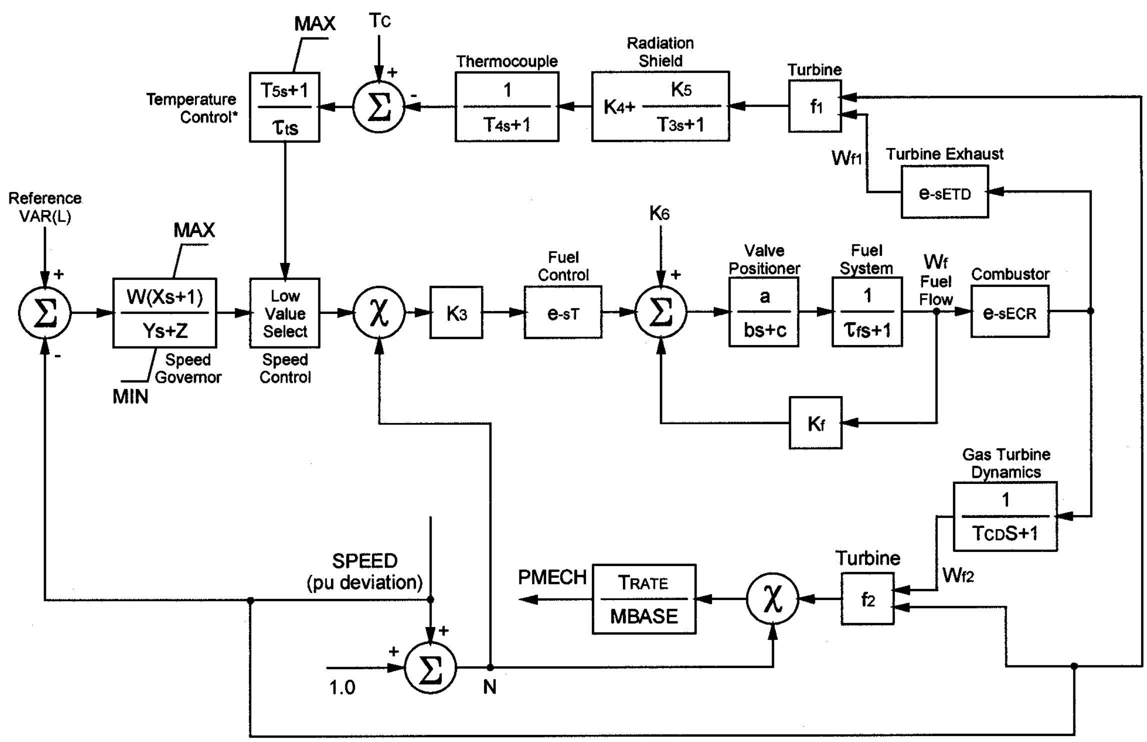
If (KP = 0 and KI = 0), then VB = 1.
If TE = 0, then EFD = E0.
VS = VOTHSG + VUEL + VOEL

GAST2A - GT

Gas Turbine Model

Value	Description
25.0	W - governor gain (1/droop) (on turbine rating)
0	X (sec) governor lead time constant
0.05	Y (sec) (>0) governor lag time constant
1.0	Z - governor mode: 1 - Droop 0 - ISO
0.04	E_{TD} (sec)
0.20	T_{CD} (sec)
179.0	T_{RATE} turbine rating (MW)
0.125	T (sec)
1.0	MAX (pu) limit (on turbine rating)
0	MIN (pu) limit (on turbine rating)
0.01	E_{CR} (sec)
1.0	K_3
1.0	a (>0) valve positioner
0.2	b (sec) (>0) valve positioner
1.0	c valve positioner
0.2	J_f (sec) (>0)
0	K_f
0.20	K_5
0.80	K_4
15.0	T_3 (sec) (>0)
2.5	T_4 (sec) (>0)
450	J_t (sec) (>0)
3.30	T_5 (sec) (>0)
700	a_{f1}
550.0	b_{f1}
0.201	a_{f2}
1.3	b_{f2}
0.5	c_{f2}
1100	Rated temperature, T_R (°F)
0.15	Minimum fuel flow, K_6 (pu)
1130	Temperature control, T_C (°F)

GAST2A



$f_1 = T_R - a_{f1}(1.-w_{f1}) - b_{f1}(\text{speed})$ $f_2 = a_{f2} + b_{f2}(w_{f2}) - c_{f2}(\text{speed})$

*Temperature control output is set to output of speed governor when temperature control input changes from positive to negative.

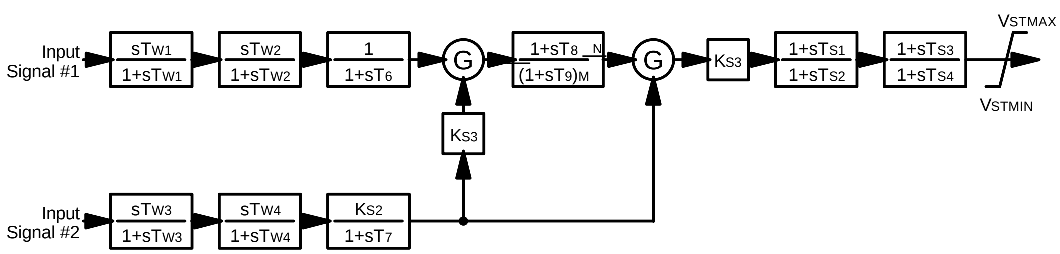
PSS2A - GT

IEEE Dual-Input Stabilizer Model

Value	Description
1	ICS1, first stabilizer input code: 1 - rotor speed deviation (pu) 2 - bus frequency deviation (pu) 3 - generator electric power on MBASE base (pu) 4 - generator accelating power (pu) 5 - bus voltage (pu) 6 - derivative of pu bus voltage
	REMBUS1, first remote bus number
3	ICS2, second stabilizer input code: 1 - rotor speed deviation (pu) 2 - bus frequency deviation (pu) 3 - generator electric power on MBASE base (pu) 4 - generator accelating power (pu) 5 - bus voltage (pu) 6 - derivative of pu bus voltage
	REMBUS2, second remote bus number
5	M, ramp tracking filter
1	N, ramp tracking filter

Value	Description
2	T_{w1} (>0)
2	T_{w2}
0	T_6
2	T_{w3} (>0)
0	T_{w4}
2	T_7
0.179	K_{S2}
1.0	K_{S3}
0.5	T_8
0.1	T_9 (>0)
30	K_{S1}
0.15	T_1
0.03	T_2
0.15	T_3
0.03	T_4
0.1	V_{STMAX}
-0.1	V_{STMIN}

PSS2A


Input Signal #1
sTW1
1+sTW1
sTW2
1+sTW2
1
1+sT6
G
1+sT8
N
(1+sT9)M
G
KS3
1+sTS1
1+sTS2
1+sTS3
1+sTS4
VSTMAX
VSTMIN
KS3
Input Signal #2
sTW3
1+sTW3
sTW4
1+sTW4
KS2
1+sT7

GENROU - ST

Round Rotor Generator Model
(Quadratic Saturation)

Value	Description
444.4	Base MVA
0.003	R_a
4.756	T'_{do} (>0) (sec)
0.031	T''_{do} (>0) (sec)
0.422	T'_{qo} (>0) (sec)
0.068	T''_{qo} (>0) (sec)
3.92	Inertia, H
0	Speed damping, D
1.834	X_d
1.77	X_q
0.277	X'_d
0.423	X'_q
0.205	$X''_d = X''_q$
0.17	X_l
0.07	S(1.0)
0.28	S(1.2)

X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_j, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

EXPIC1 - ST

Proportional/Integral Excitation System

Value	Description
0	T_R (sec)
4.20	K_A
1.0	T_{A1} (sec)
1.0	V_{R1}
-0.87	V_{R2}
0.01	T_{A2} (sec)
0	T_{A3} (sec)
0	T_{A4} (sec)
1.0	V_{RMAX}
-0.87	V_{RMIN}
0	K_F
1.0	T_{F1} (>0) (sec)
1.0	T_{F2} (sec)
5.96	EFD_{MAX}
0	EFD_{MIN}
0	K_e
0	T_e (sec)
0	E_1
0	SE_1
0	E_2
0	SE_2
4.77	K_P
0	K_I
0.09	K_C

PSS2A - ST

IEEE Dual-Input Stabilizer Model

Value	Description
1	ICS1, first stabilizer input code: 1 - rotor speed deviation (pu) 2 - bus frequency deviation (pu) 3 - generator electric power on MBASE base (pu) 4 - generator accelating power (pu) 5 - bus voltage (pu) 6 - derivative of pu bus voltage
	REMBUS1, first remote bus number
3	ICS2, second stabilizer input code: 1 - rotor speed deviation (pu) 2 - bus frequency deviation (pu) 3 - generator electric power on MBASE base (pu) 4 - generator accelating power (pu) 5 - bus voltage (pu) 6 - derivative of pu bus voltage
	REMBUS2, second remote bus number
5	M, ramp tracking filter
1	N, ramp tracking filter

Value	Description
2	T_{w1} (>0)
2	T_{w2}
0	T_6
2	T_{w3} (>0)
0	T_{w4}
2	T_7
0.255	K_{S2}
1.0	K_{S3}
0.5	T_8
0.1	T_9 (>0)
30	K_{S1}
0.15	T_1
0.03	T_2
0.15	T_3
0.03	T_4
0.1	V_{STMAX}
-0.1	V_{STMIN}

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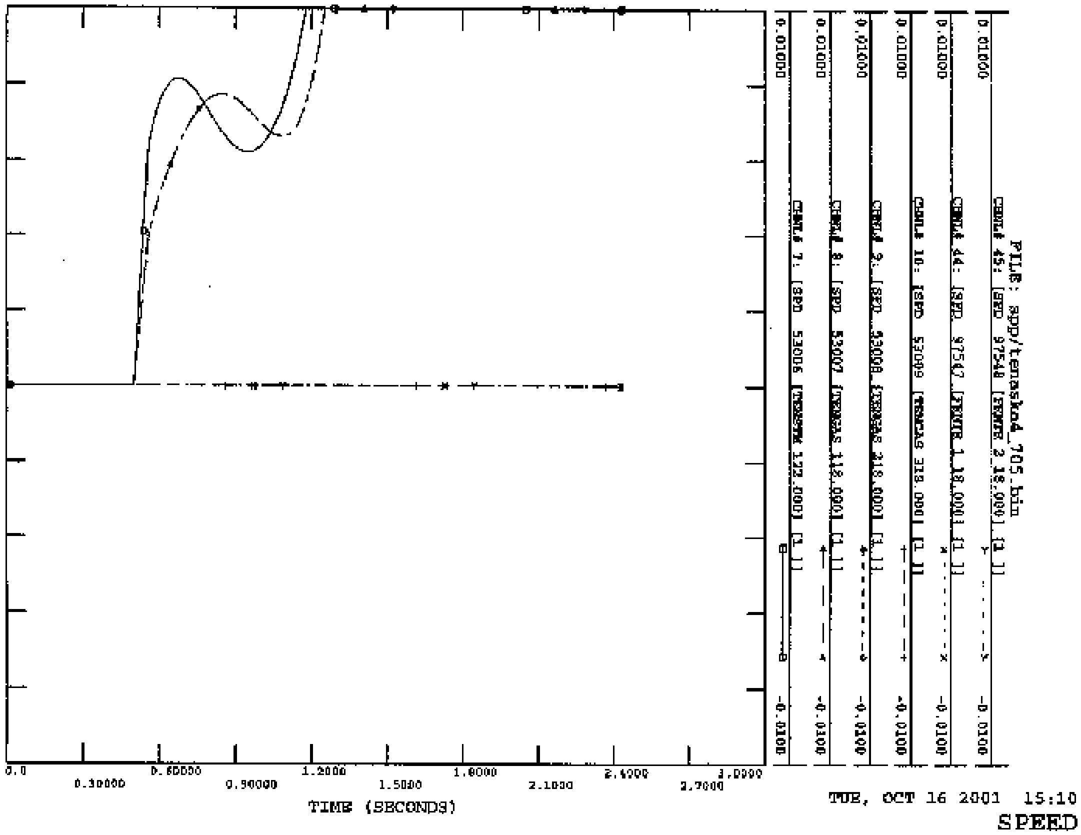
Attachment 2

Stability Simulation Results

Operating Study

Table 3 Case 4 - No Prior Outage
Gateway = 705 MW Frontier = 0 MW



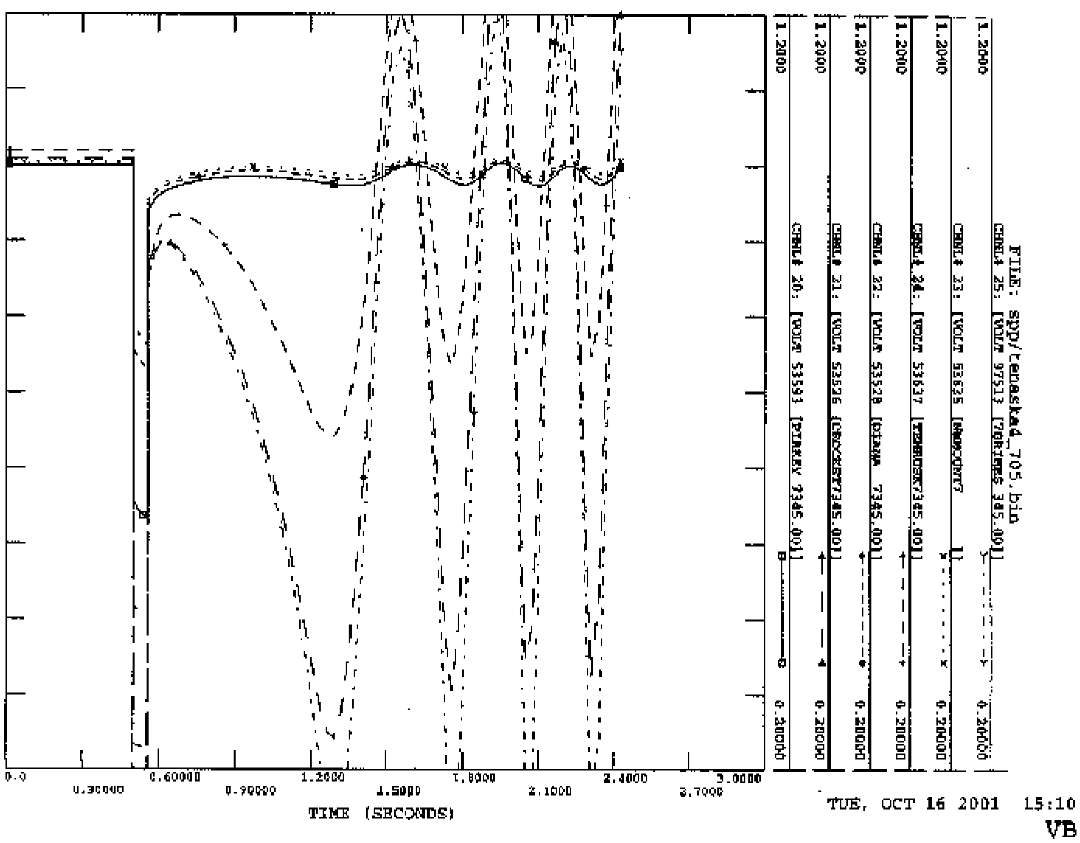
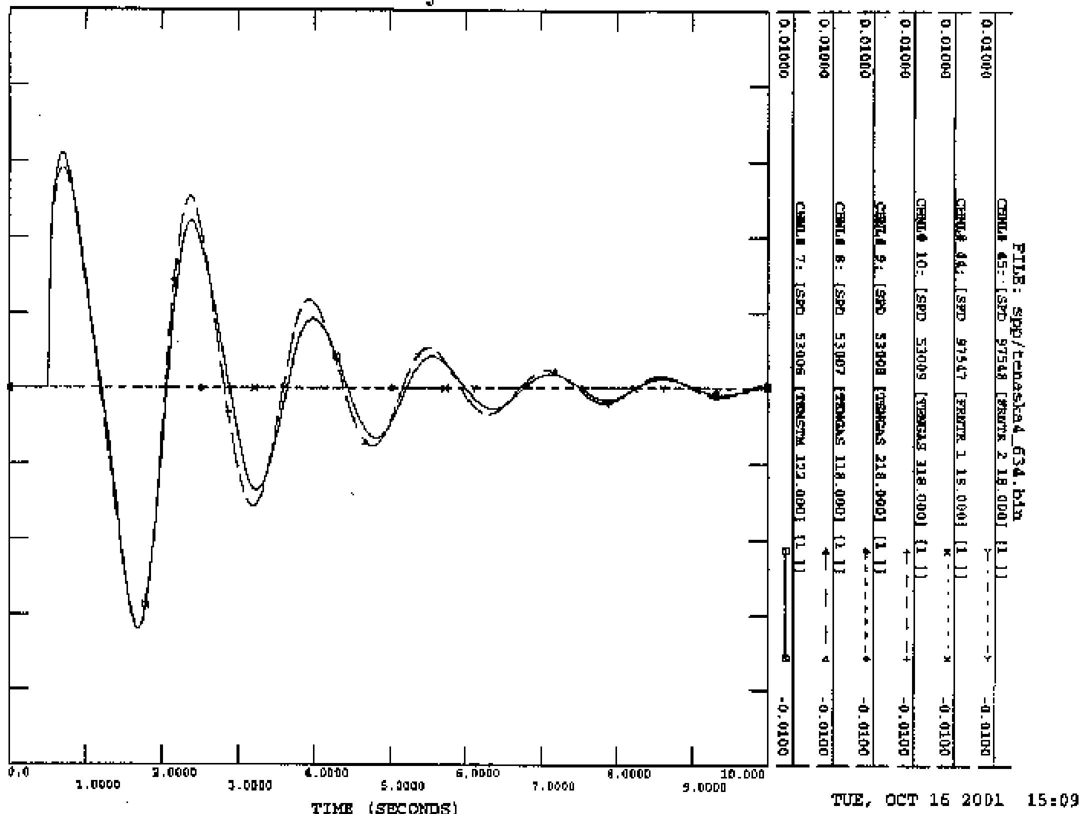
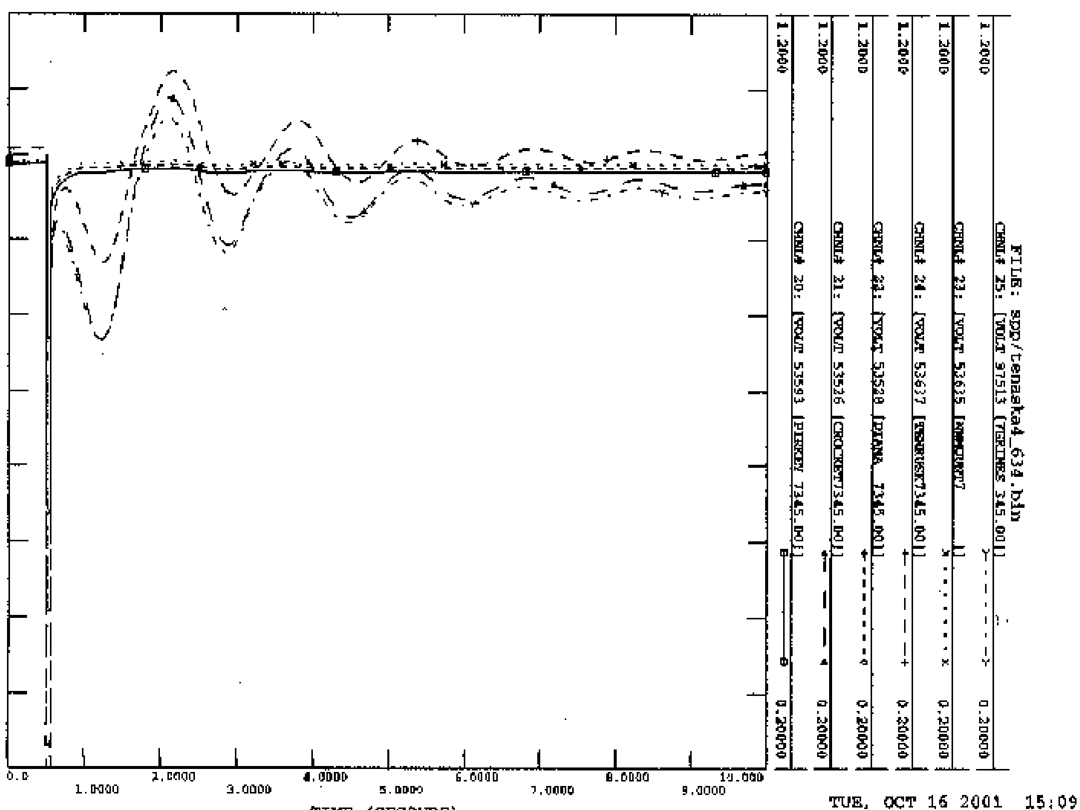


Table 3 Case 4 - No Prior Outage

Gateway = 634 MW Frontier = 0 MW

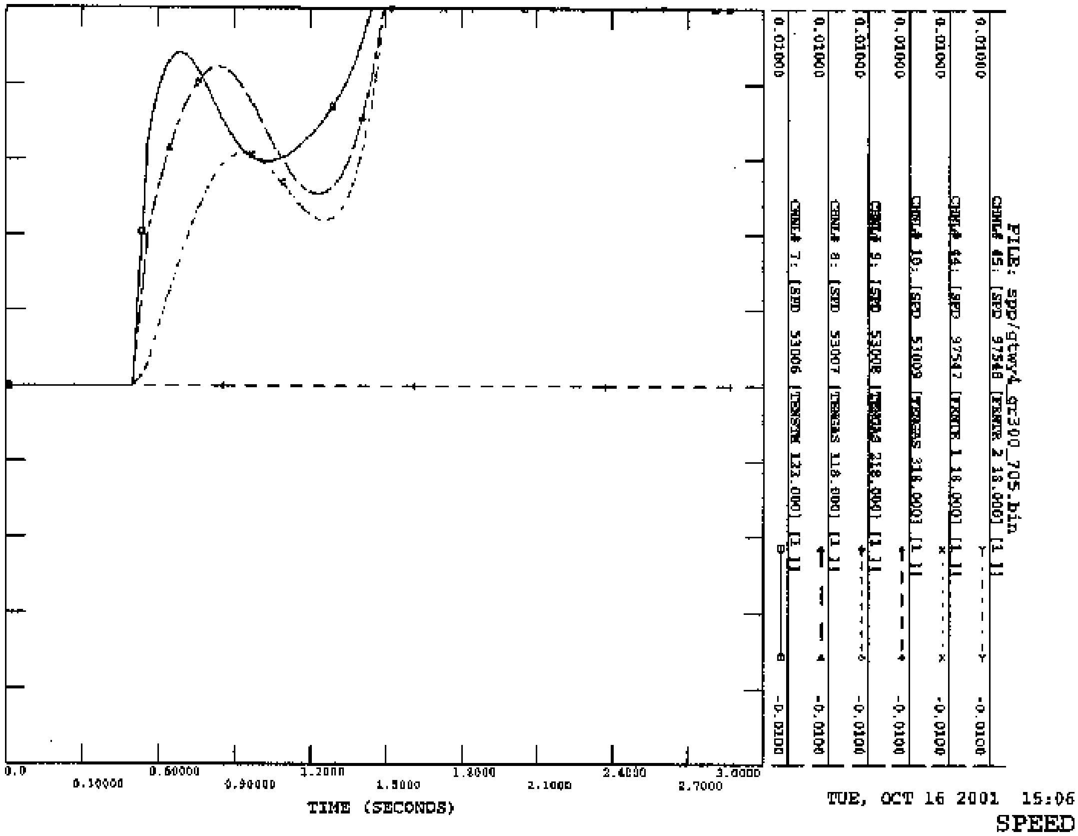


SPEED



VB

Table 4 Case 4 - No Prior Outage
Gateway = 705 MW Frontier = 300 MW



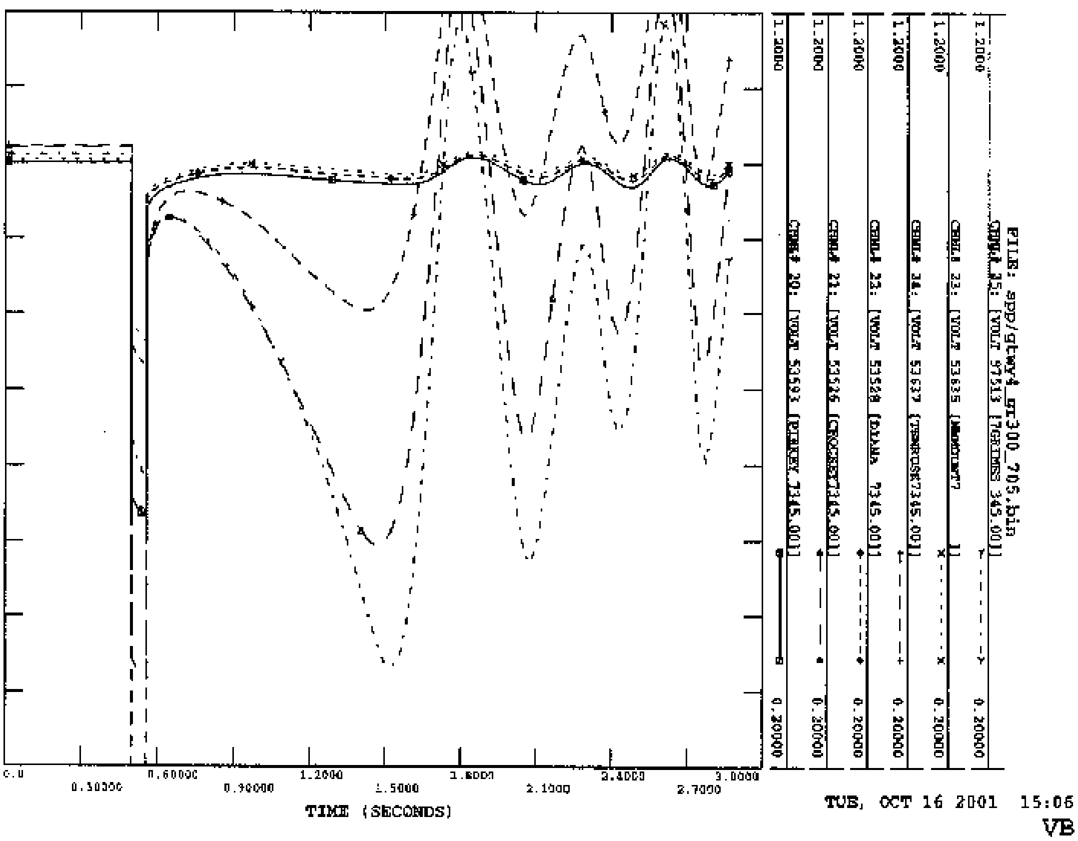
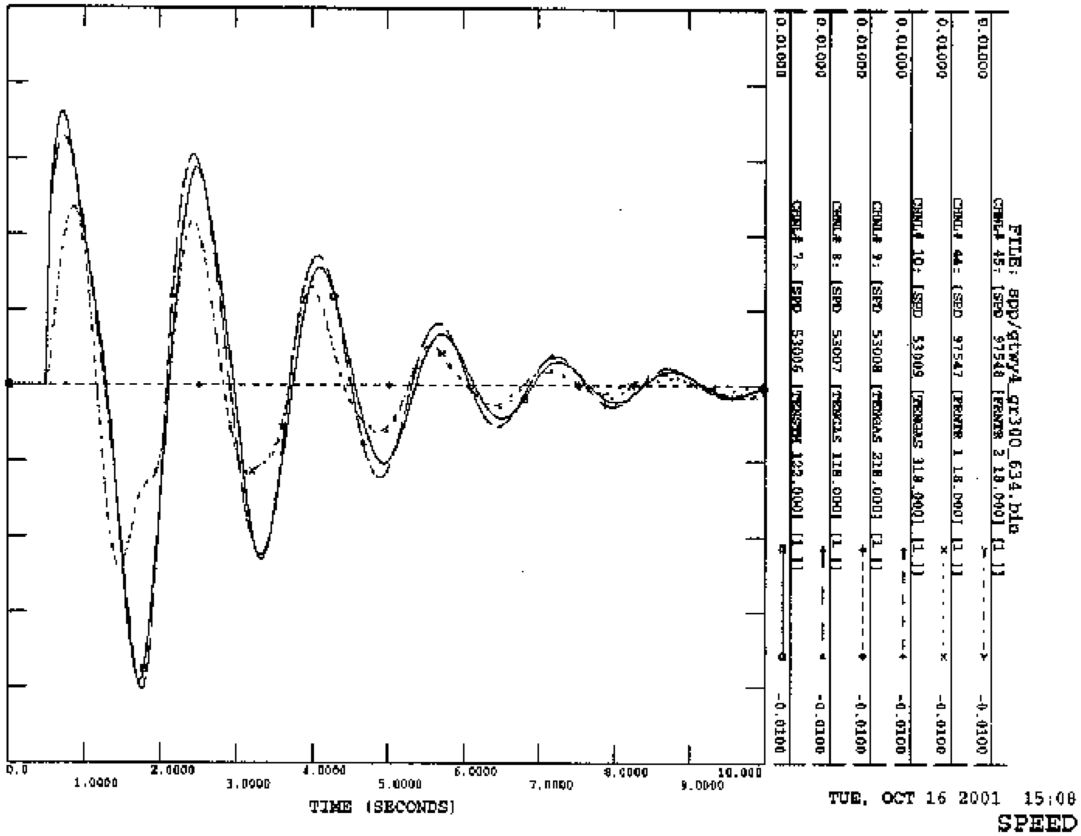


Table 4 Case 4 - No Prior Outage
Gateway = 634 MW Frontier = 300 MW



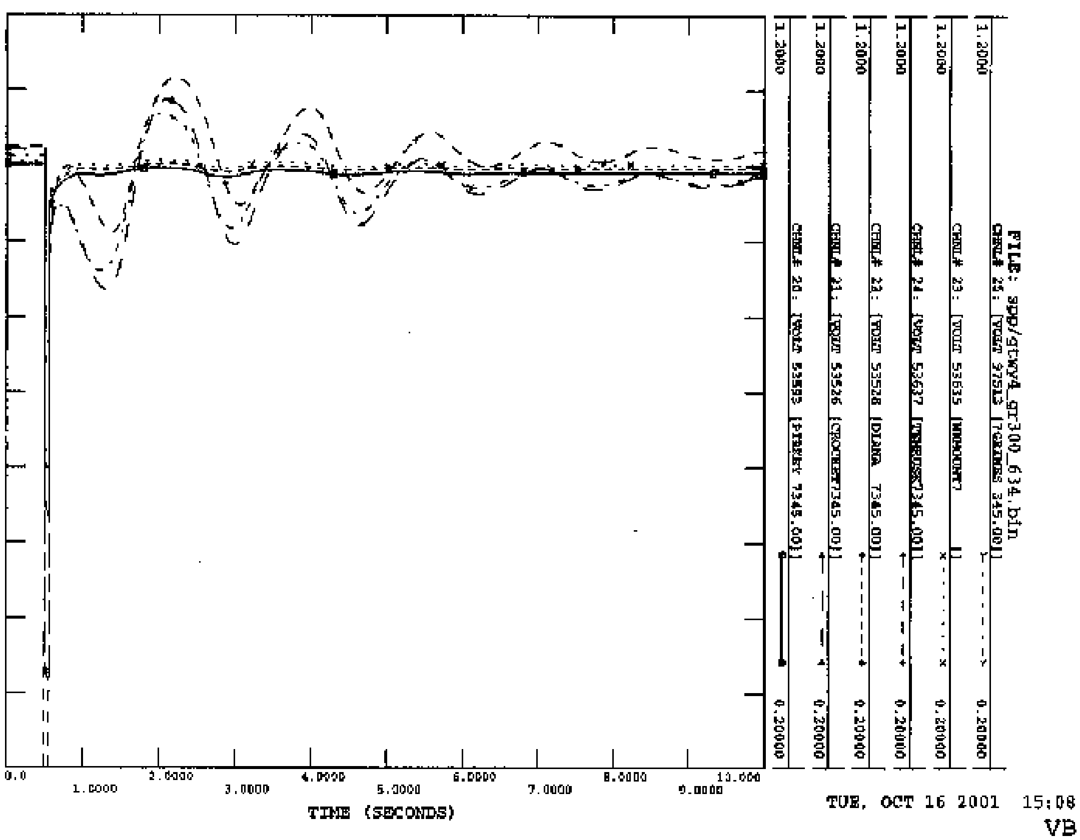
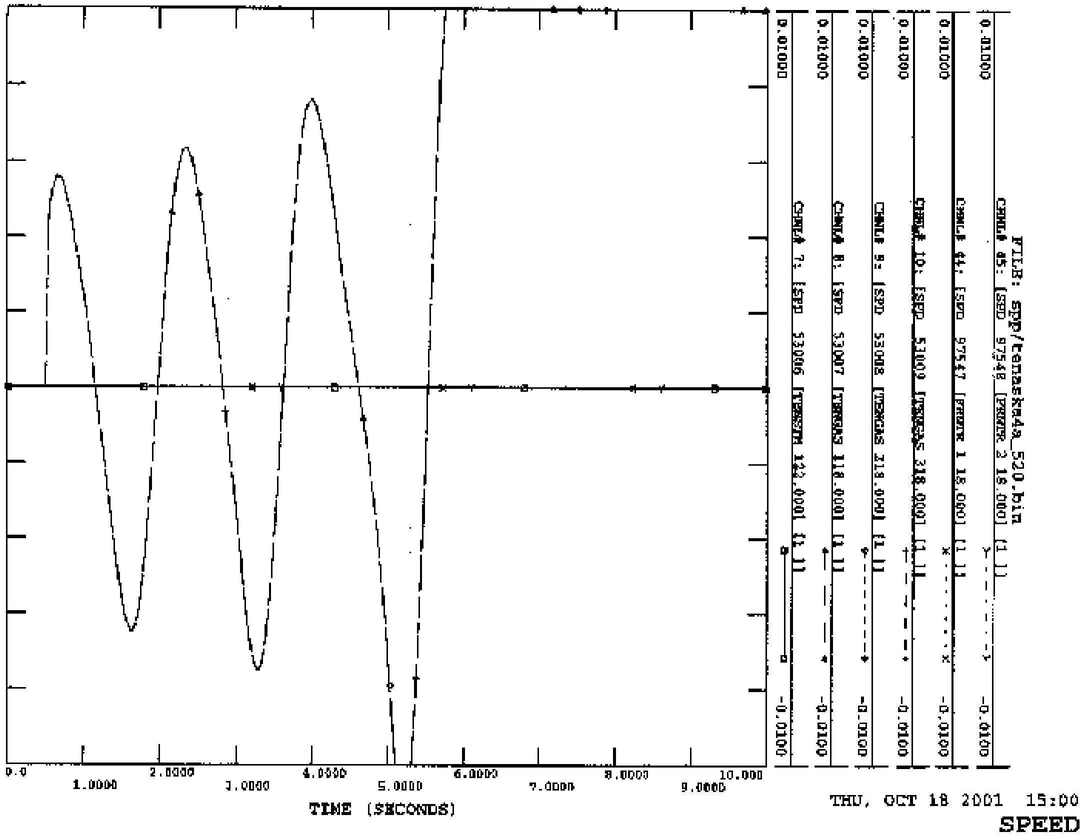


Table 5 Case 4a - Prior Outage at Crockett 345/138 kV Transformer
Gateway = 520 MW Frontier = 0 MW



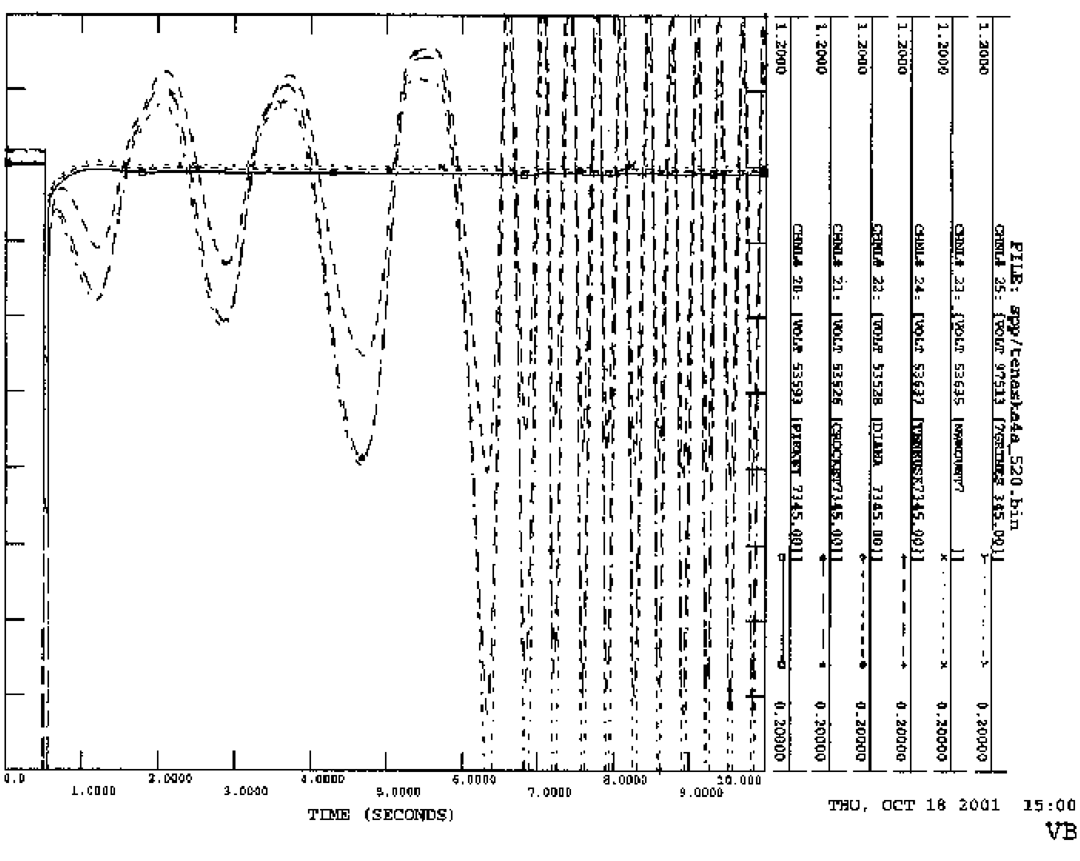
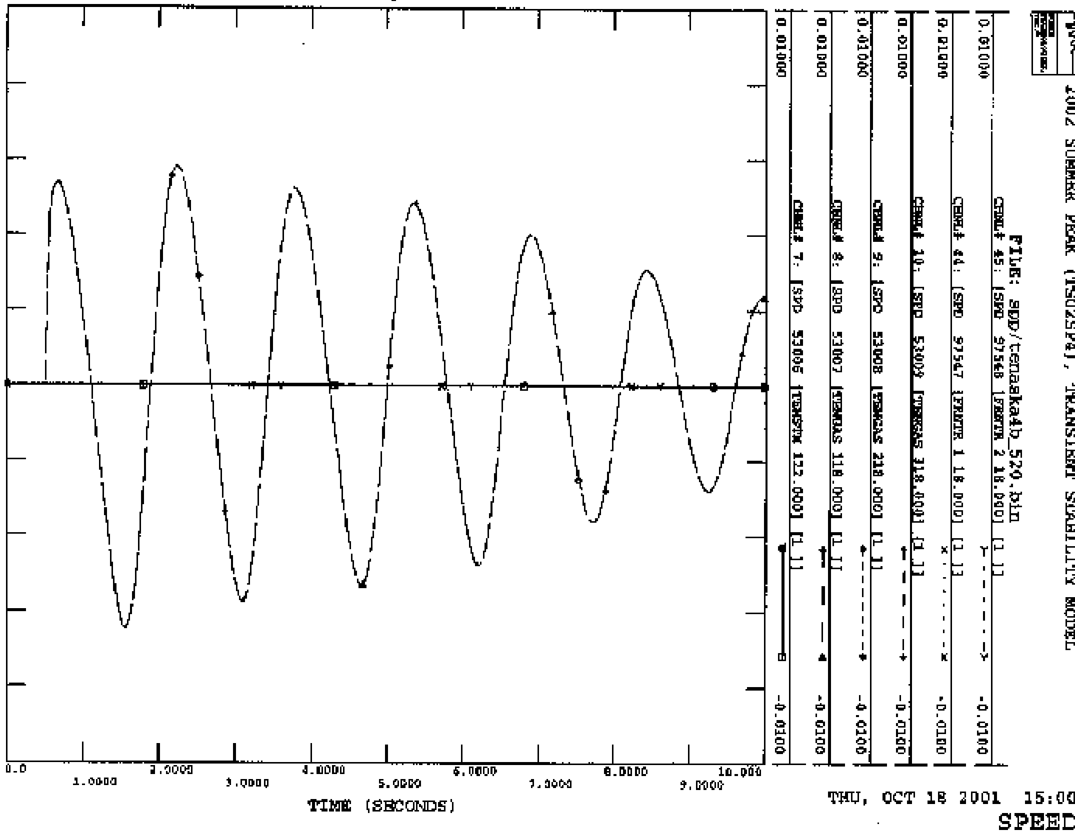


Table 5 Case 4b - Prior Outage at Grimes - Huntsville 138 kV
Gateway = 520 MW Frontier = 0 MW



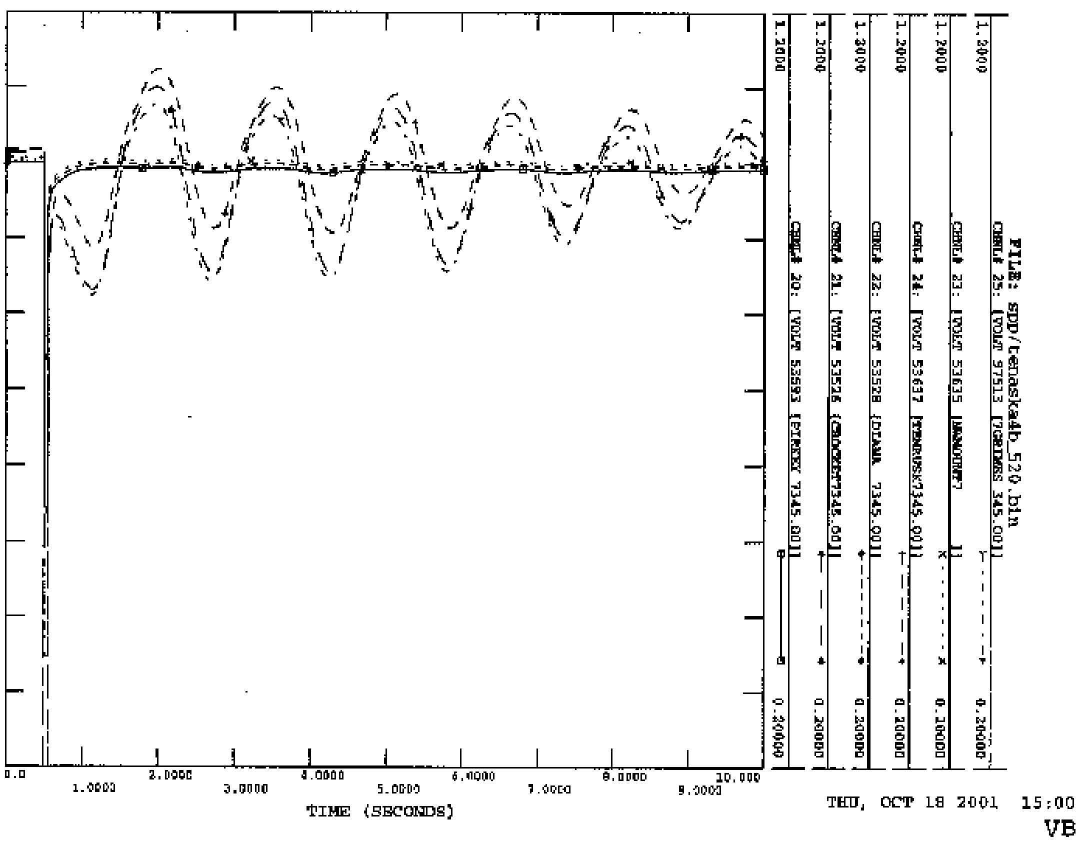
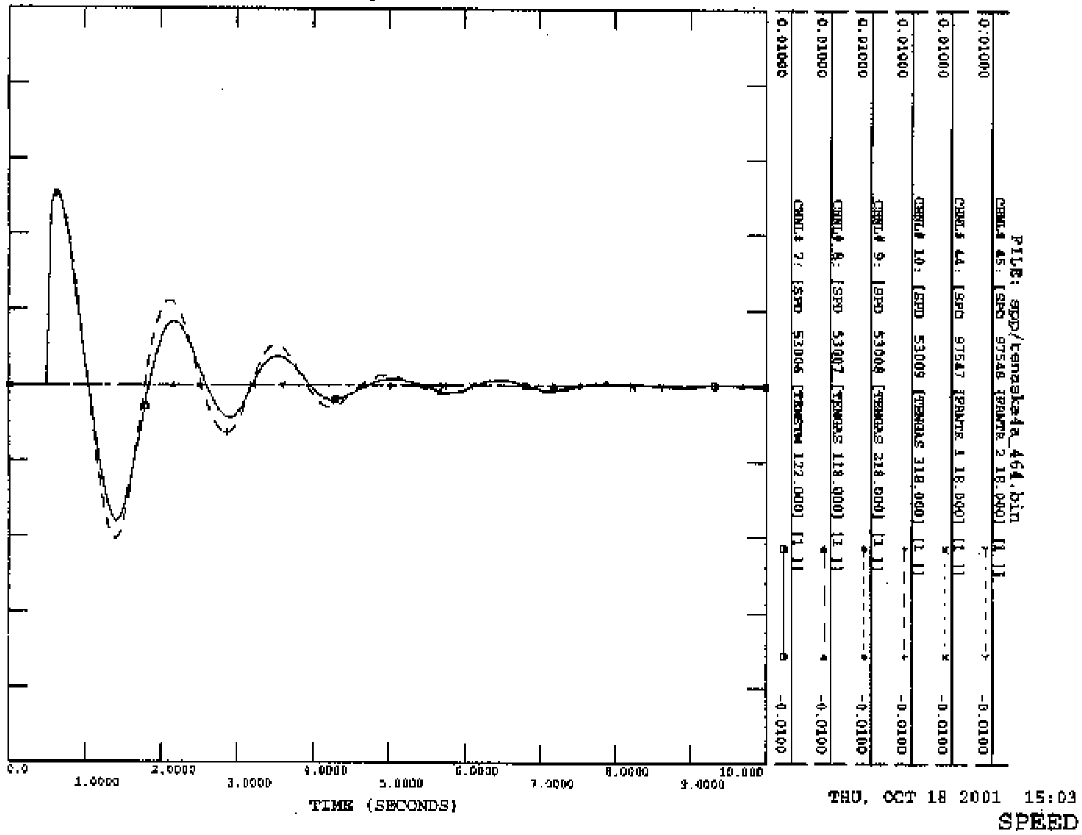


Table 5 Case 4a - Prior Outage at Crockett 345/138 kV Transformer
Gateway = 464 MW Frontier = 0 MW



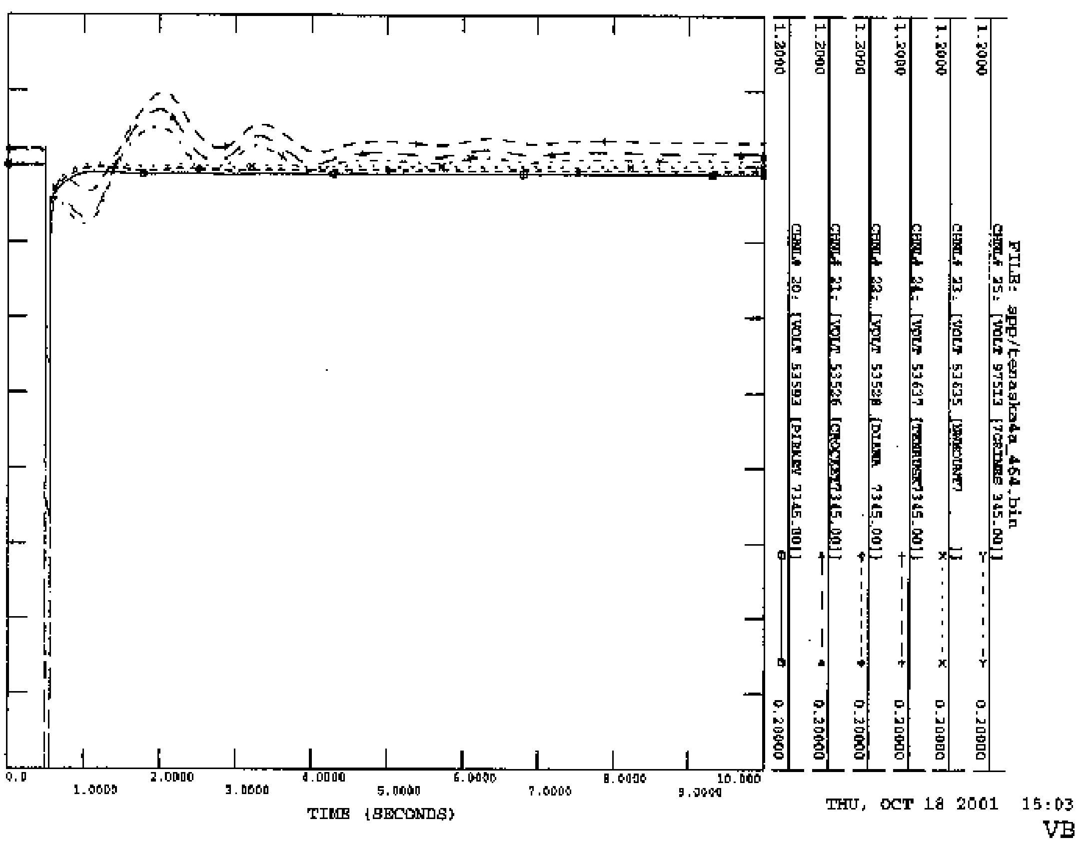
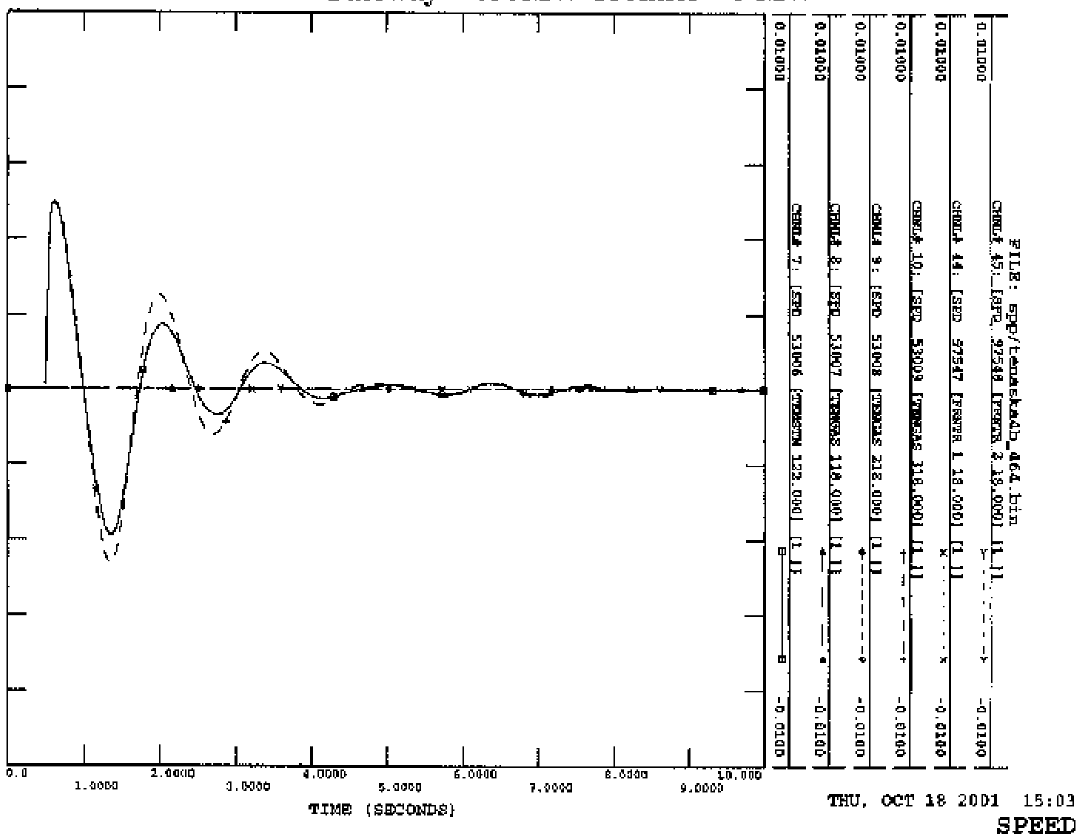


Table 5 Case 4b - Prior Outage at Grimes - Huntsville 138 kV
Gateway = 464 MW Frontier = 0 MW



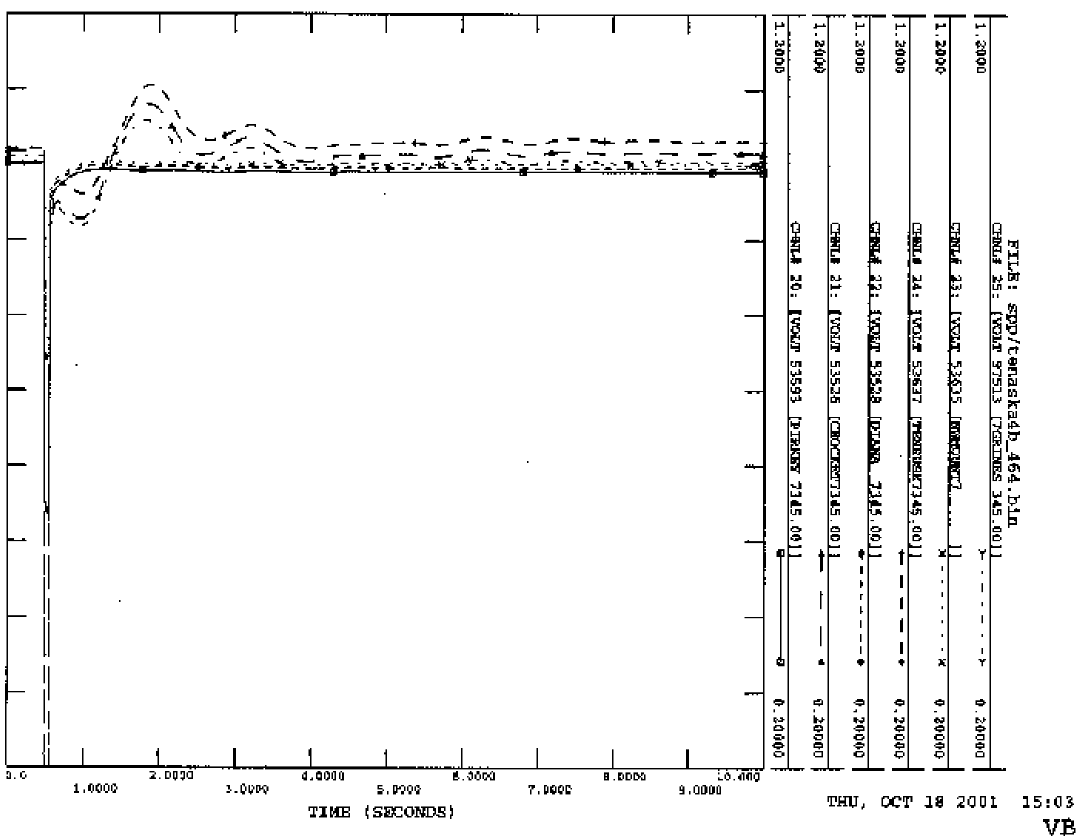
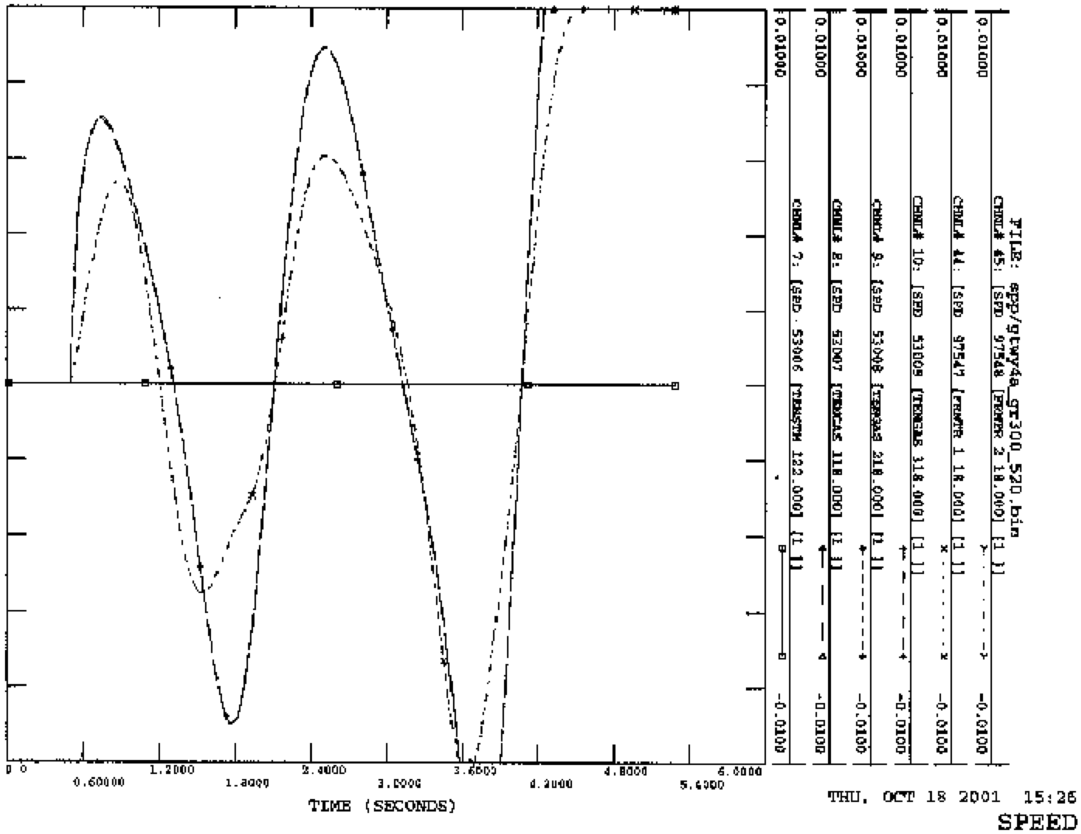


Table 6 Case 4a - Prior Outage at Crockett 345/138 kV
Gateway = 520 MW Frontier = 300 MW



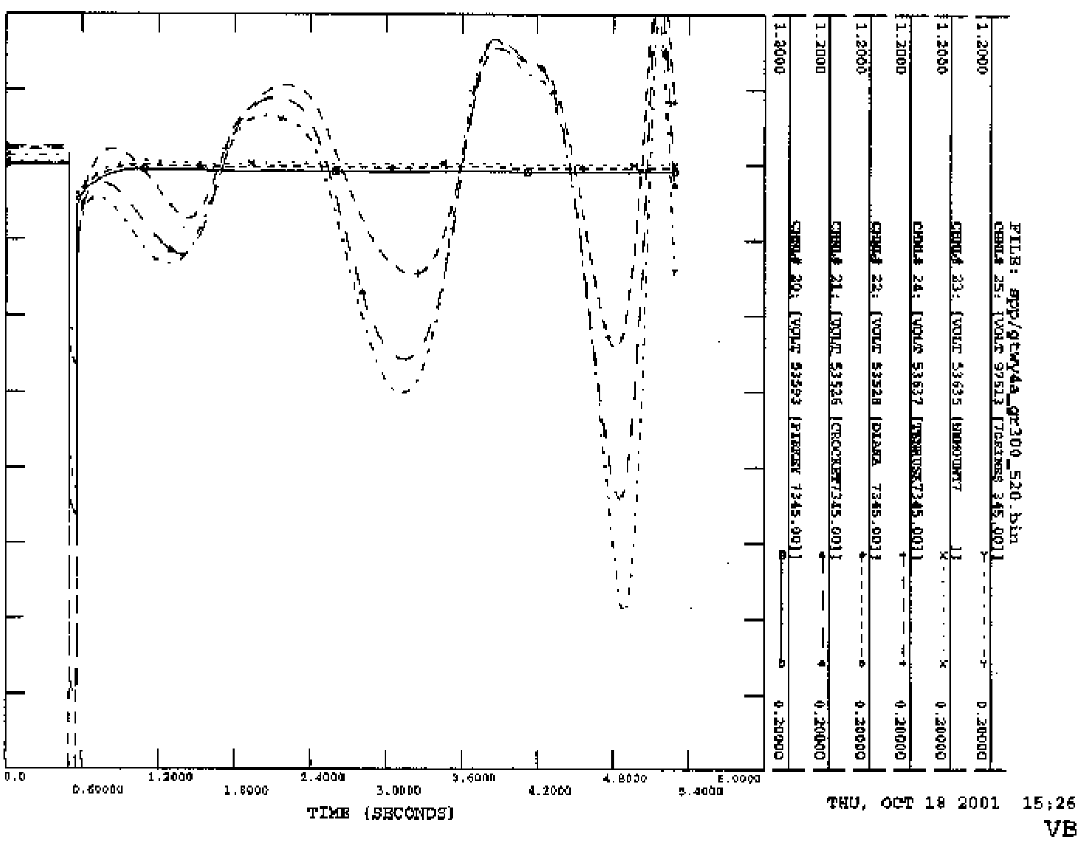
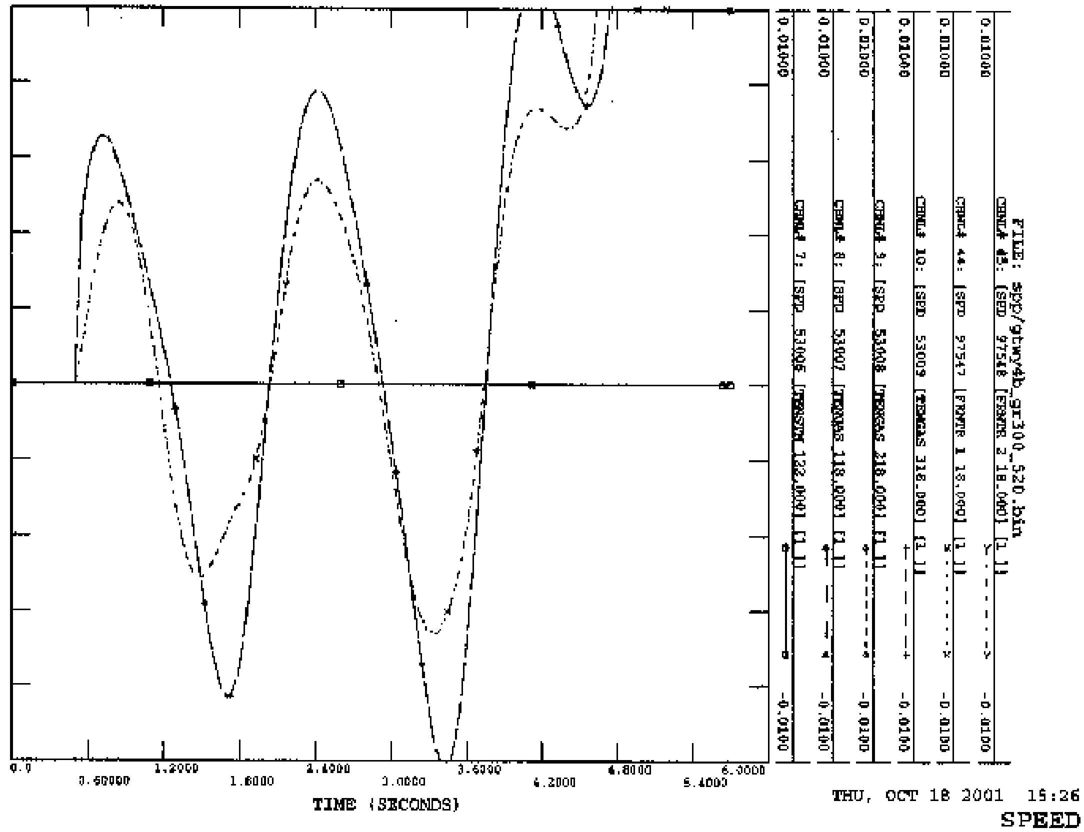


Table 6 Case 4b - Prior Outage at Grimes - Huntsville 138 kV
Gateway = 520 MW Frontier = 300 MW



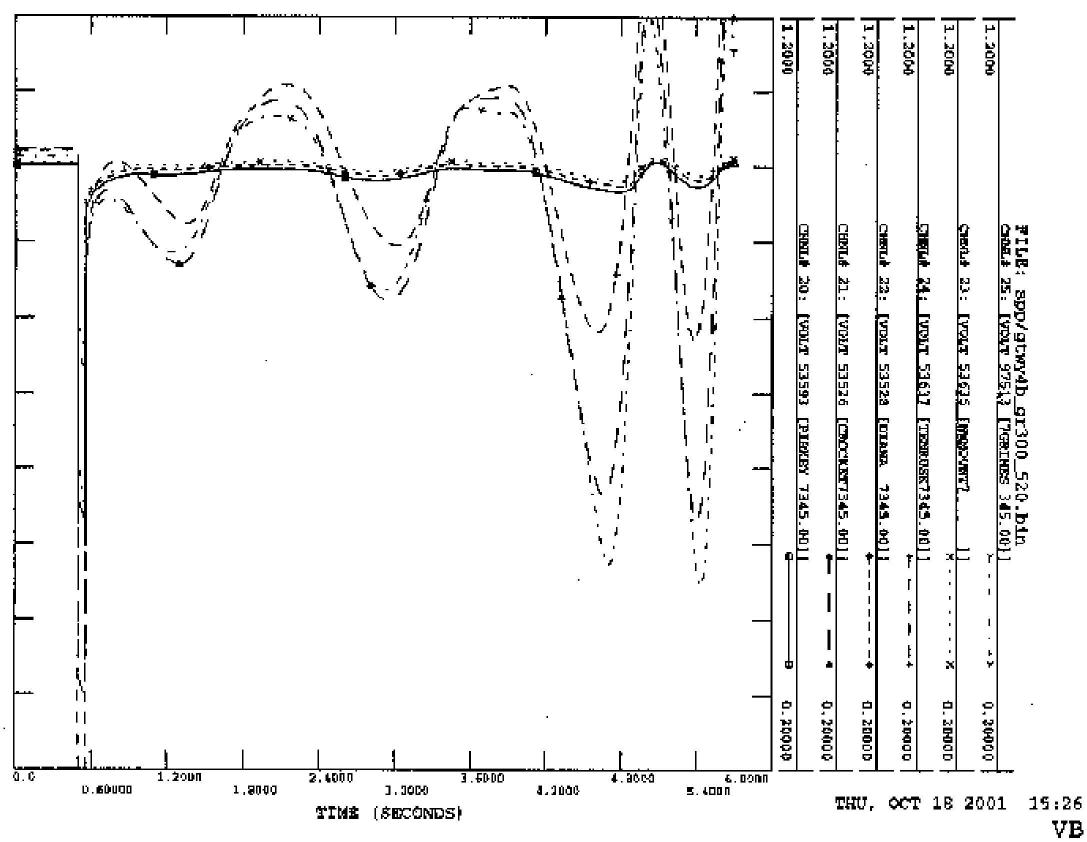
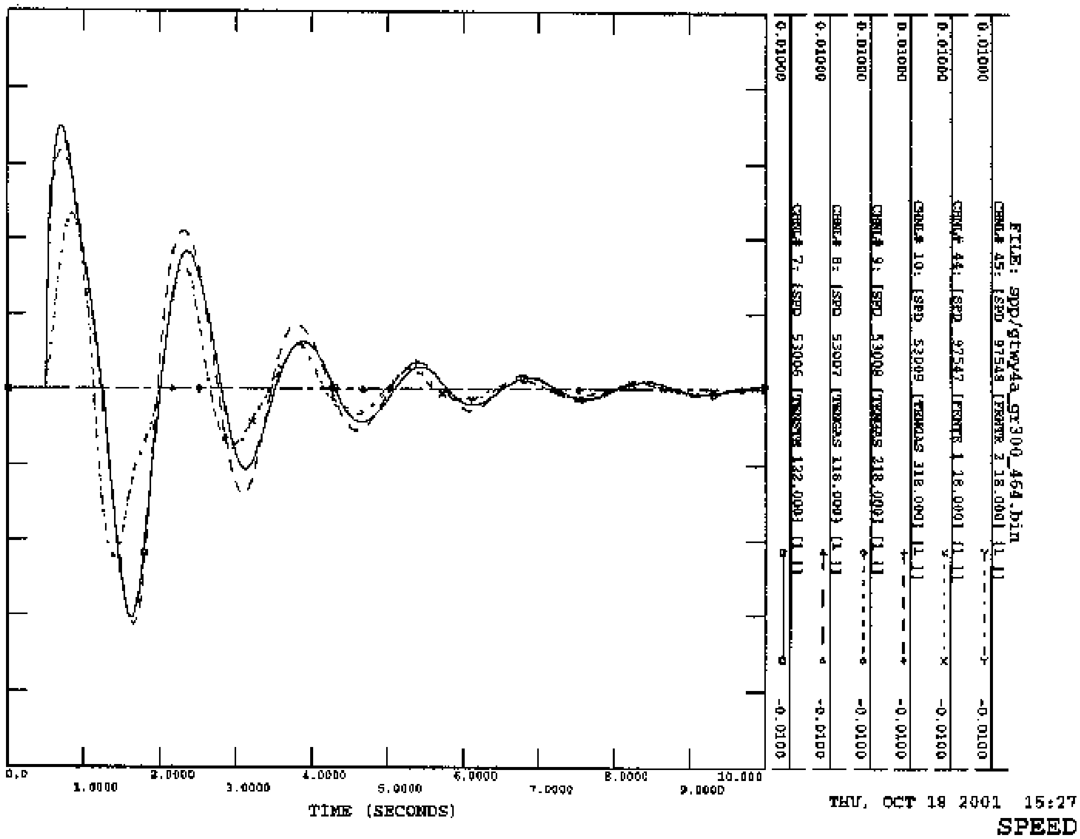


Table 6 Case 4a - Prior Outage at Crockett 345/138 kV
Gateway = 464 MW Frontier = 300 MW



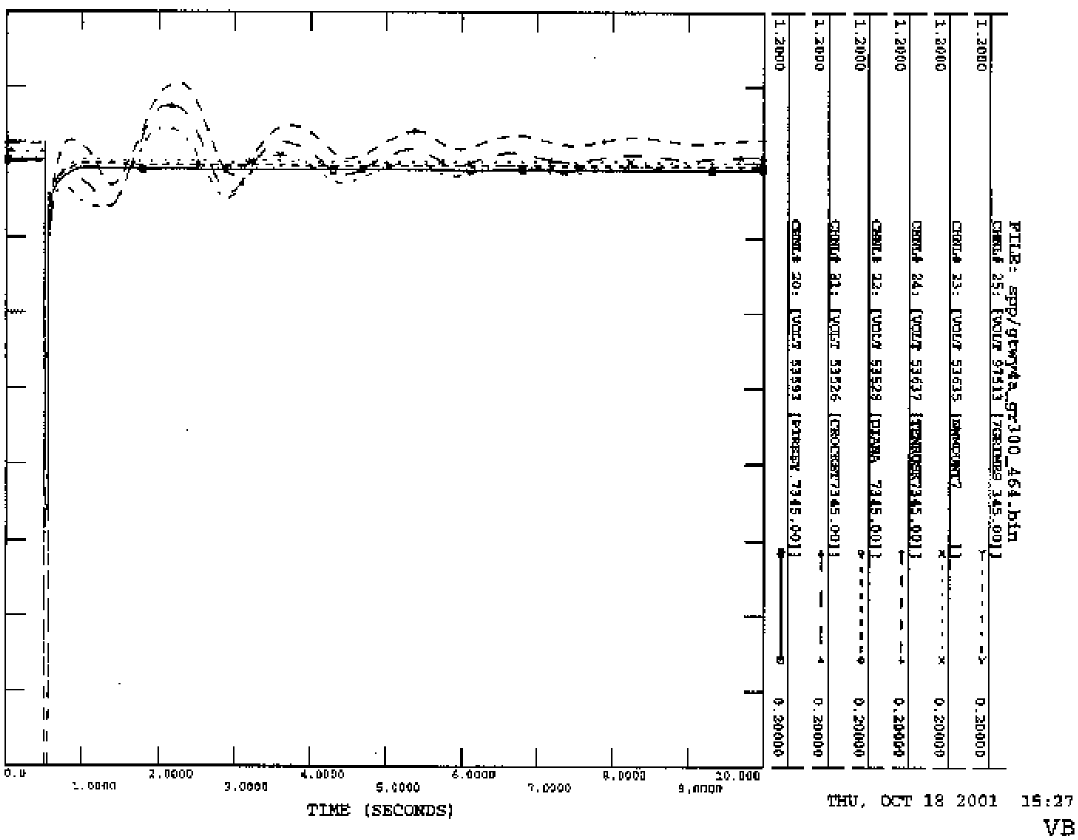
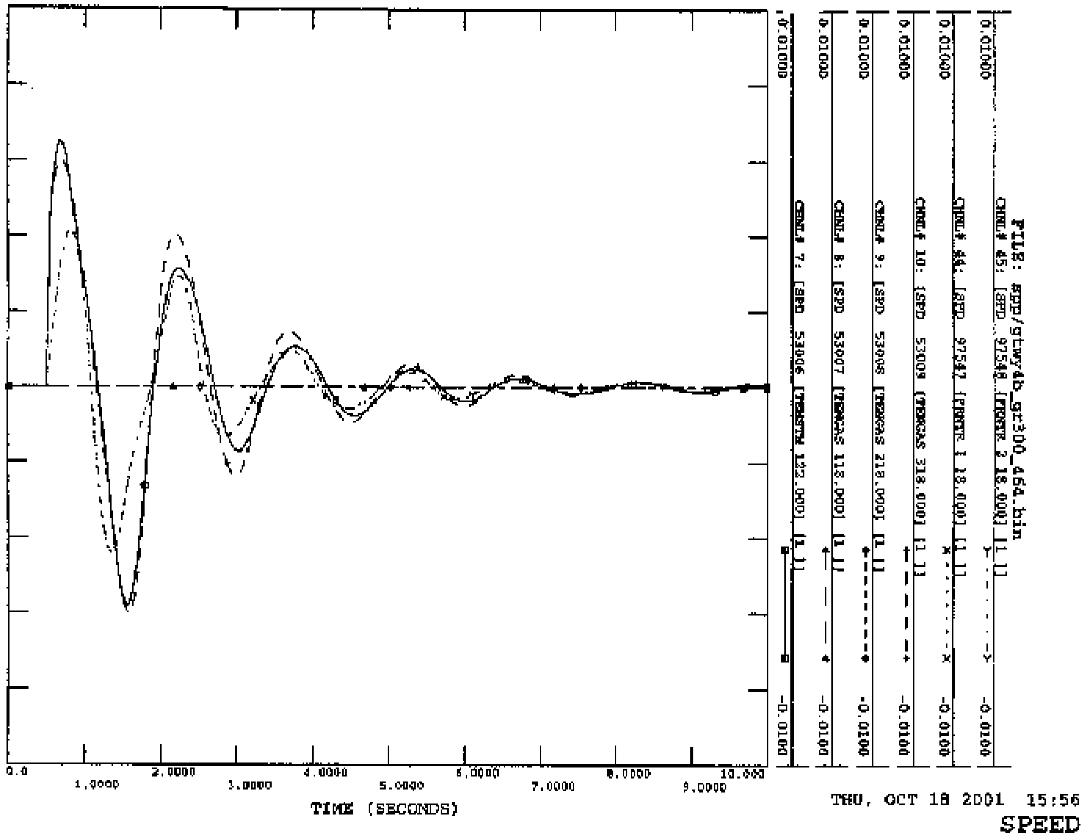


Table 6 Case 4b - Prior Outage at Grimes - Huntsville 138 kV
Gateway = 464 MW Frontier = 300 MW



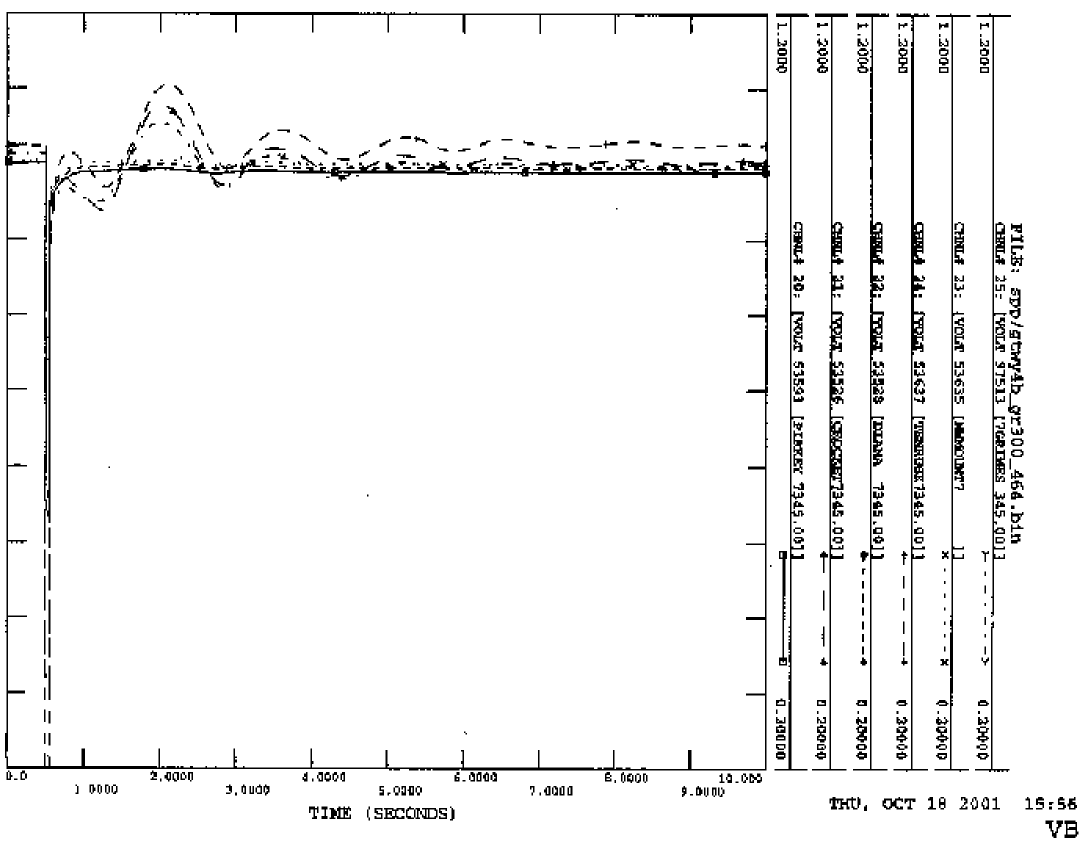
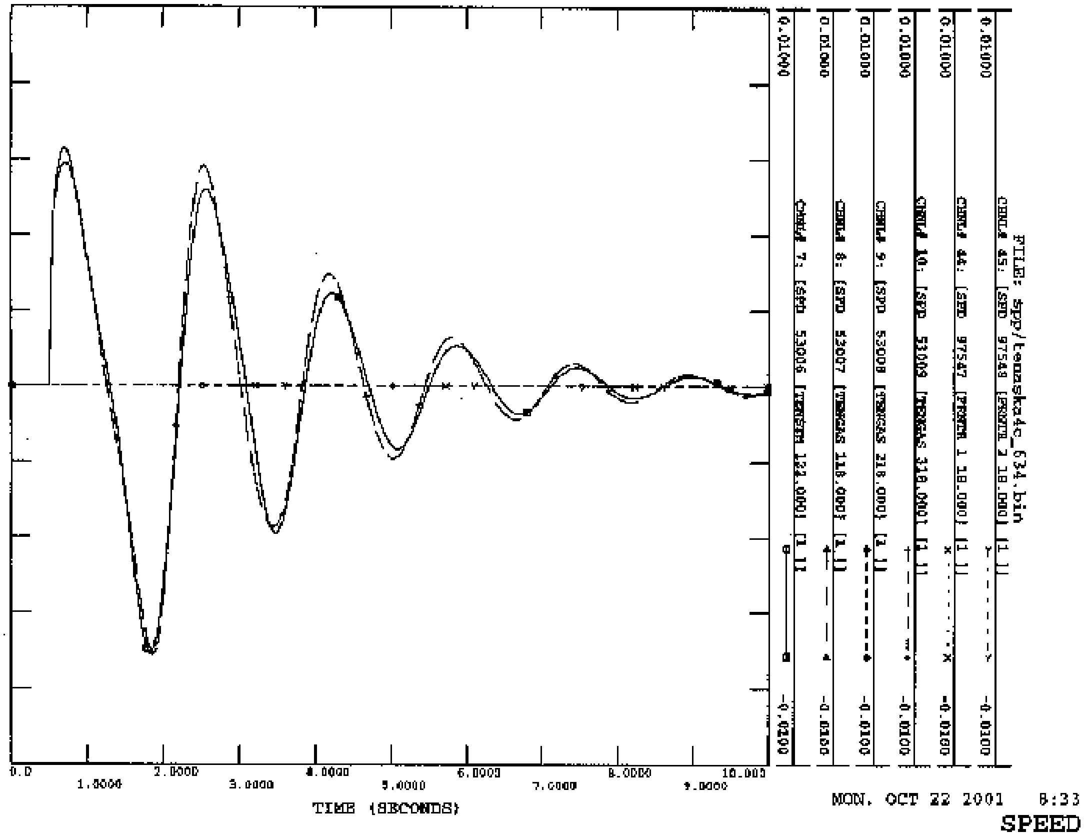


Table 7 Case 4c - Prior Outage at Grimes 345/138 (1)
Gateway = 634 MW Frontier = 0 MW



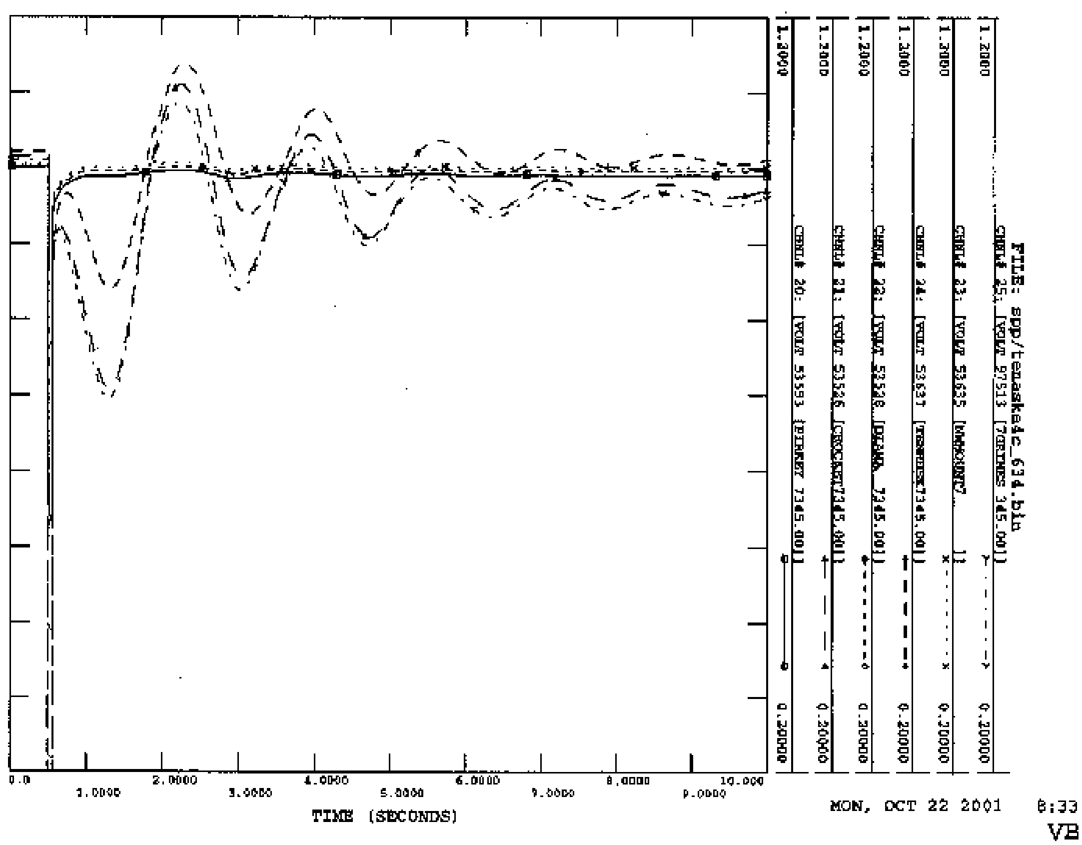
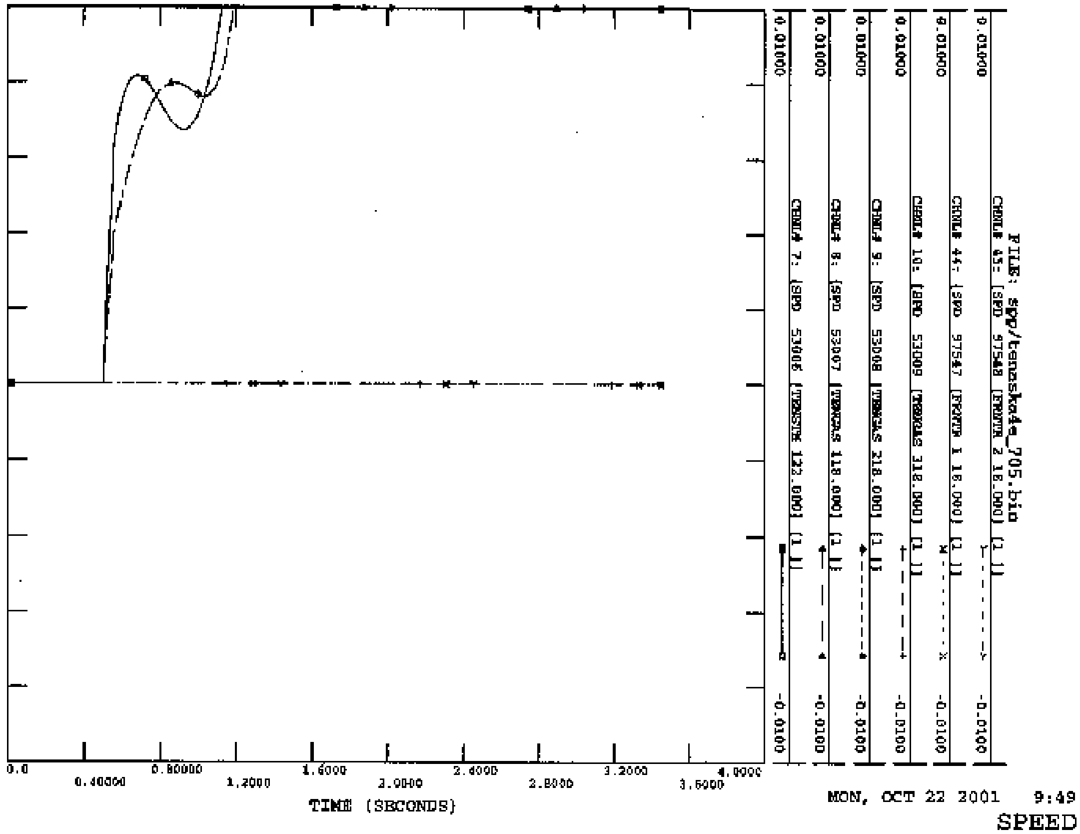


Table 7 Case 4e - Prior Outage at Grimes - Coletta - Bryan 138 kV
Gateway = 705 MW   Frontier = 0 MW



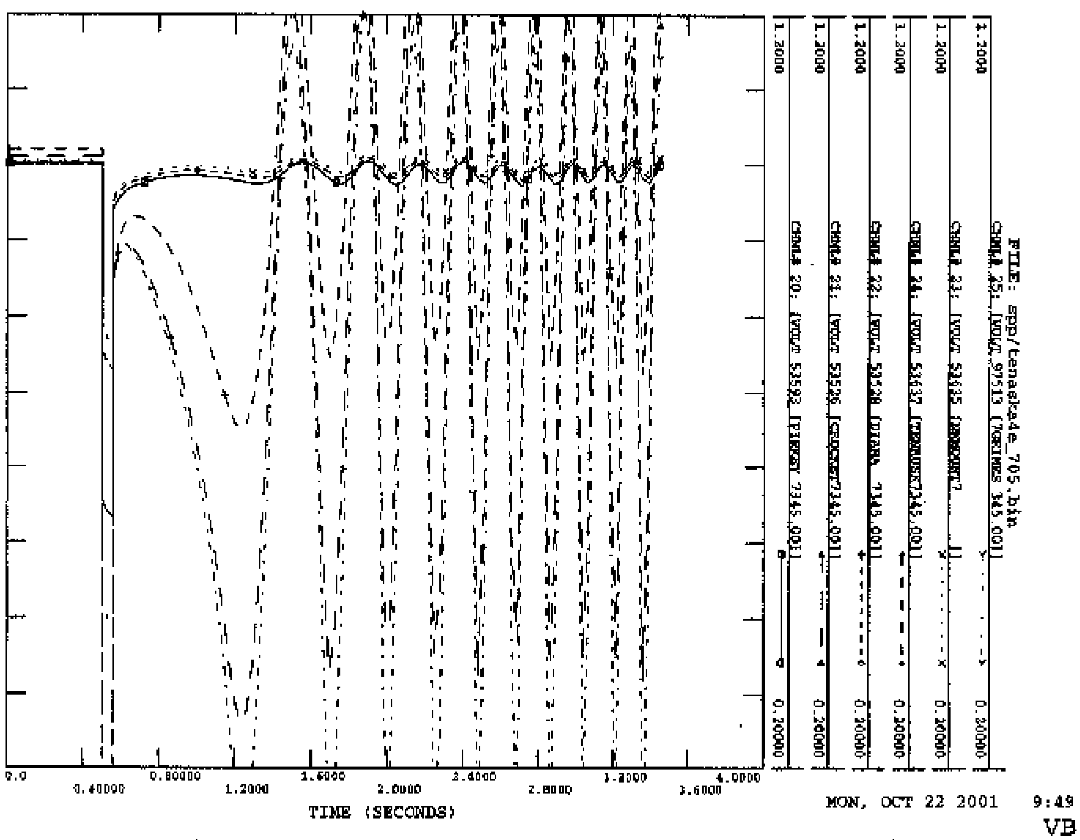
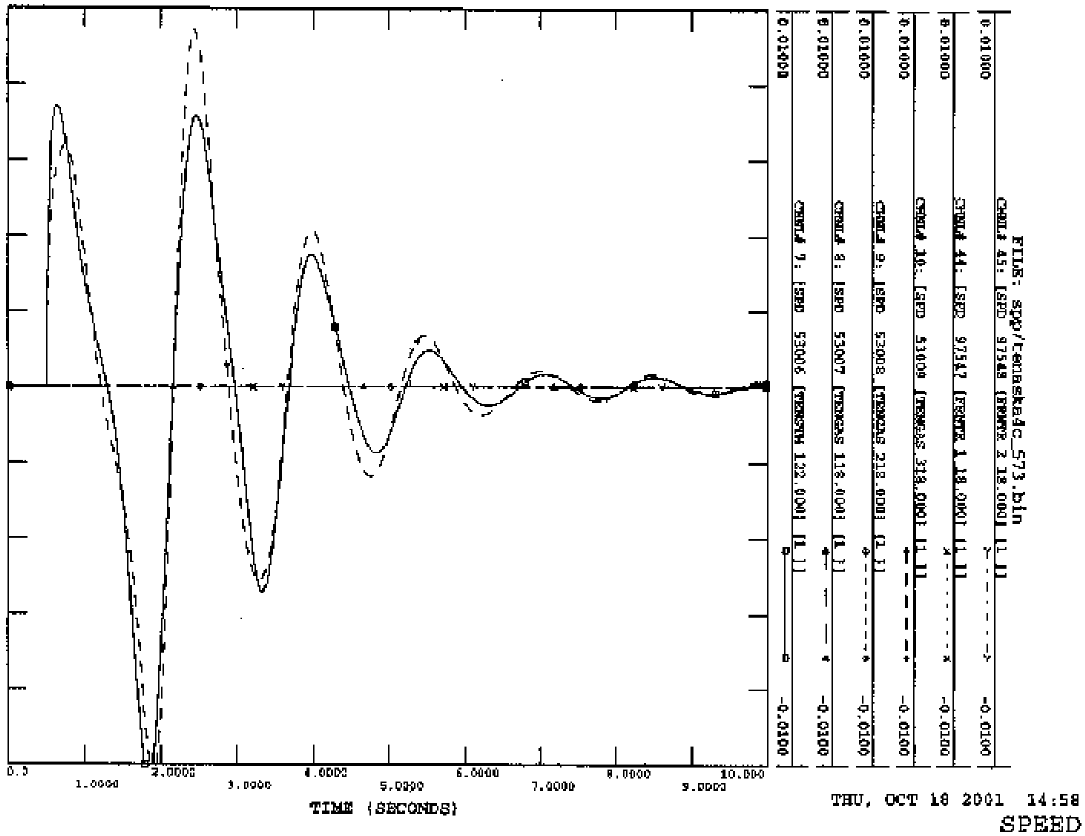


Table 7 Case 4c - Prior Outage at Grimes 345/138 kV (1)
Gateway = 573 MW Frontier = 0 MW



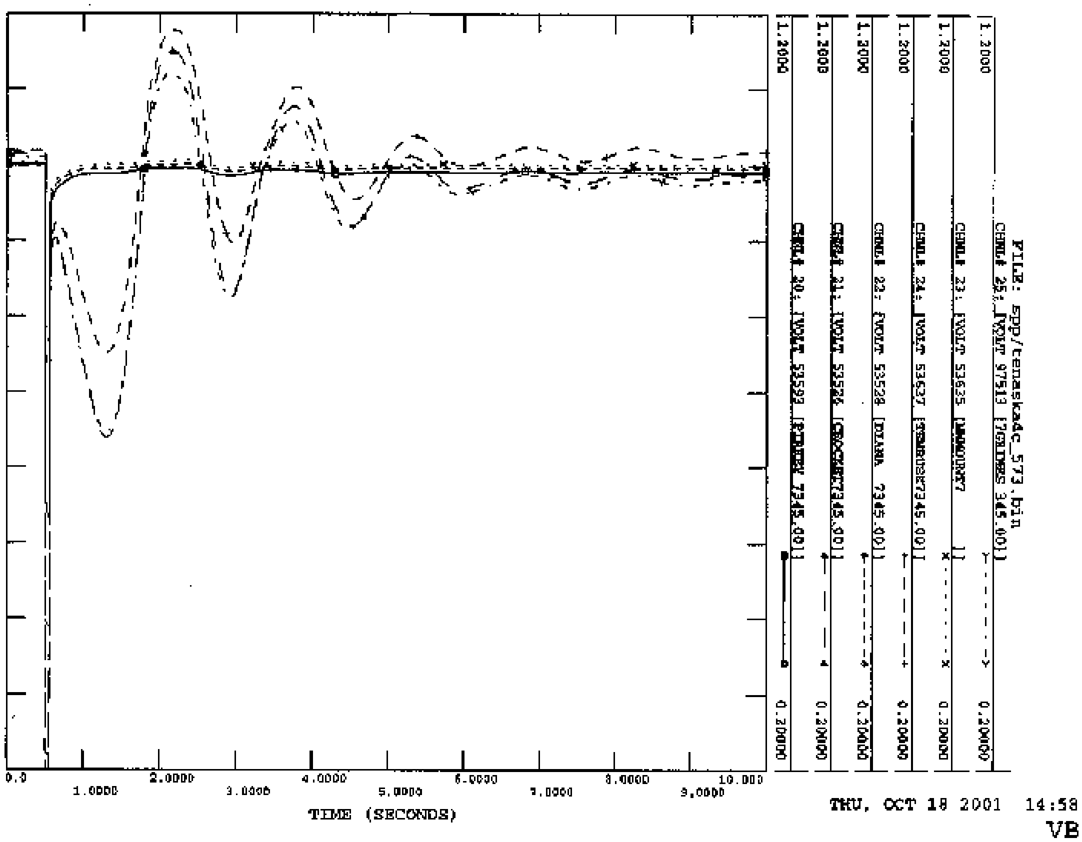
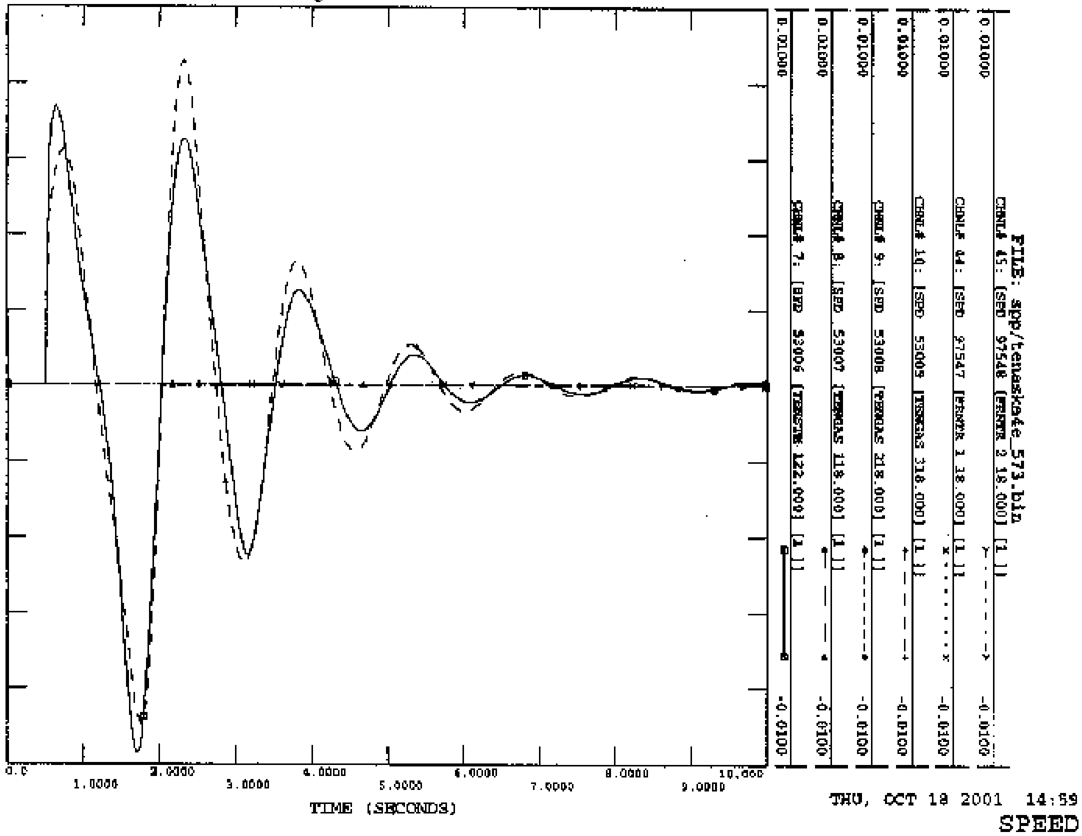


Table 7 Case 4e - Prior Outage at Grimes - Coletta - Bryan 138 kV
Gateway = 573 MW Frontier = 0 MW



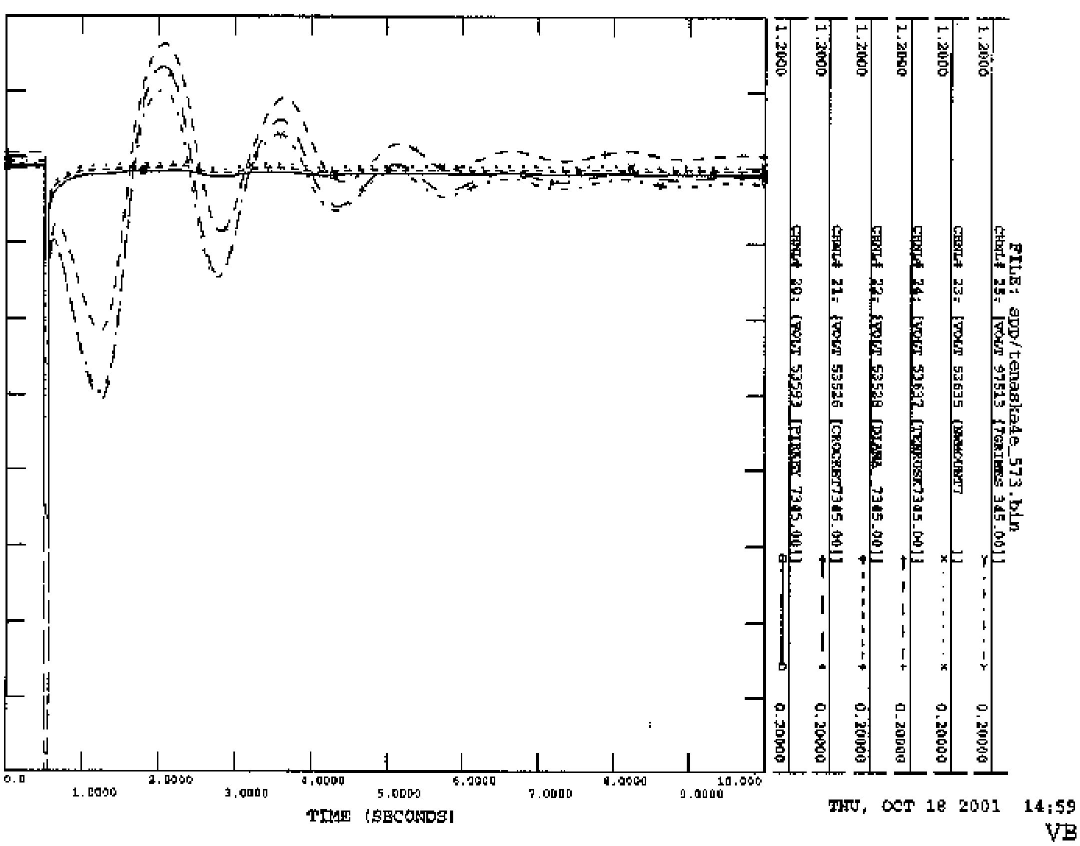
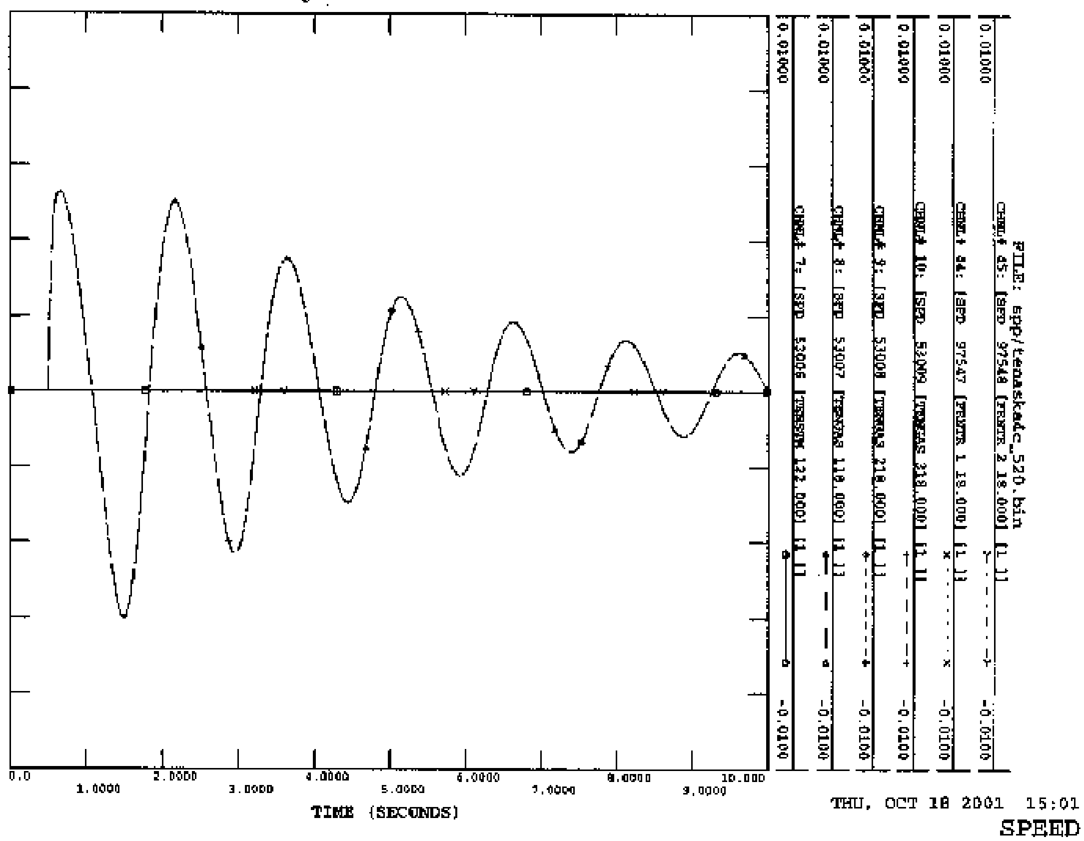


Table 7 Case 4c - Prior Outage at Grimes 345/138 kV
Gateway = 520 MW Frontier = 0 MW



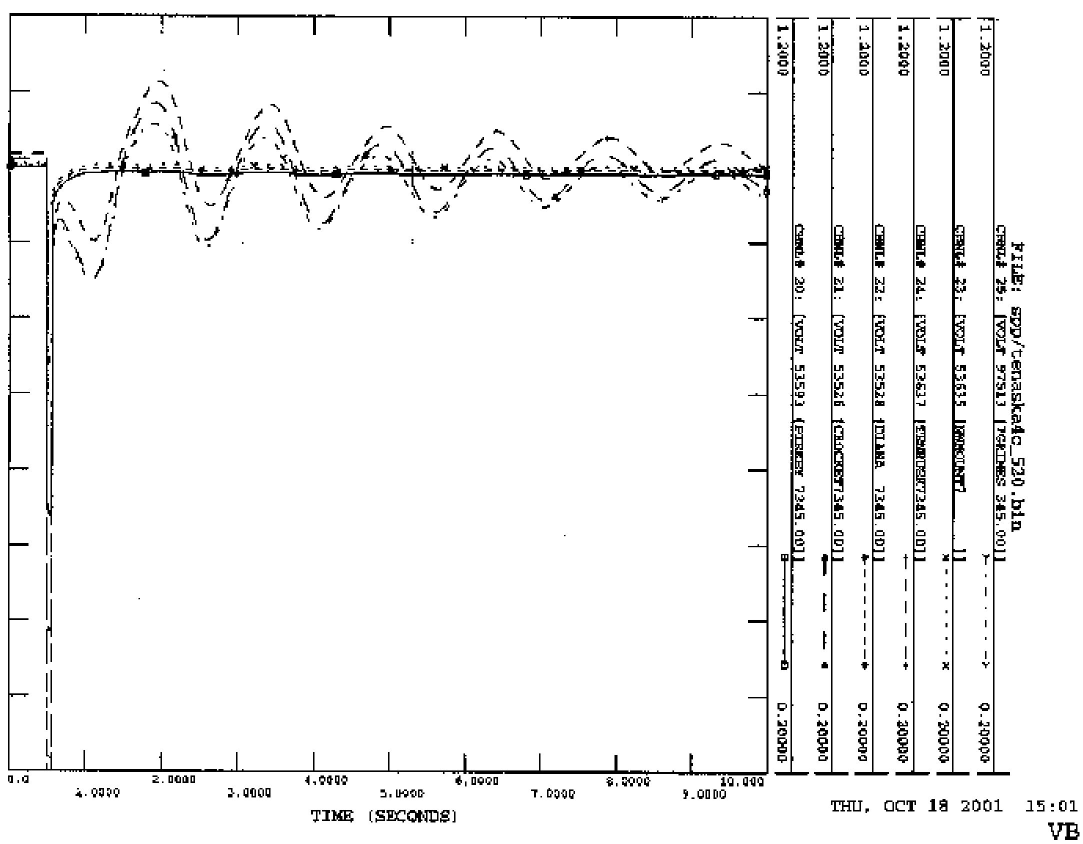
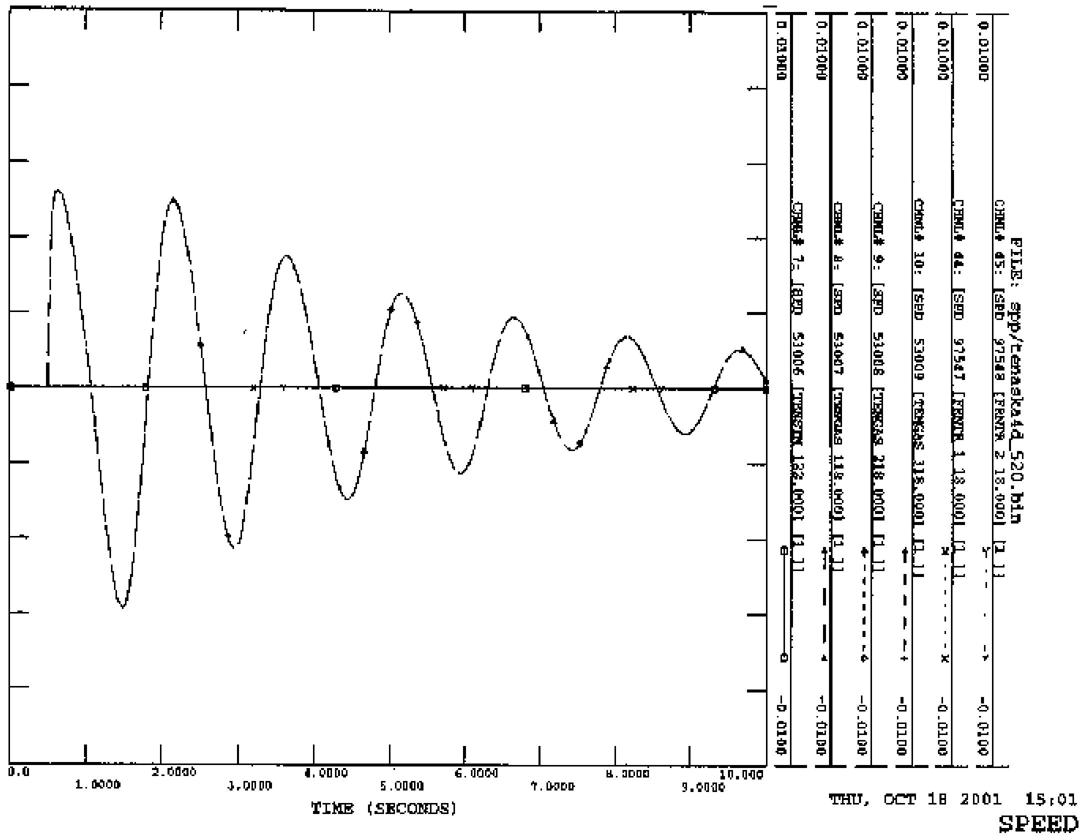


Table 7 Case 4d - Prior Outage at Grimes - Walden - Conroe 138 kV
Gateway = 520 MW Frontier = 0 MW



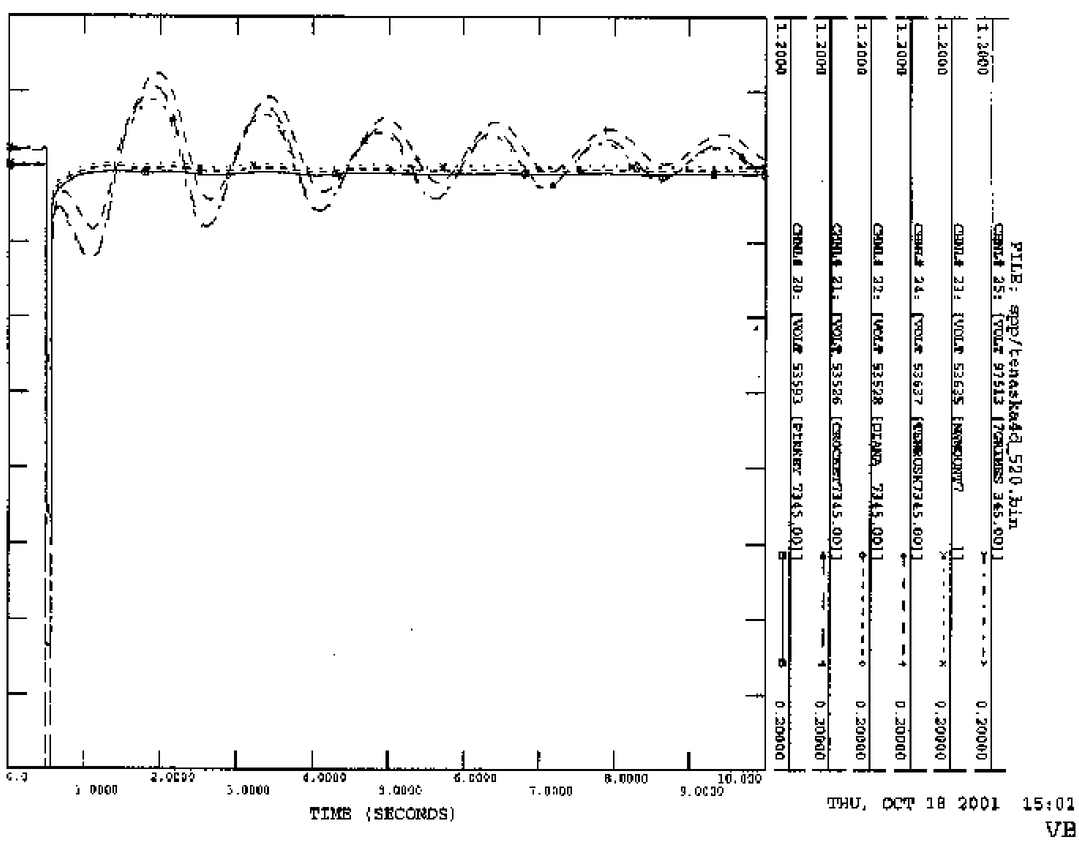
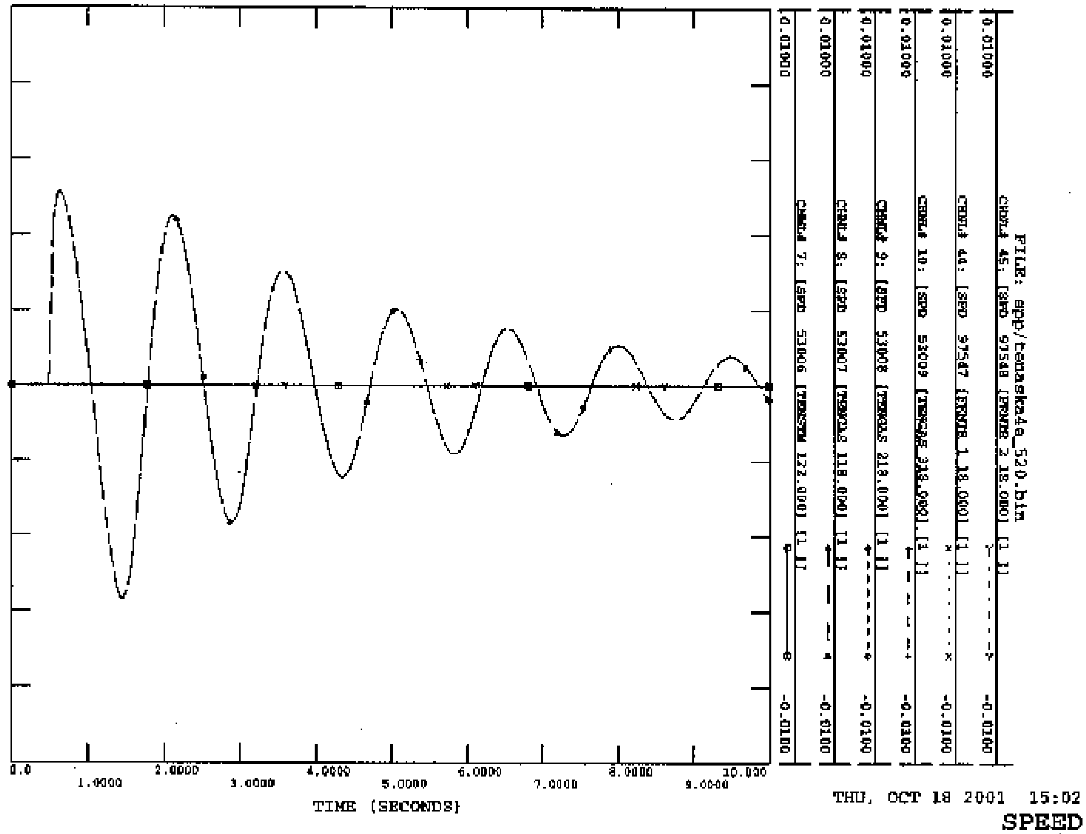


Table 7 Case 4 e - Prior Outage at Grimes - Coletta - Bryan 138 kV
Gateway = 520 MW Frontier = 0 MW



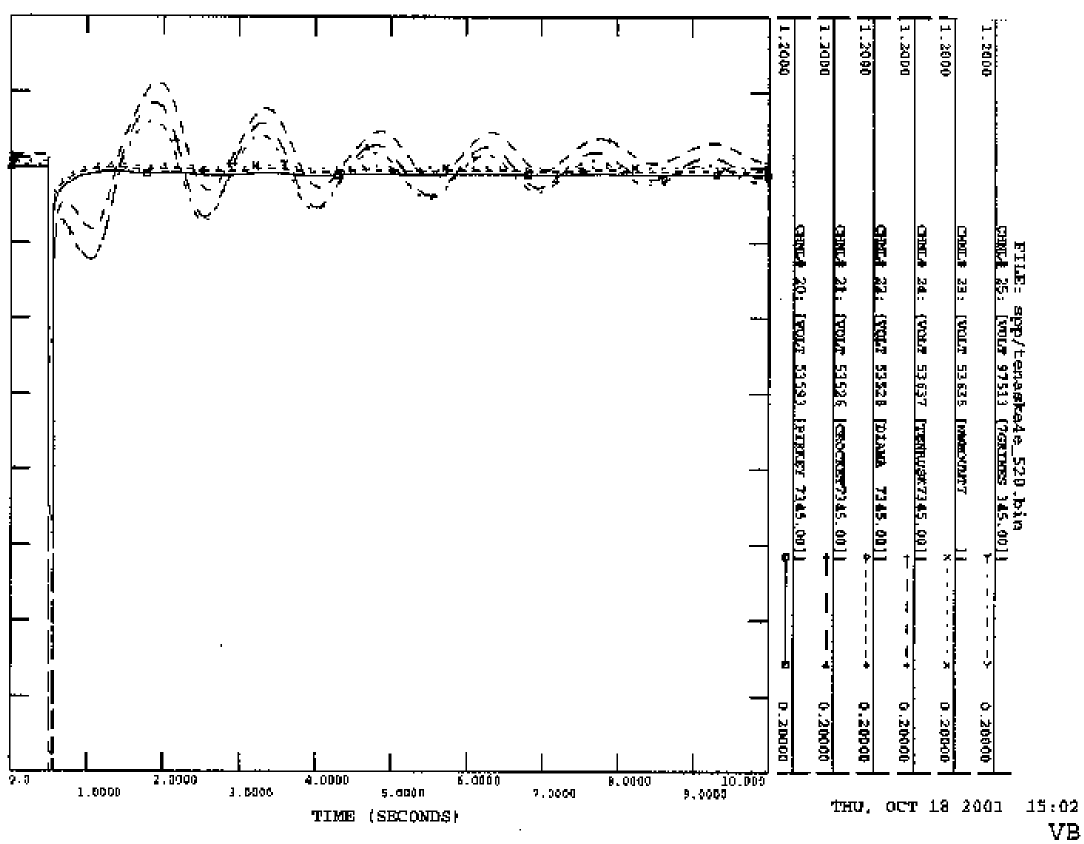
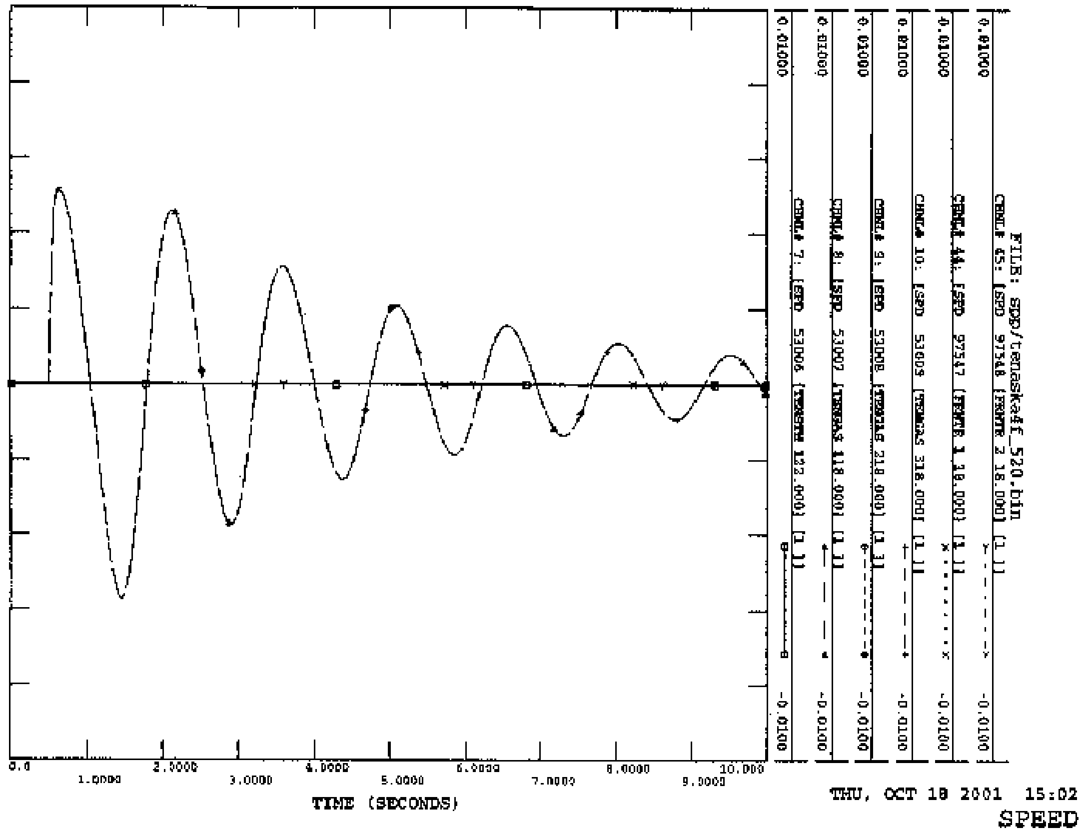


Table 7 Case 4f - Prior Outage at Grimes - MagAnd - Navasota 138 kV
Gateway = 520 MW Frontier = 0 MW



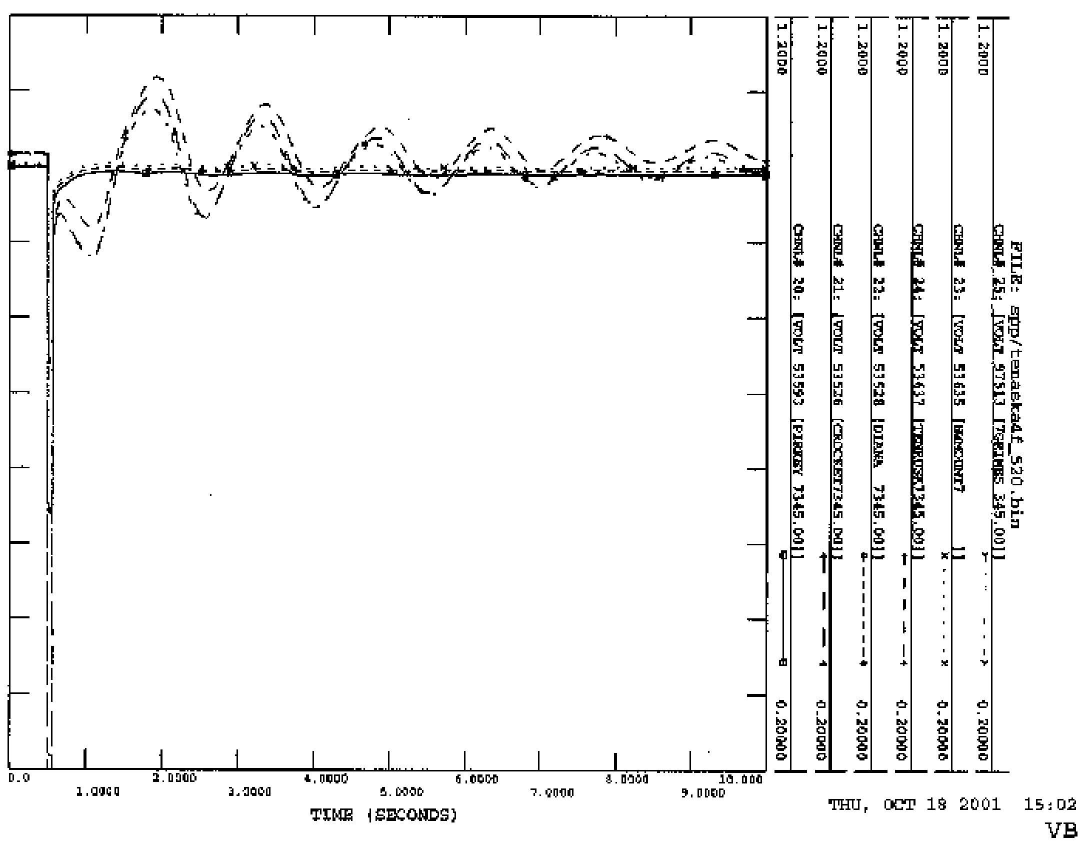
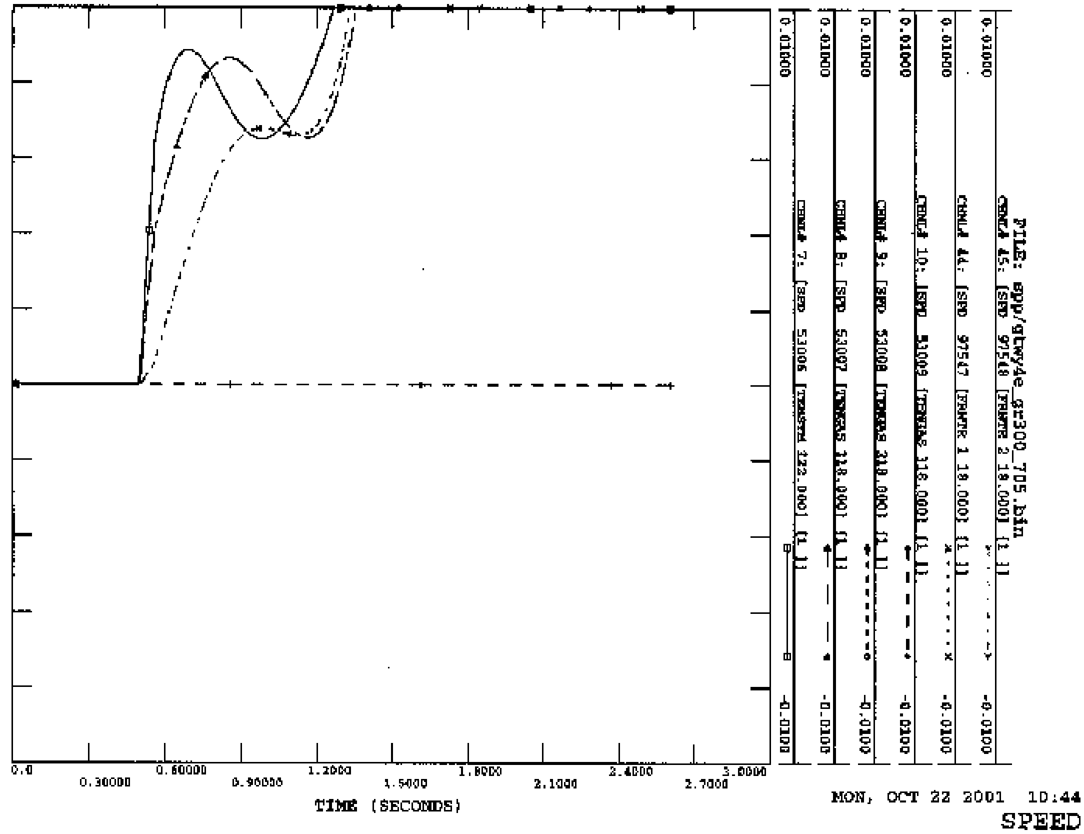


Table 8 Case 4 e -Prior Outage at Grimes - Coletta - Bryan 138 kV
Gateway = 705 MW Frontier = 300 MW



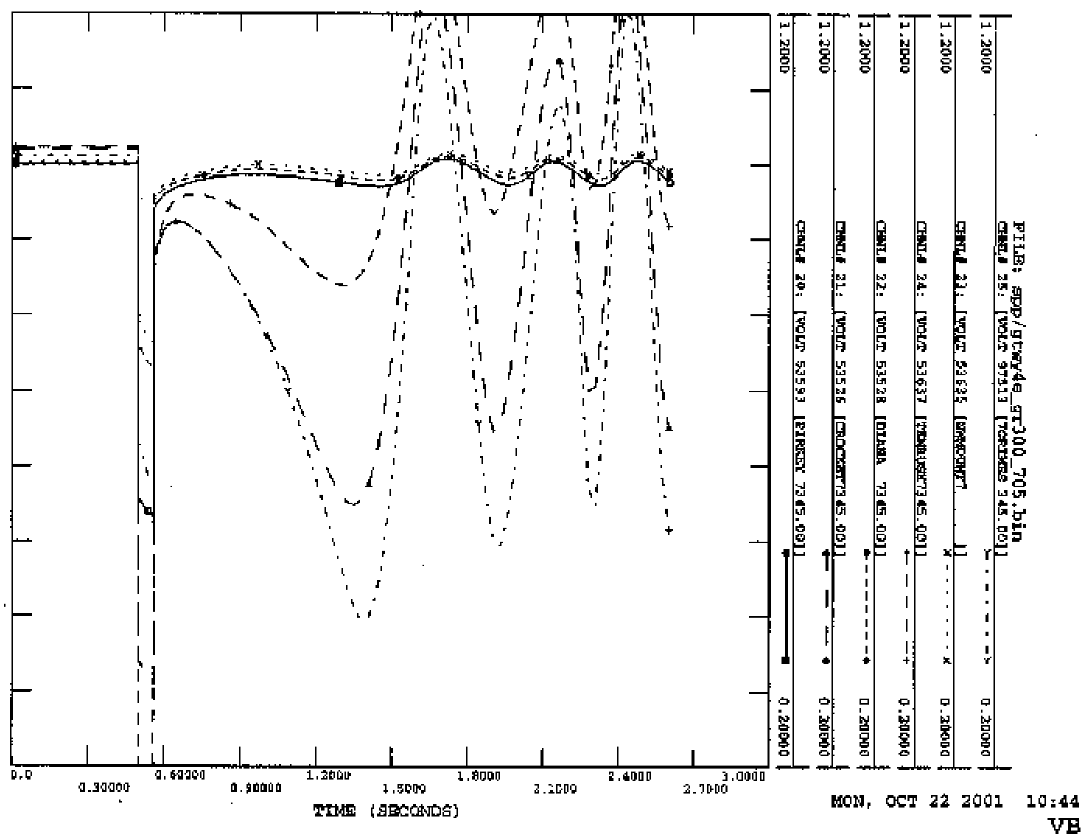
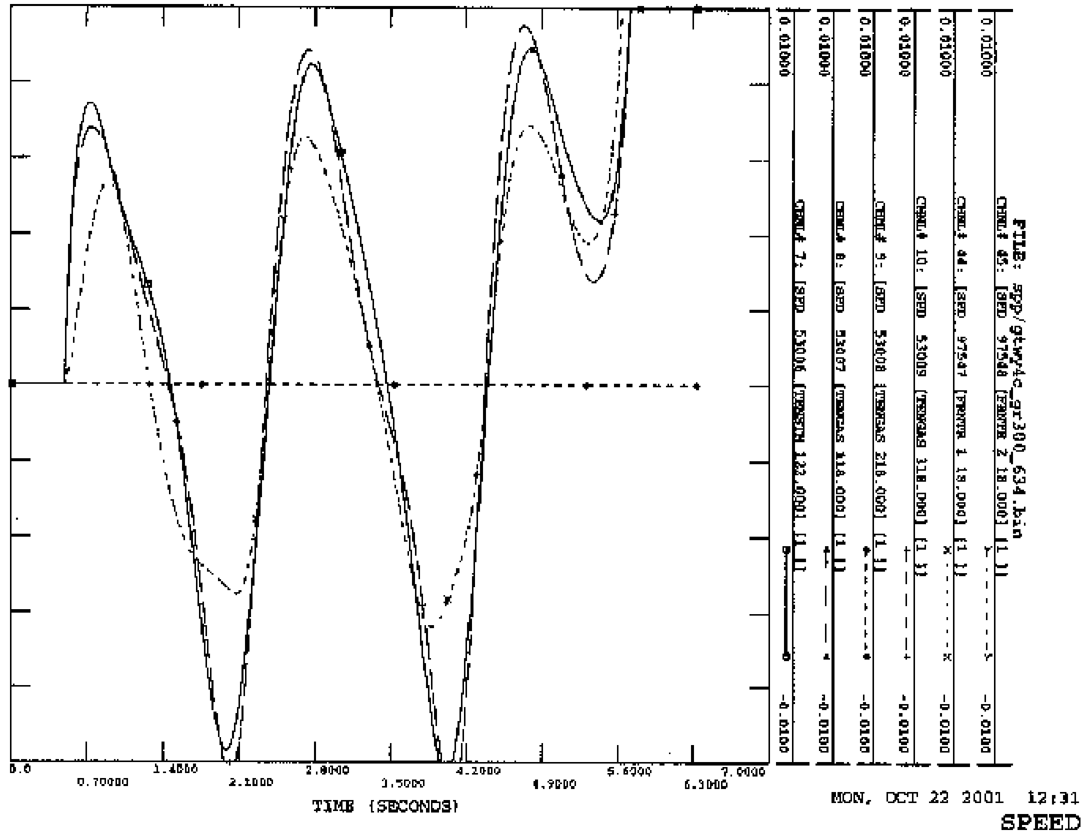


Table 8 Case 4c - Prior Outage at Grimes 345/138 kV (1)
Gateway =634 MW Frontier = 300 MW



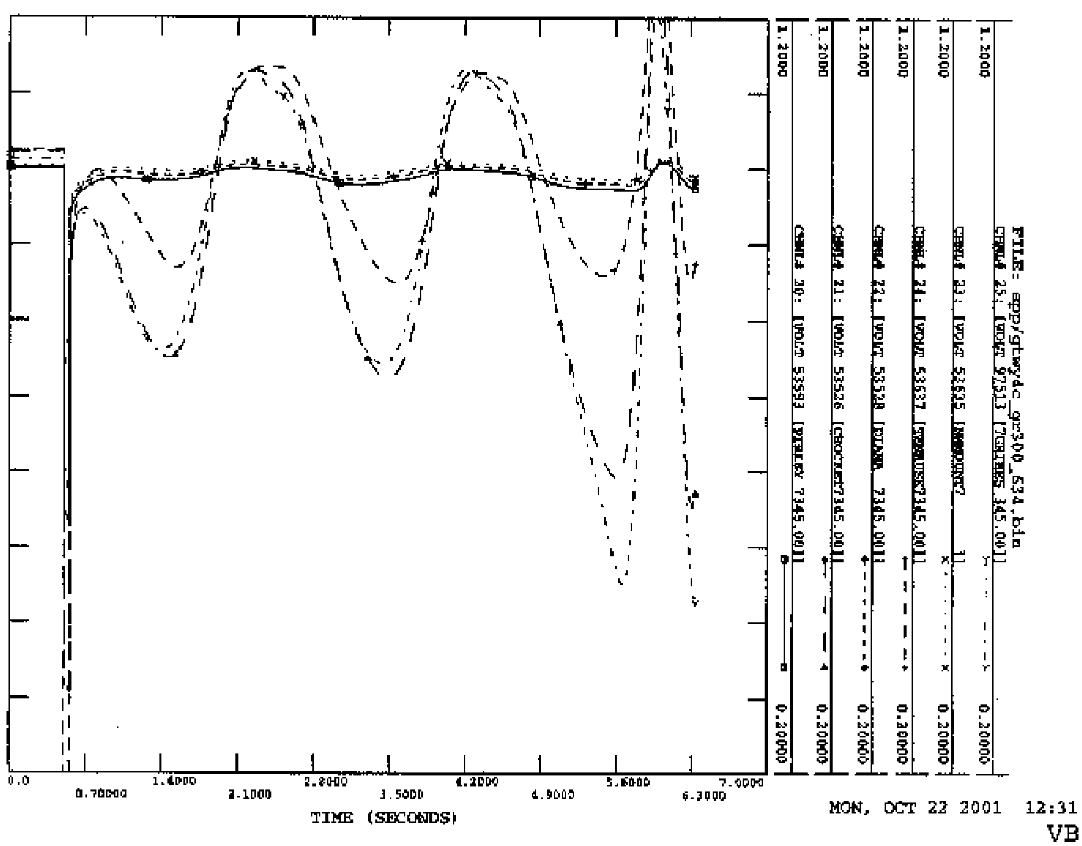
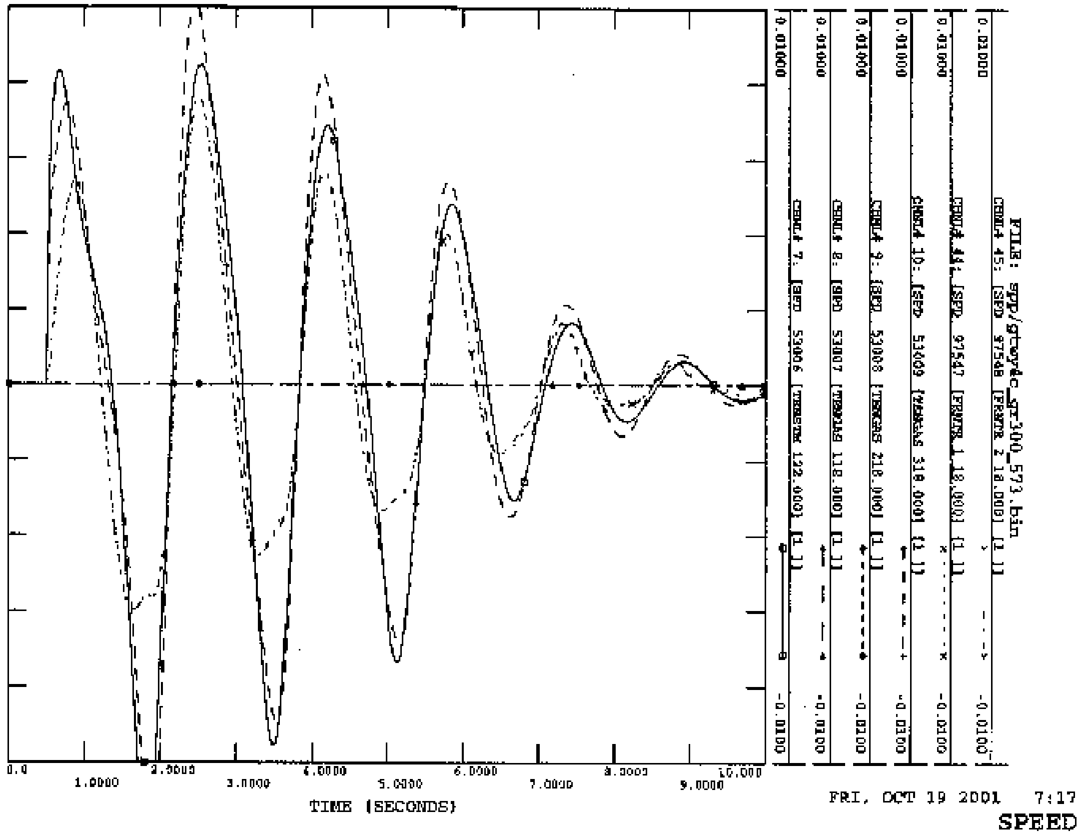


Table 8 Case 4c - Prior Outage at Grimes 345/138 kV (1)
Gateway = 573 MW Frontier = 300 MW



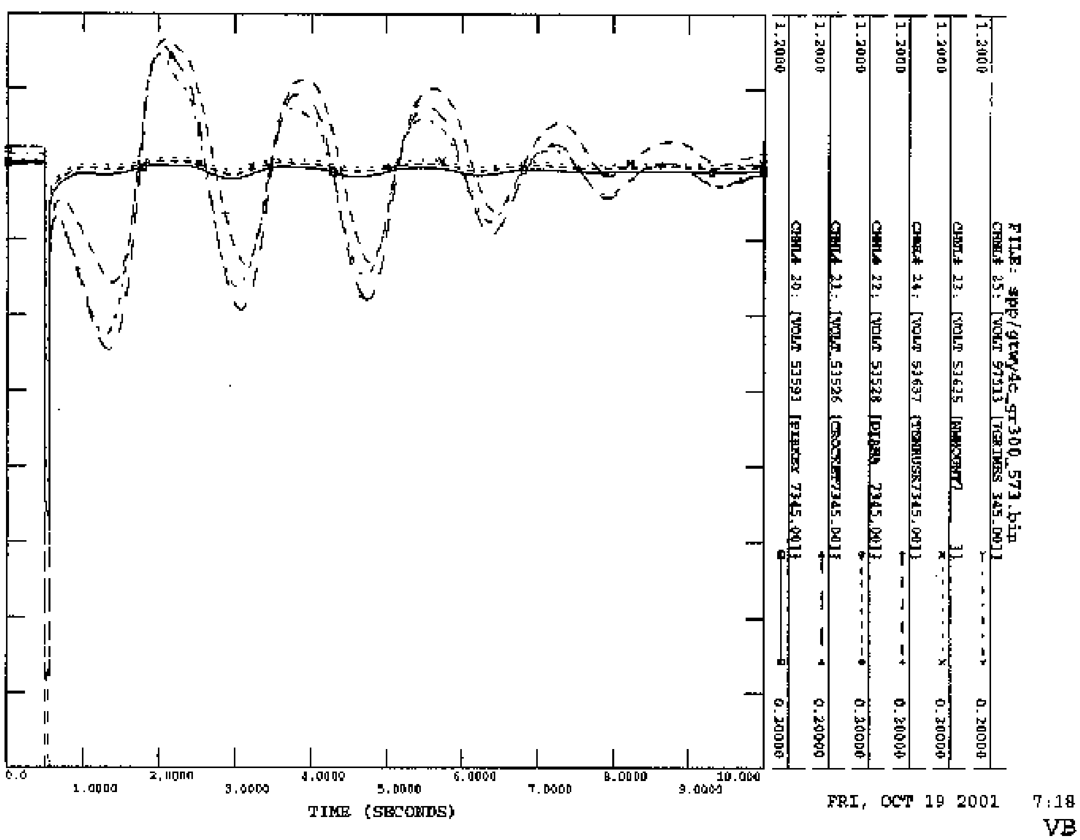
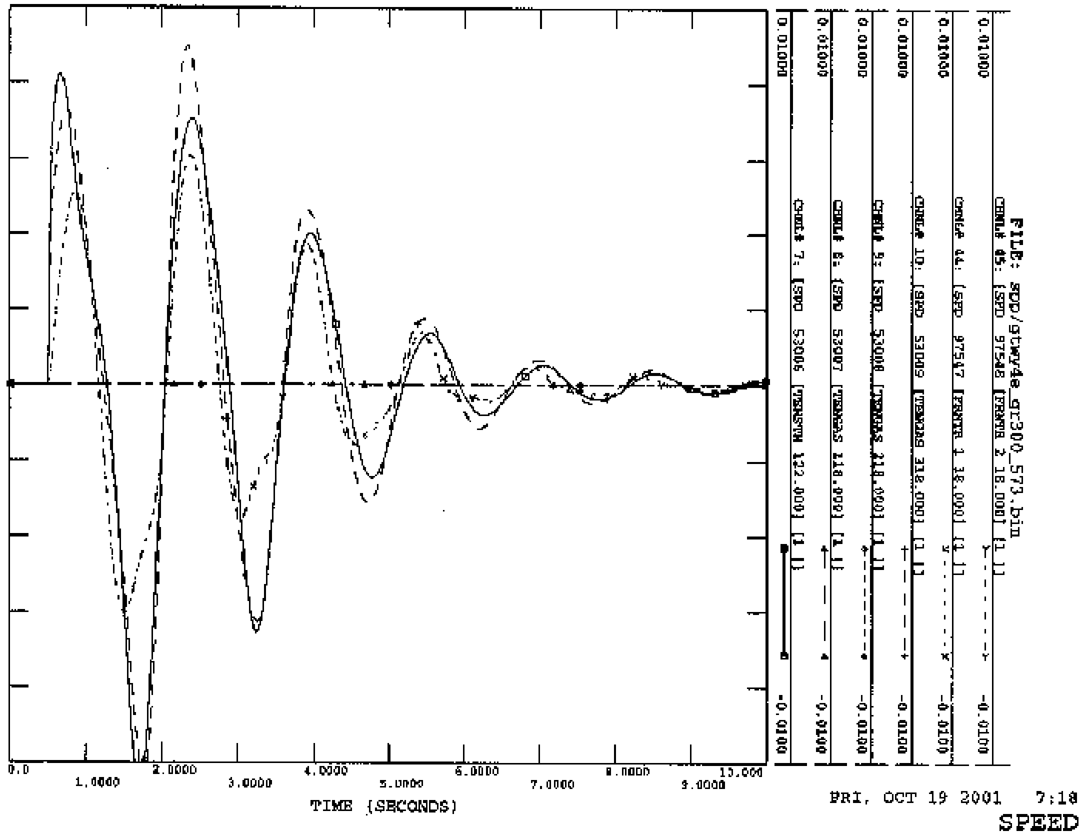


Table 8 Case 4 e - Prior Outage at Grimes - Coletta - Bryan 138 kV
Gateway = 573 MW Frontier = 300 MW



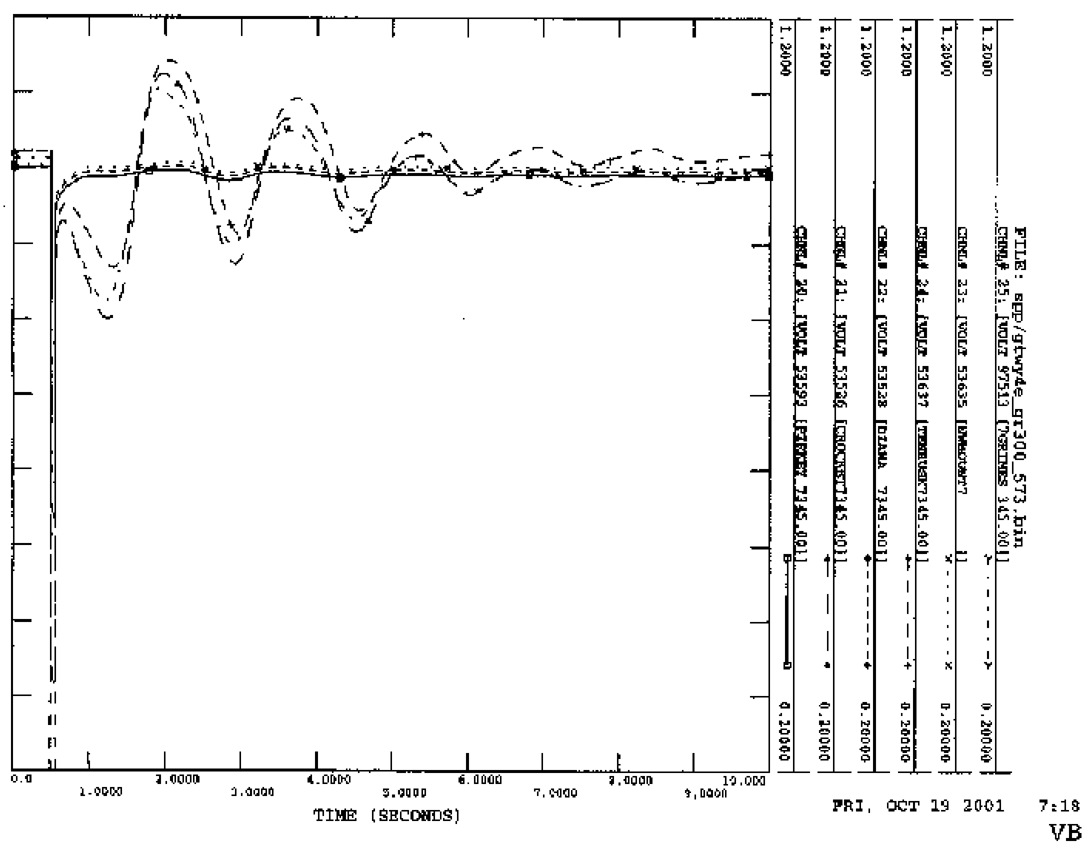
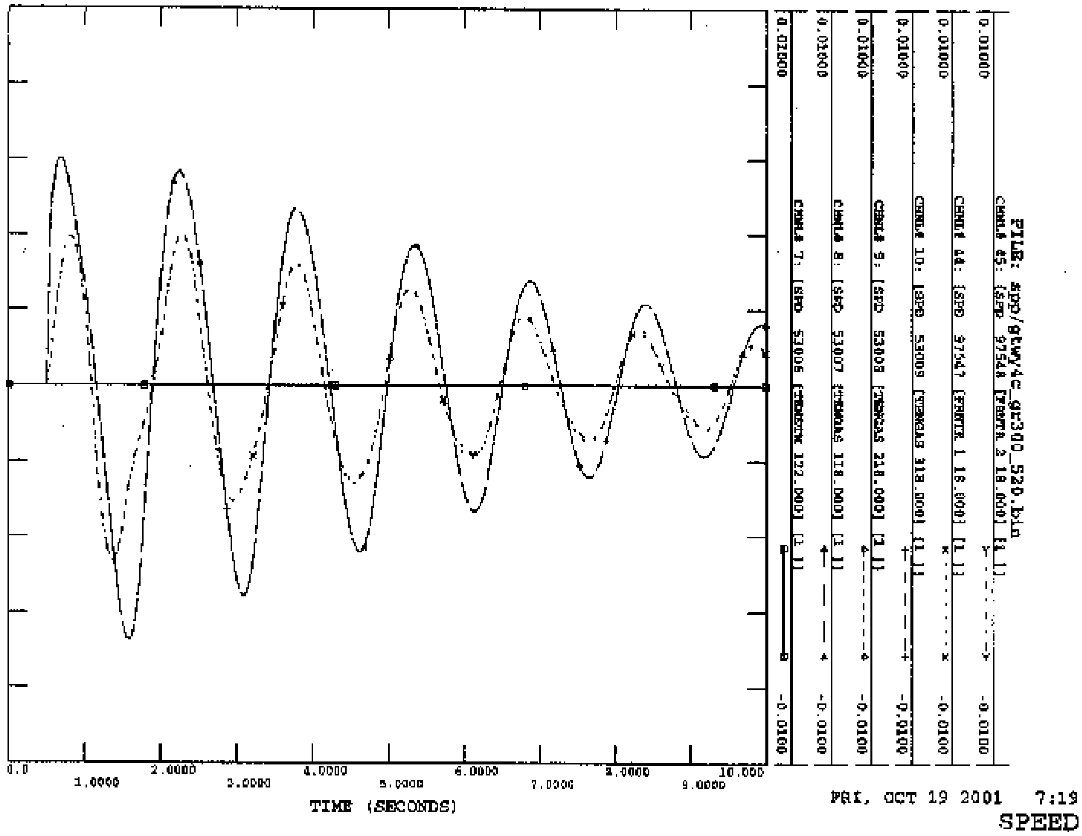


Table 8 Case 4c - Prior Outage at Grimes 345/138 kV (1)
Gateway = 520 MW Frontier = 300 MW



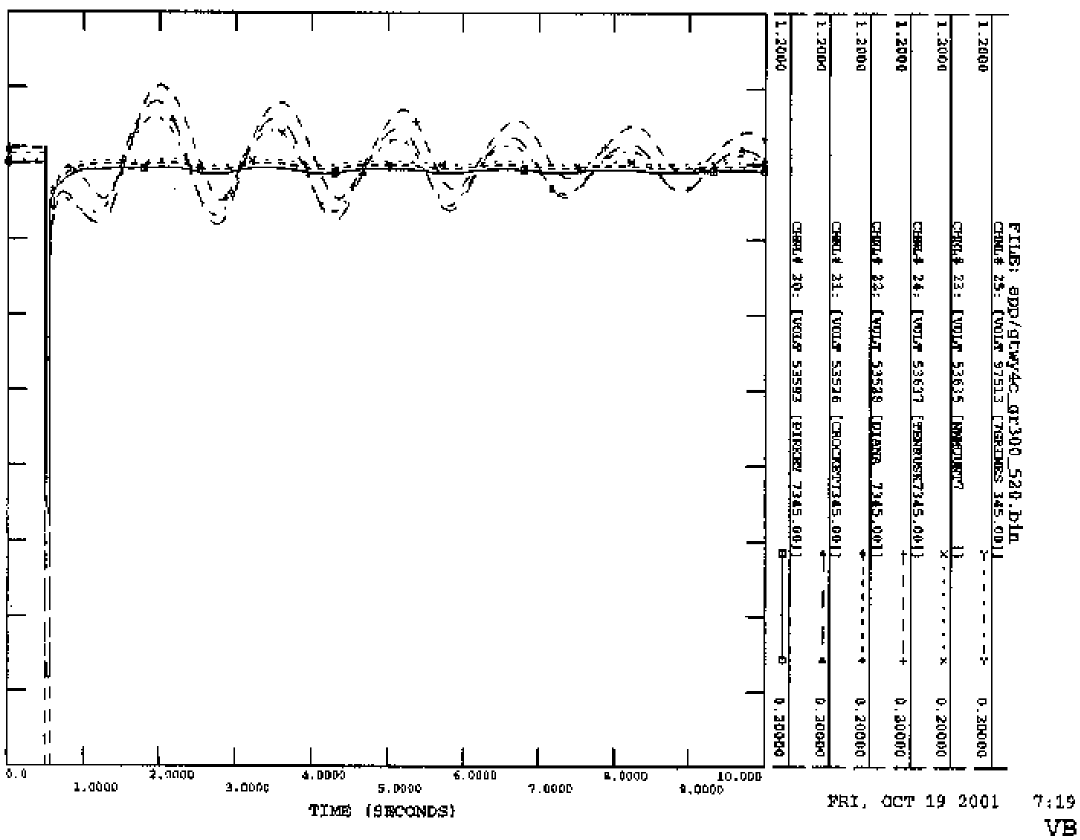
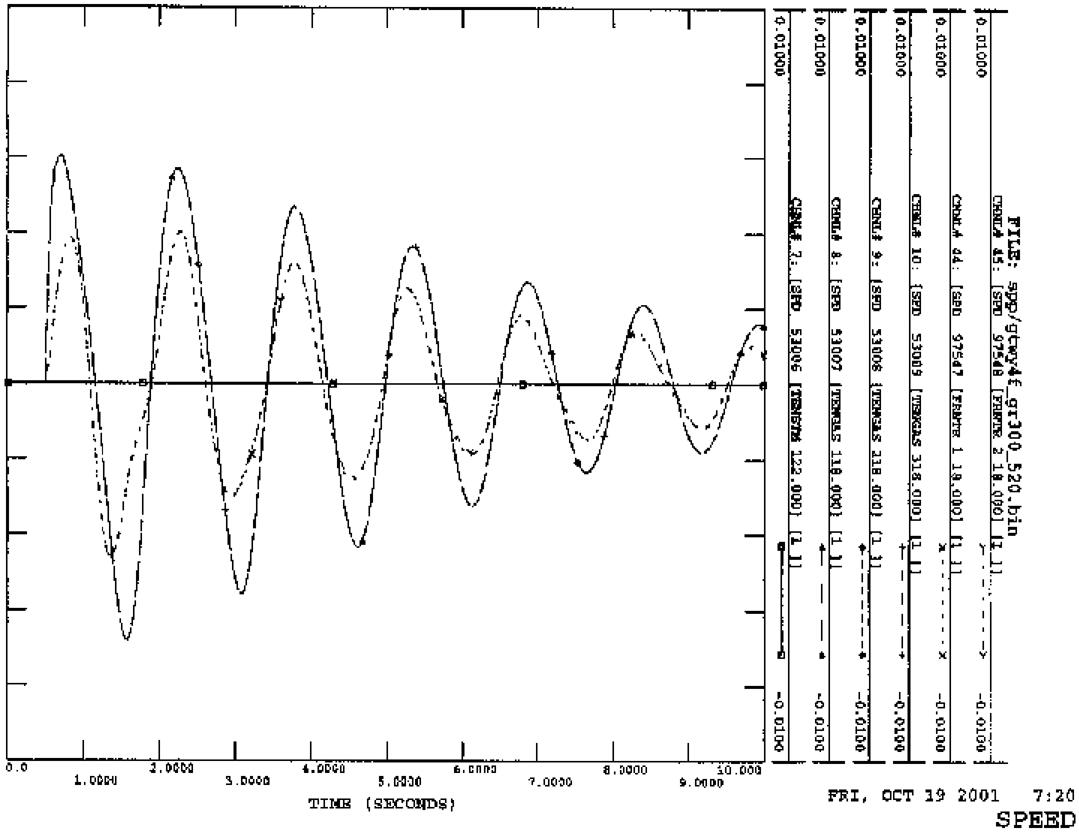
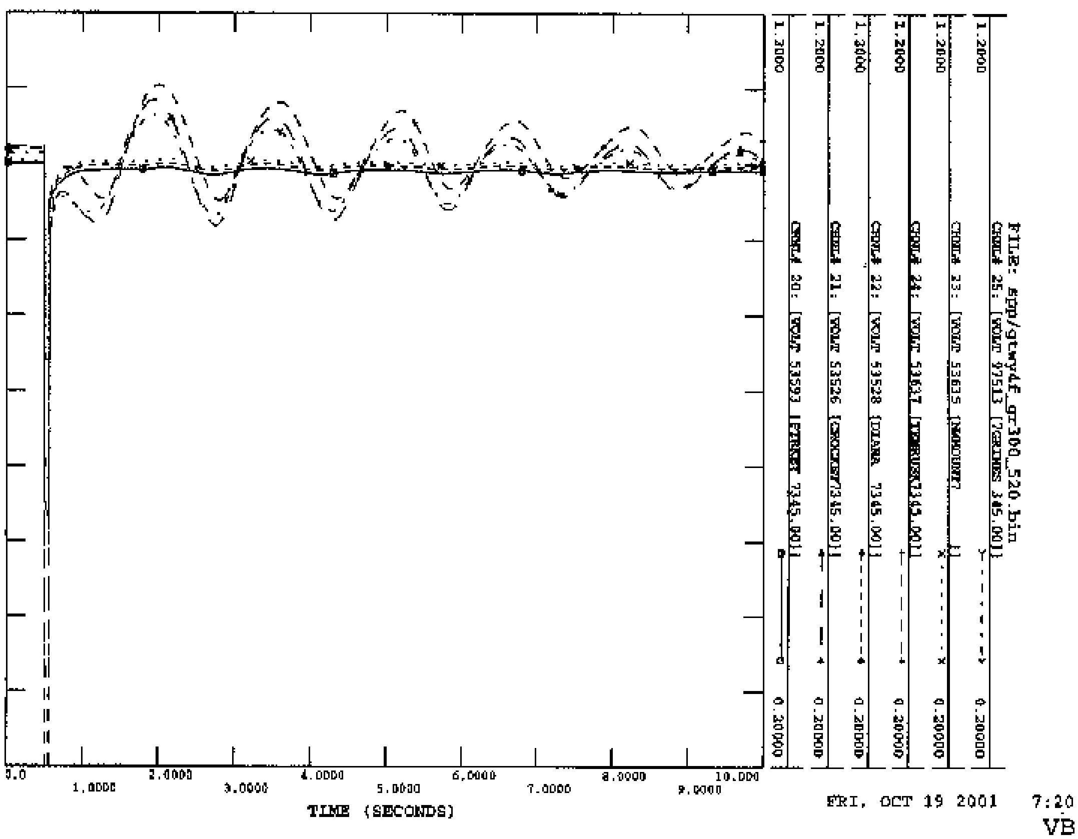
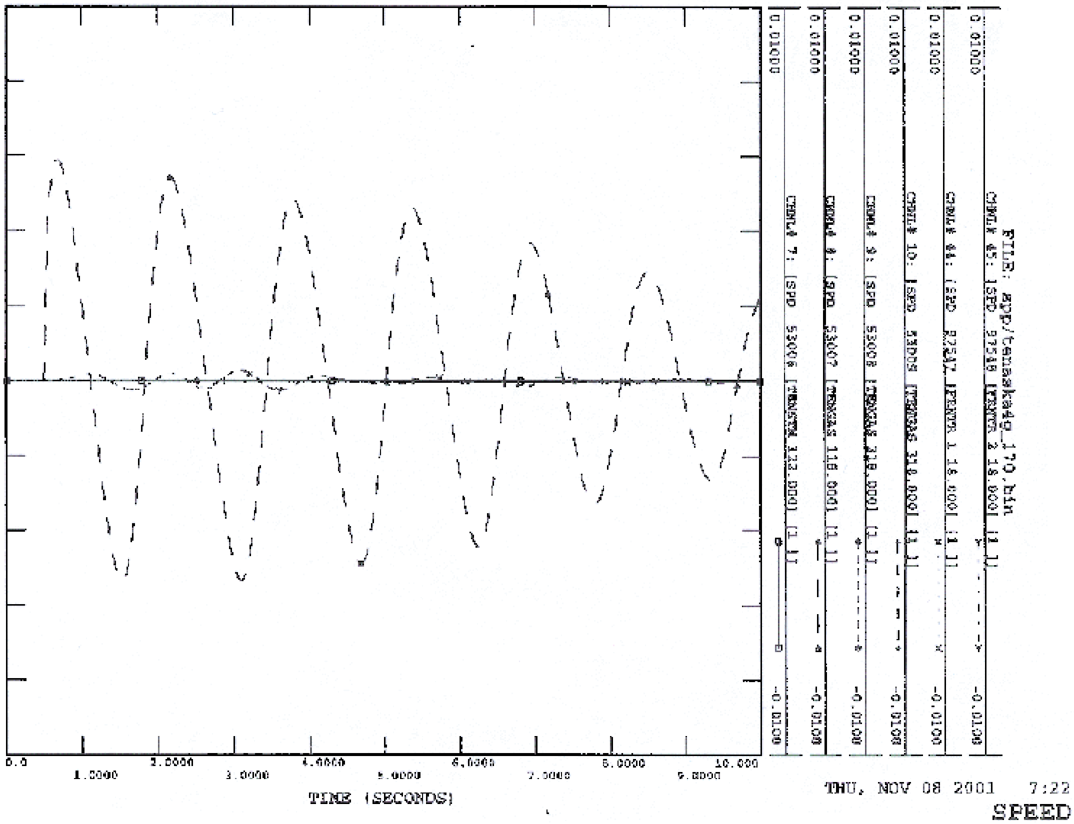


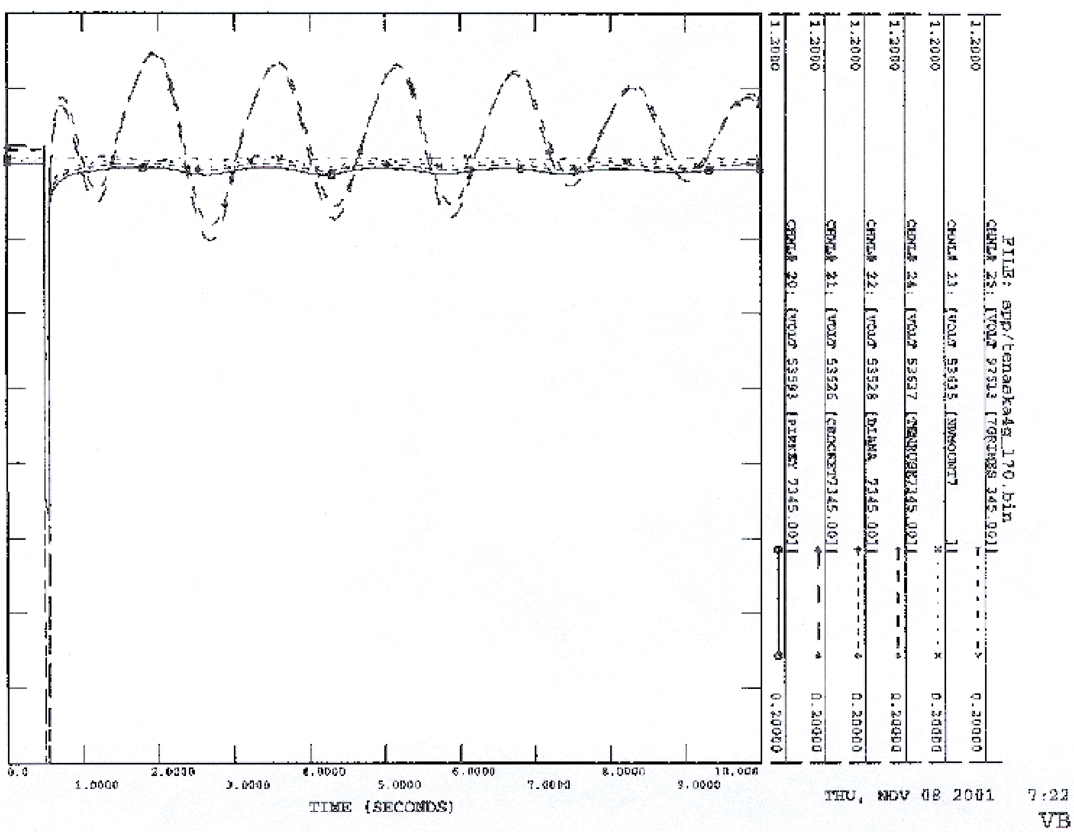
Table 8 Case 4f - Prior Outage at Grimes - MagAnd - Navasota 138 kV
Gateway = 520 MW Frontier = 300 MW



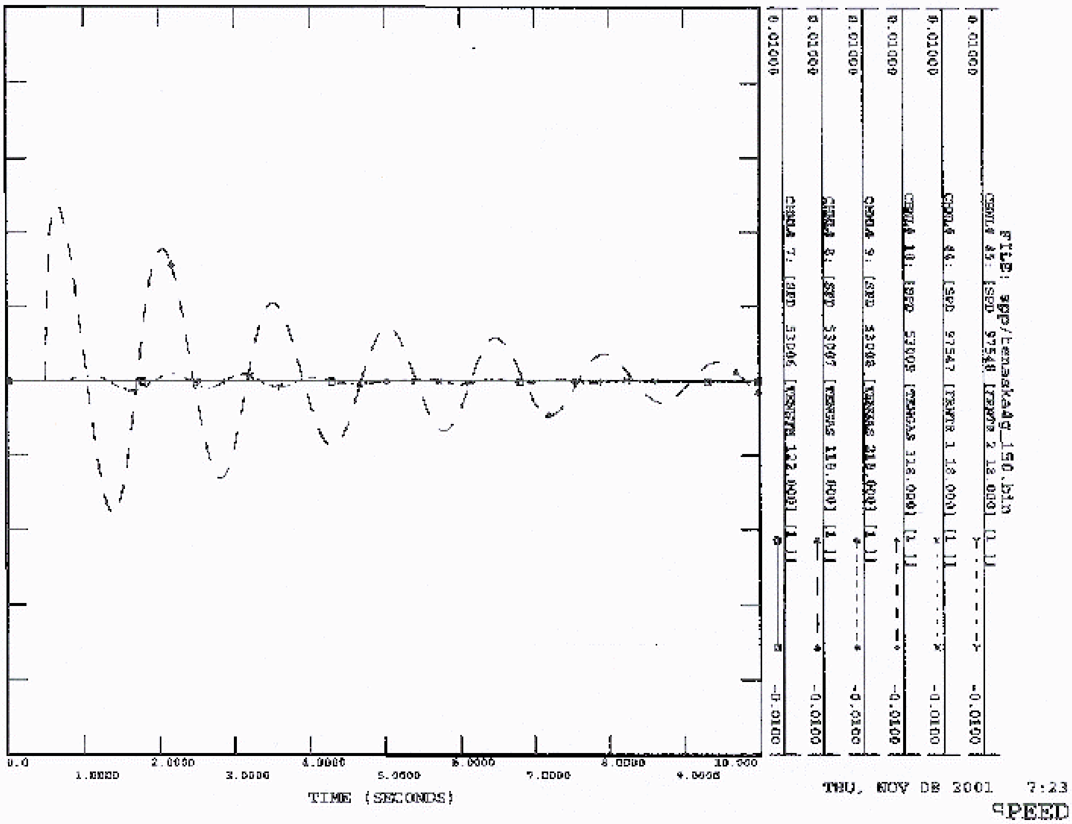


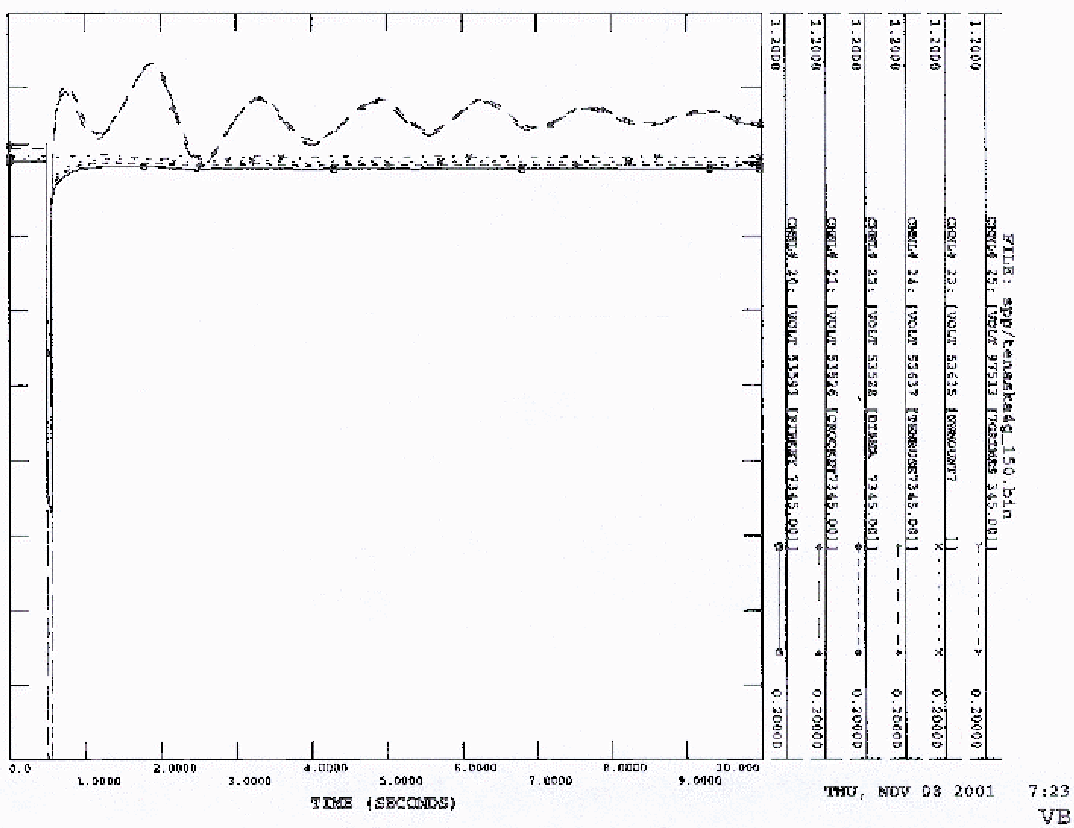
Case 4g - Prior Outage at Crockett - Grimes 345 kV
Gateway = 170 MW





Case 4g - Prior Outage at Crockett - Grimes 345 kV
Gateway = 150 MW



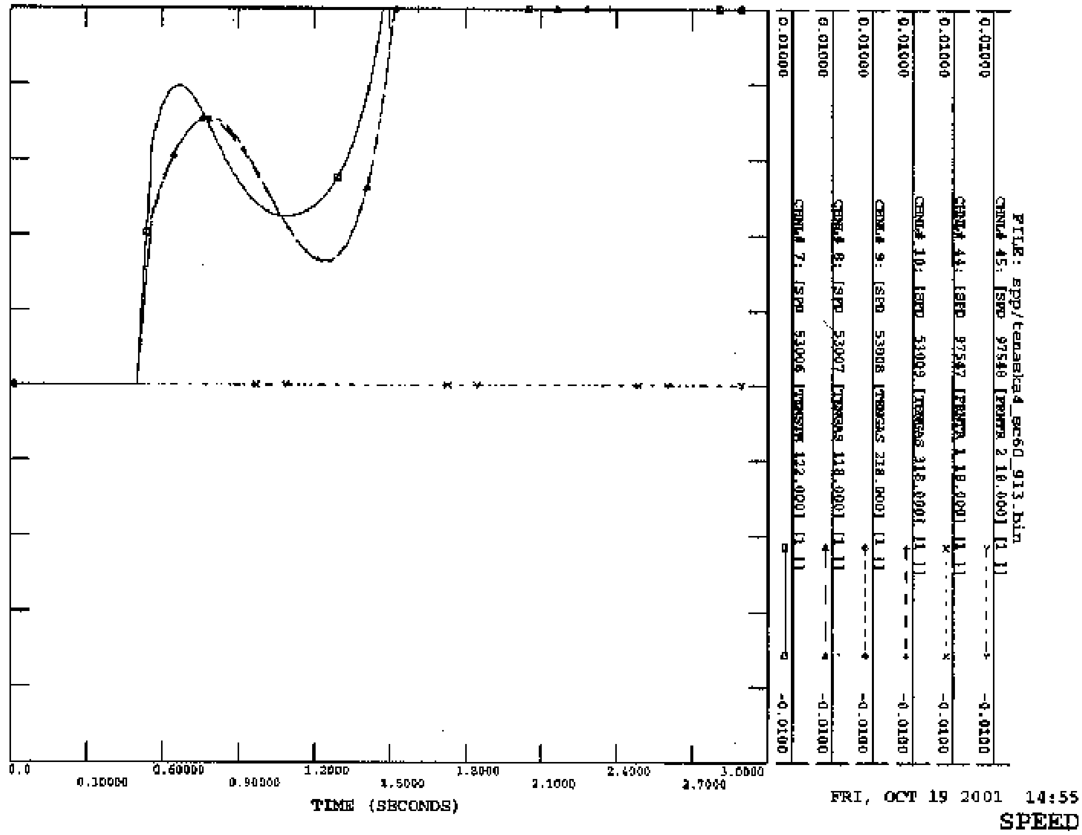


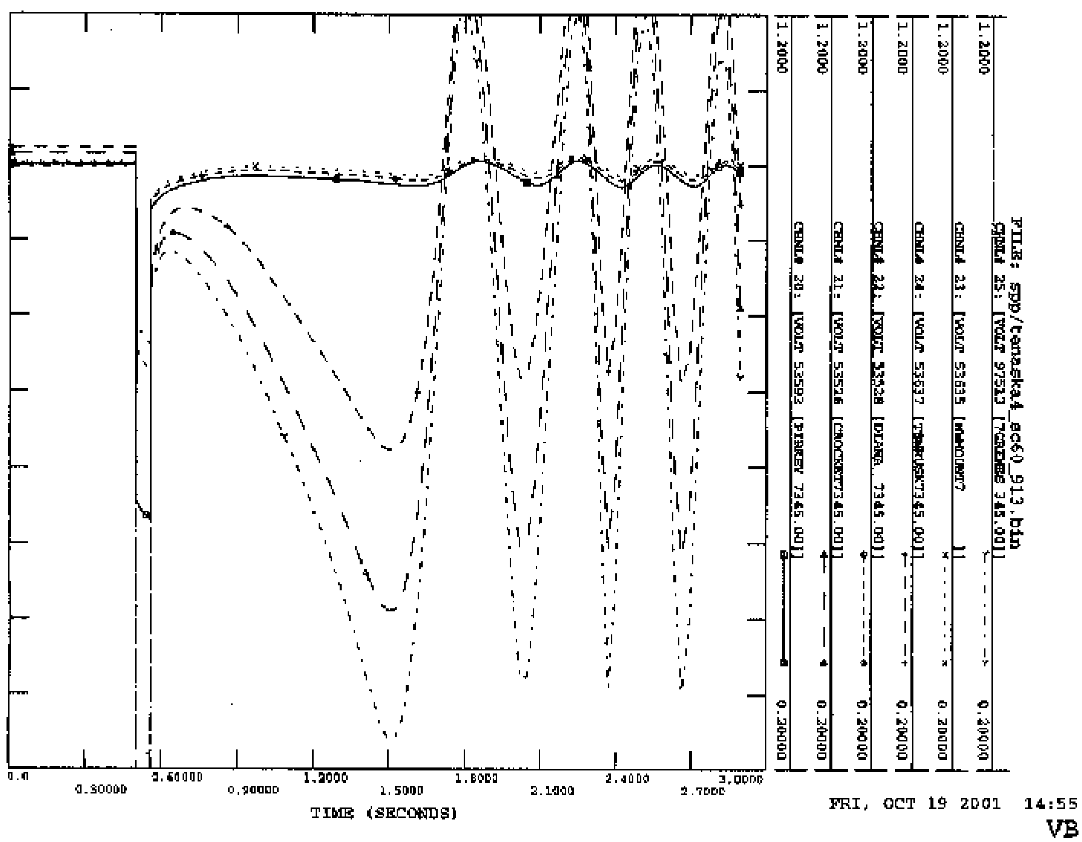
Attachment 3

Stability Simulation Results

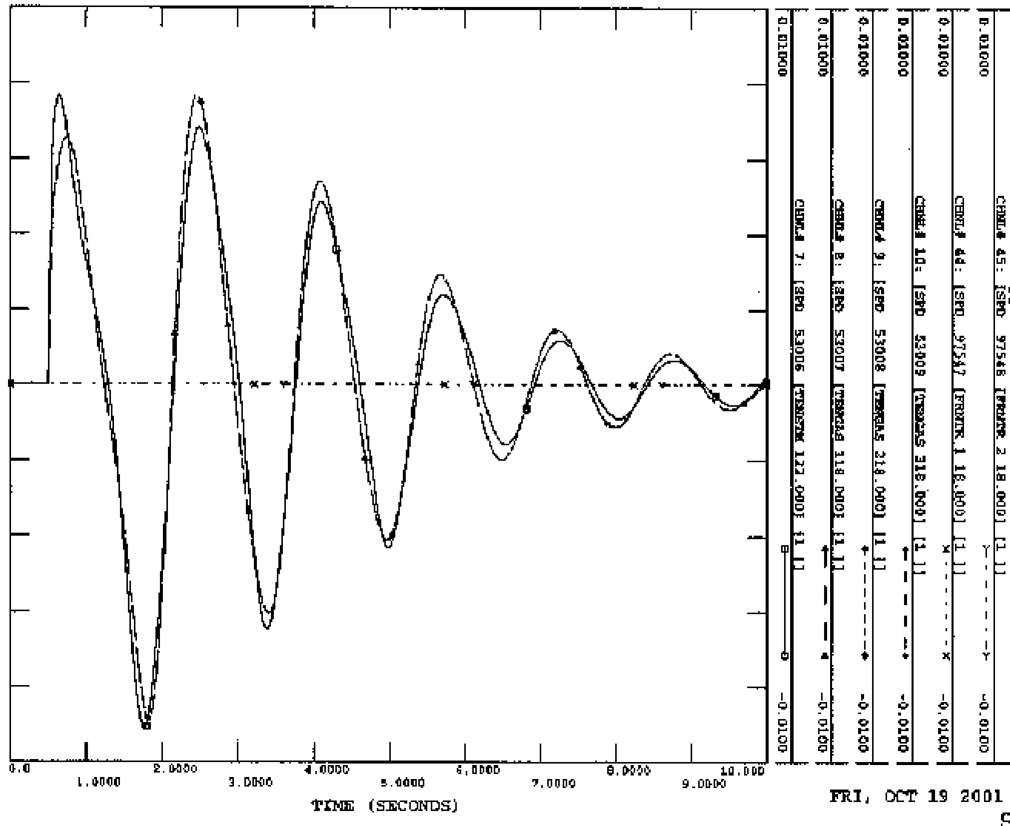
Series Compensation

Case 4 -No Prior Outage 60% Series Capacitor
Gateway = 913 MW Frontier = 0 MW

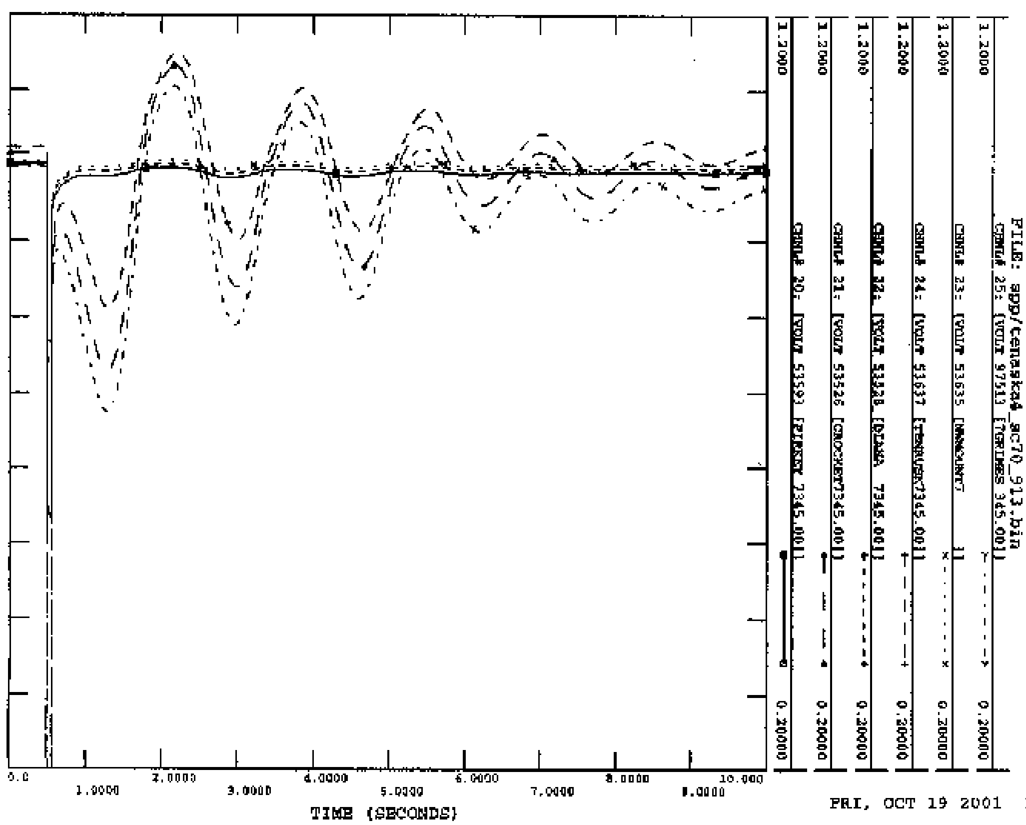




Case 4 -No Prior Outage 70% Series Capacitor
Gateway = 913 MW Frontier = 0 MW



SPEED



VB

Case 4 -No Prior Outage 80% Series Capacitor
Gateway = 913 MW Frontier = 300 MW