SPP Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2006-018

SPP Tariff Studies

(#GEN-2006-018)

December, 2006

Executive Summary

<OMITTED TEXT> (Customer) has requested a Feasibility/Impact Study for the purpose of interconnecting 160MW of generation within the service territory of Southwestern Public Service (SPS) d/b/a Xcel Energy Inc. in Hale County, Texas. The proposed combustion turbine has a proposed point of interconnection at the 230kV bus of SPS's Tuco substation. The proposed in-service date is June 1, 2007.

Power flow analysis has indicated that for the powerflow cases studied, it is possible to interconnect the 160MW of generation with transmission system reinforcements within the local transmission systems.

The requirements for interconnection consist of adding a new 230kV terminal at Tuco substation. The total cost for adding the terminal, the required interconnection facility, is estimated at $947,650. Other Network Constraints in the SPS transmission system that may be verified with a transmission service request and associated studies are listed in Table 3. These Network Constraints are in the local area of the new generation when this generation is sunk throughout the SPP footprint for the Energy Resource (ER) Interconnection request. With a defined source and sink in a Transmission Service Request (TSR), this list of Network Constraints will be refined and expanded to account for all Network Upgrade requirements. This cost does not include building any Customer facilities beyond the point of interconnection. This cost does not include any facilities that may be necessary due to short circuit fault duty considerations. These facilities will be identified in the Facility Study if the Customer executes a Facility Study Agreement.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer for future analyses including the determination of lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. If the loading of a facility is higher, the level of ATC will be lower. These contingency analyses will have to be re-evaluated as part of a transmission service request.

A dynamic stability study was conducted by TRC Power Delivery in Chicago, IL. Stability studies showed no problems associated with interconnecting the requested generation. The entire study can be found in Attachment 1.

There are several other proposed generation additions in the general area of the Customer's facility. It was assumed in this preliminary analysis that these other projects within the SPS service territory will be in service. Those previously queued projects that have advanced to nearly complete phases were included in this Feasibility/Impact Study. In the event that another request for a generation interconnection with a higher priority withdraws, then this request may have to be re-evaluated to determine the local Network Constraints.

The required interconnection costs listed in Table 2 and other upgrades associated with Network Constraints listed in Table 3 do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS.

Introduction

<OMITTED TEXT> (Customer) has requested a Feasibility/Impact study for the purpose of interconnecting a 160MW combustion turbine within the service territory of Southwestern Public Service (SPS) d/b/a Xcel Energy in Hale County, Texas. The proposed method of interconnection is to add a new 230kV terminal into the existing SPS Tuco substation. The proposed in-service date is June 1, 2007.

Interconnection Facilities

The primary objective of this study is to identify the system problems associated with connecting the plant to the area transmission system. The Feasibility and other subsequent Interconnection Studies are designed to identify attachment facilities, Network Upgrades and other direct assignment facilities needed to accept power into the grid at the interconnection receipt point.

Description of the Customer's generator can be found in Attachment 1, section 2.3. The Customer's GSU high side will interconnect at 230kV at the Tuco substation owned by SPS. The requirements for interconnection consist of adding a new 230kV terminal at Tuco substation.

The total cost for adding a new 230kV terminal into the Tuco substation and miscellaneous transmission construction, the required interconnection facility, is estimated at $947,650. Other Network Constraints in the SPS transmission system that were identified are listed in Table 3. These estimates will be refined during the development of the Facility study based on the final designs. This cost does not include building the 230kV facilities from the Customer substation into the SPS Tuco substation. The Customer is responsible for these 230kV facilities up to the point of interconnection. This cost also does not include the Customer's 230kV step-down substation, which should be determined by the Customer.

The costs of interconnecting the facility to the SPS transmission system are listed in Table 1 & 2. **These costs do not include any cost that might be associated with short circuit study results**. These costs will be determined when and if a Facility Study is conducted.

A preliminary one-line drawing of the interconnection and direct assigned facilities are shown in Figure 1.

Table 1: Direct Assignment Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
Customer – 230kV Step-down Facilities	*
Customer – 230kV facilities between Customer Step-down facility and SPS Tuco substation	*
Customer - Right-of-Way for Customer facilities.	*
Total	*****

Note: *Estimates of cost to be determined by Customer.

Table 2: Required Interconnection Network Upgrade Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
SPS – Add 230kV breaker and associated equipment to the Tuco substation. Equipment to include breaker, switches, control relaying, high speed communications, all structures and metering and other related equipment	$620,000
Surveying and Miscellaneous	$30,000
Transmission	$297,650
Total	**$947,650**

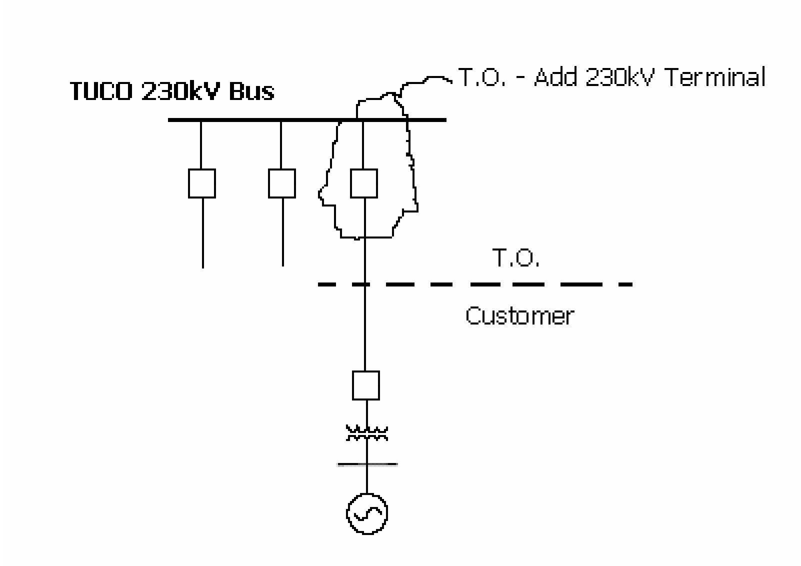

Figure 1: Proposed Interconnection
(Final substation design to be determined)

Powerflow Analysis

A powerflow analysis was conducted for the facility using modified versions of the 2007, 2008 & 2011 Summer and Winter Peak, and 2016 Summer Peak models. The output of the Customer's facility was offset in each model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ER) Interconnection request. The proposed in-service date of the generation is June 1, 2007. The available seasonal models used were through the 2016 Summer Peak of which is the end of the current SPP planning horizon.

The analysis of the Customer's project indicates that, given the requested generation level of 160MW and location, additional criteria violations will occur on the existing SPS transmission system under steady state and contingency conditions in the peak seasons.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. When a facility is overloaded for more than one contingency, only the highest loading on the facility for each season is included in the table.

There are several other proposed generation additions in the general area of the Customer's facility. These local projects that were previously queued were assumed to be in service in this Feasibility Study. Those local projects that were previously queued and have advanced to nearly complete phases were included in this Feasibility Study.

Powerflow Analysis Methodology

The Southwest Power Pool (SPP) criteria states that: "The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable *NERC Planning Standards* for System Adequacy and Security – Transmission System Table l hereafter referred to as NERC Table l) and its applicable standards and measurements".

Using the created models and the ACCC function of PSS\E, single contingencies in portions or all of the modeled control areas of American Electric Power West and Southwestern Public Service Company (d/b/a Xcel Energy, Inc.) were applied and the resulting scenarios analyzed. This satisfies the 'more probable' contingency testing criteria mandated by NERC and the SPP criteria.

Table 3: Network Constraints

Network Constraints
SPS - 'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 1'
SPS - 'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 2'
SPS - 'TUCO INTERCHANGE (TUCO XX4) 345/230/13.2KV TRANSFORMER CKT 1'

Table 4: Contingency Analysis

ELEMENT	SEASON	RATE	LOADING (%)	ATC	CONTINGENCY
2007 SUMMER PEAK					
'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 1'	07sp	252	100.8	137	'CARLISLE INTERCHANGE - TUCO INTERCHANGE 230KV CKT 1'
2016 SUMMER PEAK					
'TUCO INTERCHANGE (TUCO XX4) 345/230/13.2KV TRANSFORMER CKT 1'	16sp	560	121.0	8	'GEN:50891 1'
'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 1'	16sp	252	109.0	0	'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 2'
'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 2'	16sp	252	108.0	0	'TUCO INTERCHANGE 230/115KV TRANSFORMER CKT 1'

Note: When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. If the loading of a facility is higher, the level of ATC will be lower.

Dynamic Stability Analysis

A dynamic stability analysis was conducted by TRC Power Delivery in Chicago, IL for this request. The analysis revealed no stability issues associated with this generation interconnection request. The entire study can be found in Attachment 1.

Conclusion

The minimum cost of interconnecting the Customer project is estimated at $947,620 for SPS's Transmission Owner interconnection facilities listed in Table 2 excluding upgrades of other transmission facilities by SPS in Table 3 of which are Network Constraints. At this time, the cost estimates for Direct Assignment facilities including those in Table 1 have not all been defined by the Customer.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. These contingency analyses will have to be re-evaluated as part of a transmission service request.

Dynamic Stability Analysis shows that the interconnection of the proposed generation request will pose no adverse reliability conditions to the transmission system.

These interconnection costs do not include any cost that may be associated with short circuit analysis. A short circuit study will be performed if the Customer executes a Facility Study Agreement.

The required interconnection costs listed in Table 2 and other upgrades associated with Network Constraints listed in Table 3 and Table 4 do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS.

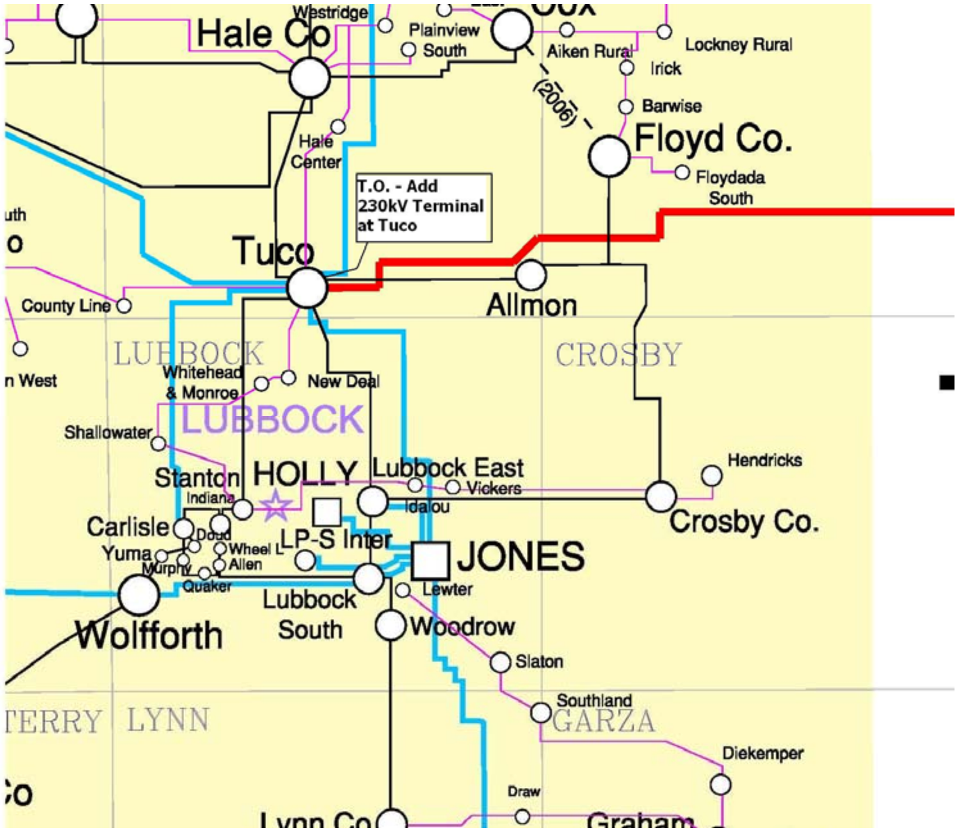

Figure 2: Map of the Local Area

ATTACHMENT 1.

STABILITY STUDY

GEN-2006-018

Generation Interconnection Impact Study

December 13, 2006

Submitted to SPP

Prepared by:

TRC

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Executive Summary

<Omitted Text> has a requested a generator interconnection study through the Southwest Power Pool (SPP) Tariff for a 230 kV interconnection for a new Frame 7 170 MW (nominal) combustion turbine connected to the existing Tuco substation, owned by SWPS (d/b/a Xcel Energy). This CT will be interconnected using a new 230 kV breaker and switches.

This study simulated the dynamic performance of the proposed unit at generator rated output of 156 MW. Additional stability runs were made at reduced output to determine the maximum capability without transmission reinforcements.

The proposed unit can be operated at full rated output at the Tuco site under summer 2007 and winter 2007 conditions, given existing transmission and the specified dispatch pattern, and remain stable for all faults considered.

1 Study Objectives

<Omitted Text> has a requested a generator interconnection study through the Southwest Power Pool (SPP) Tariff for a 230 kV interconnection for a new Frame 7 170 MW combustion turbine connected to the existing Tuco substation. This CT will be interconnected using a new 230 kV breaker and switches. The existing substation is owned by SWPS (d/b/a Xcel Energy).

The primary objectives of this study are:

- To determine whether the proposed unit can stably operate at maximum output during representative fault conditions on nearby EHV transmission lines.
- If not, to determine output levels at which it can operate during such faults.

2 Study Area

2.1 Transmission System

The proposed site of the plant is within a somewhat isolated portion of the Eastern Interconnection, tied to the rest of this interconnection by a single 345 kV line to Oklaunion and by a predominantly 230 kV network to western Kansas. Back-to-back DC ties to the Western and Texas interconnections also exist, but are of limited capacity and lead to areas with limited support. A map showing principal transmission lines (as of August, 2003) in the West Texas area is shown as Figure 1.

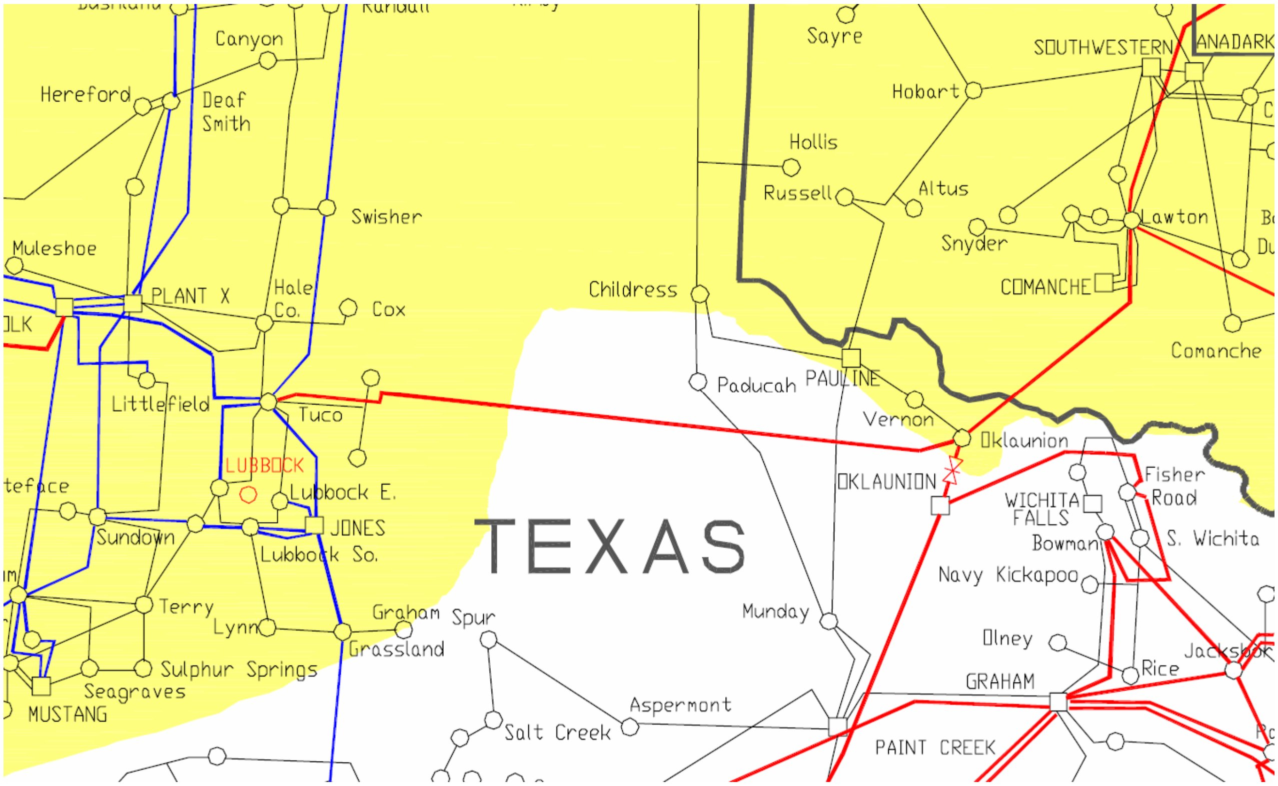

Figure 1 – Principal transmission lines in the Tuco area

2.2 Power Flow Model

A one-line diagram of the EHV transmission system in the Tuco area, showing the location of simulated contingencies, is shown as Figure 2. The system configuration studied reflects existing facilities and those expected to be in service in 2007, notably a wind farm between Tuco and Oklaunion. Two seasonal models were studied, the 2007 summer peak and the 2007 winter peak. These power flow models were provided by the client. Minimal detail of transmission in the WECC and ERCOT regions, which are tied to the study area only through DC links, is included in the system model.

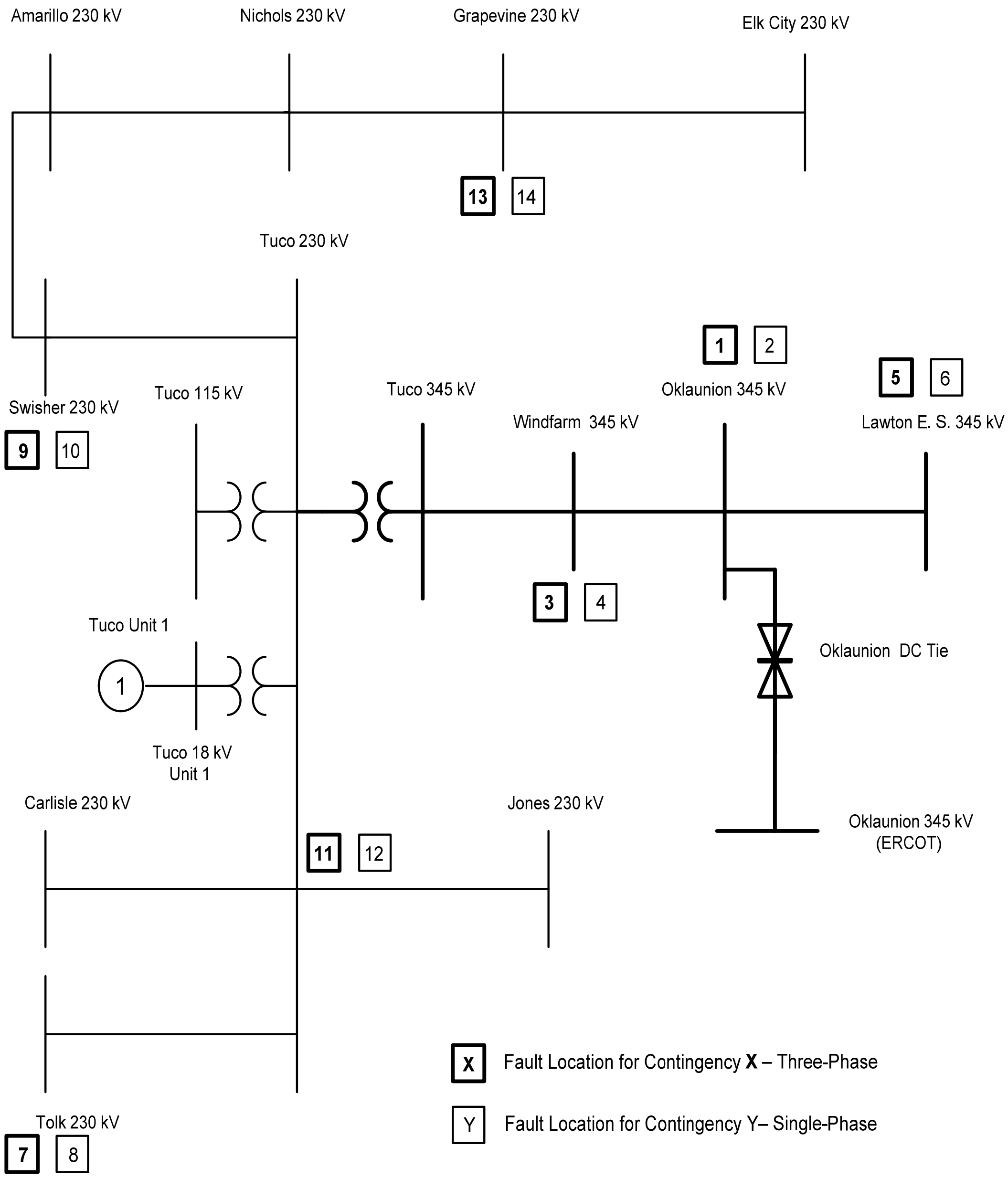

Figure 2 – Proposed CT installation on the Tuco 230 kV bus

2.3 Proposed Unit

In the scoping document the proposed unit is shown as having a nominal unit capability of 170 MW. However, based on the GE estimated data provided (generator drawing 378A8802, excitation system drawing 378A5910), the capability of the unit was assumed to be its generator rating at 30 PSIG, 40 deg C of 155.635 MW (183.1 MVA at 0.85 power factor).

The GE estimated data mentioned above was used to provide generator, exciter and stabilizer dynamic model parameters for the proposed unit. Field adjustments during commissioning may modify some of the parameters assumed. A generic GAST turbine-governor model was assumed. See Appendix A for modeling details of the proposed unit.

2.4 Dynamic Models of Other Facilities

Dynamic models of other generators and their ancillary systems, DC lines and other system elements were used as supplied by the client.

2.5 Generating Unit Dispatch

The commitment and loading of generating units was as specified by the client and shown below in Tables 1 (summer) and 2 (winter). Alternative generation scenarios in either season may result in better or worse dynamic performance in marginal cases and should be considered in scheduling operating levels of the plant. The proposed unit at Tuco was dispatched var neutral at the interconnection point.

Table 1 – 2007 summer re-dispatch

Unit	Initial Dispatch	Re-dispatch for 156 MW Unit addition at TUCO 230 kV
Nichols 1	97.0 MW	0.0 MW (Unit Off)
Nichols 2	103.0 MW	44.0

Table 2 – 2007 winter re-dispatch

Unit	Initial Dispatch	Re-dispatch for 156 MW Unit addition at TUCO 230 kV
Nichols 2	41.0 MW	0.0 MW (Unit Off)
Harrington 1	346.0 MW	231.0 MW

3 Study Methodology

Fourteen contingencies or cases were considered for the transient stability simulations which included three-phase faults and single-phase line faults on the 345 kV and 230 kV substations near the proposed project. Single-phase line faults were simulated by adding fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP’s current practice of simulating single-phase line faults. Table 3 shows the list of simulated contingencies. The table also shows the fault clearing time and the time delay before re-closing (where required) for each study contingency. Where reclosing is indicated it was assumed to be unsuccessful and the line tripped and locked out in the same time as for the initial clearing.

Table 3 – Cases simulated (same in summer and winter seasons)

Cases	kV	Faulted Bus	Remote Bus	Clearing time (cycles)	Reclose time (cycles)
1 and 2	345	GEN-2005-015 Wind Farm Switching Station	Oklaunion	4	30
3 and 4	345	Tuco	GEN-2005-015 Wind Farm Switching Station	5	30
5 and 6	345	Lawton Eastside	Oklaunion	2.5	30
		DC line 44 at Oklaunion and associated capacitor tripped by special protection system.			
7 and 8	230	Tolk	Tuco	5	None
9 and 10	230	Tuco	Swisher	5	20
11 and 12	230	Tuco	Jones	5	None
13 and 14	230	Grapevine	Elk City	5	20

Briefly, odd numbered cases represent three-phase fault scenarios and even numbered cases represent phase-to-ground fault scenarios at the same location. Cases 1 through 6 represent scenarios impacting the 345 kV tie across ERCOT to central Oklahoma, while cases 7 through 14 represent scenarios impacting the predominantly 230 kV network in west Texas. Except for cases 5 and 6, each contingency represents outage of a single line. It is assumed that sufficient breakers are installed to allow selective tripping as indicated by the contingency definitions.

4 Simulation Results

Plots of rotor angle for the proposed unit are given on the following pages as Figures 3 through 16. More detailed plots are provided in Appendices II (for summer conditions) and III (for winter conditions), including the following

- Plots comparing the rotor angle of the proposed unit following three-phase and phase-to-ground faults at the same location. This demonstrates that in most cases the three-phase fault is the more severe challenge.
- Plots comparing the voltage at the fault location during the three-phase and phase-to-ground scenarios, documenting that the voltage during the latter was approximately 0.60 PU as intended.
- Rotor angle and speed of the subject unit, and voltage at the fault location (also included in the body of the report, repeated in the Appendix for completeness.
- Rotor angles of nearby fossil units.(eight plots per case)
- Speeds of selected units at the GEN 2005-015 wind farm.

4.1 Summer Cases

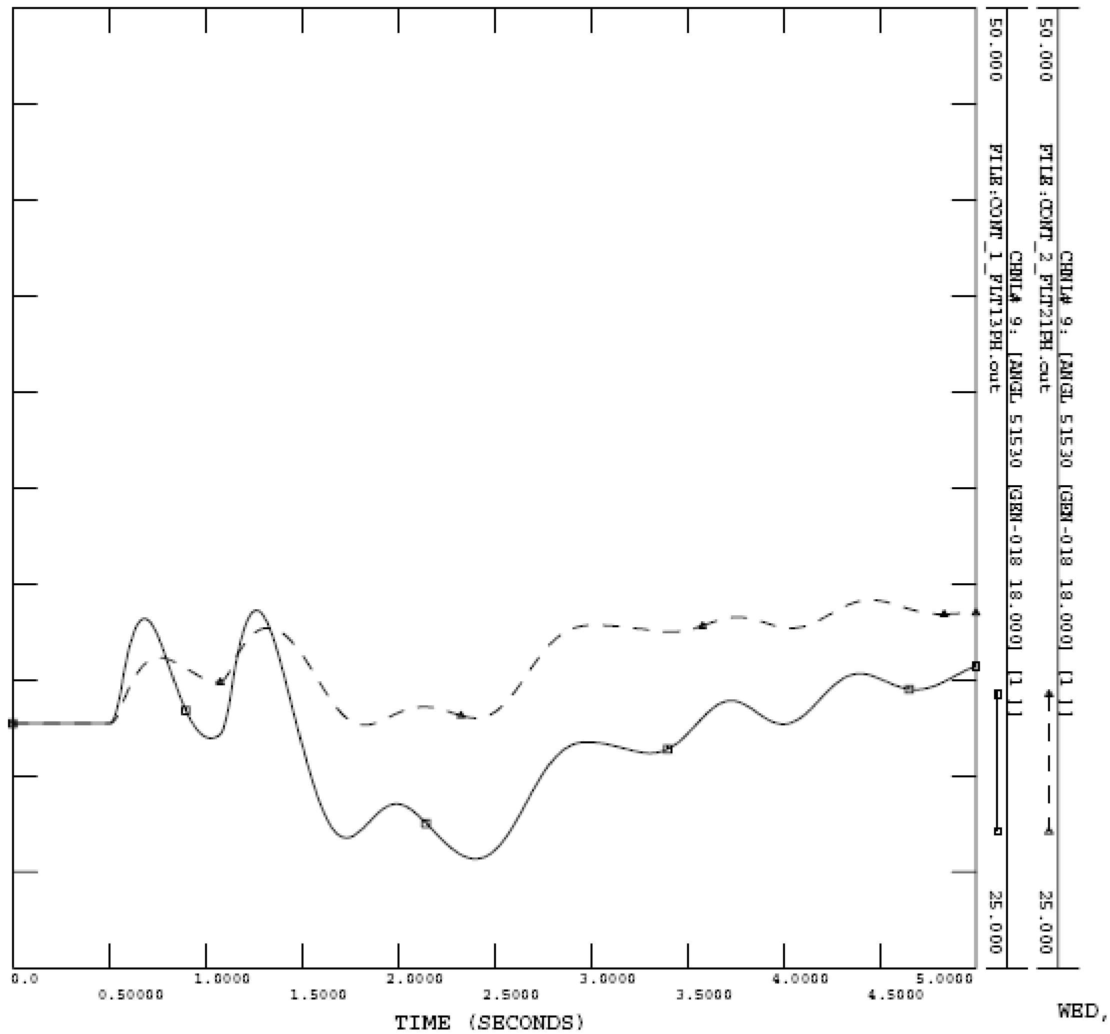

Figure 3 – Fault on Wind Farm – Oklaunion 345 kV Line (Summer).
Cases 1 (three-phase fault) and 2 (phase-to-ground fault)

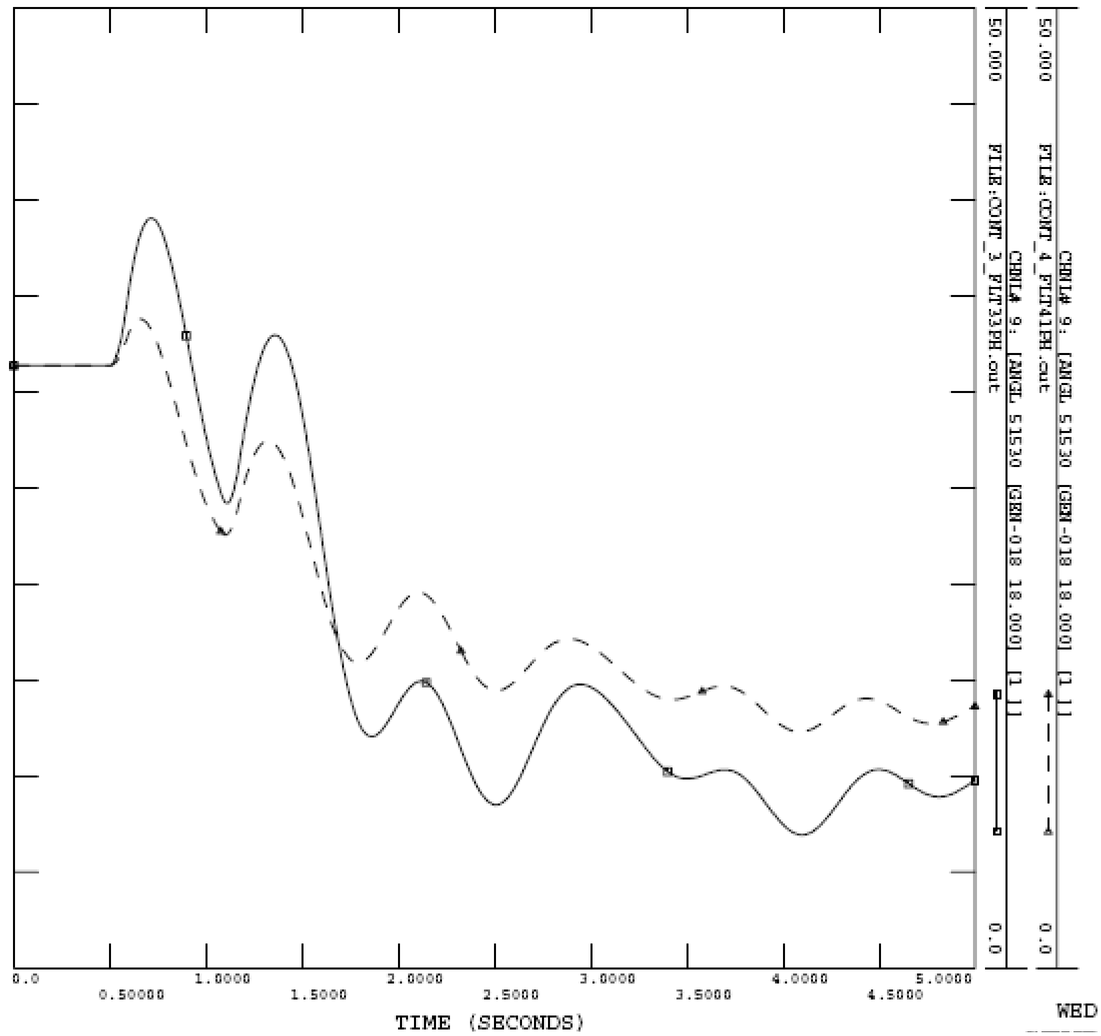

Figure 4 - Fault on Tuco – Wind Farm 345 kV line (Summer).
Cases 3 (three-phase fault) and 4 (phase-to-ground fault)

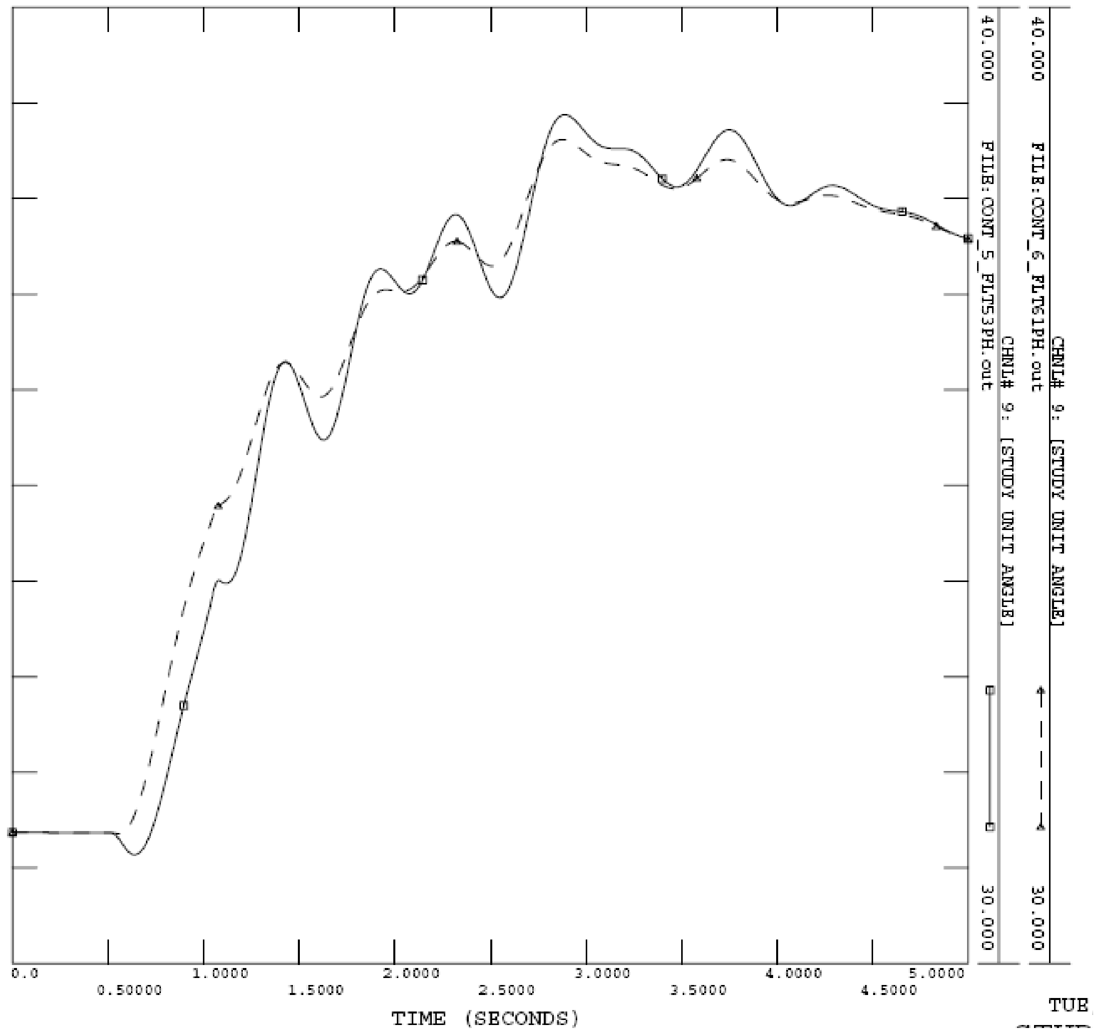

Figure 5 - Fault on Lawton – Oklaunion 345 kV line, also outaging Oklaunion DC Link and associated capacitor (Summer).

Cases 5 (three-phase fault) and 6 (phase-to-ground fault)

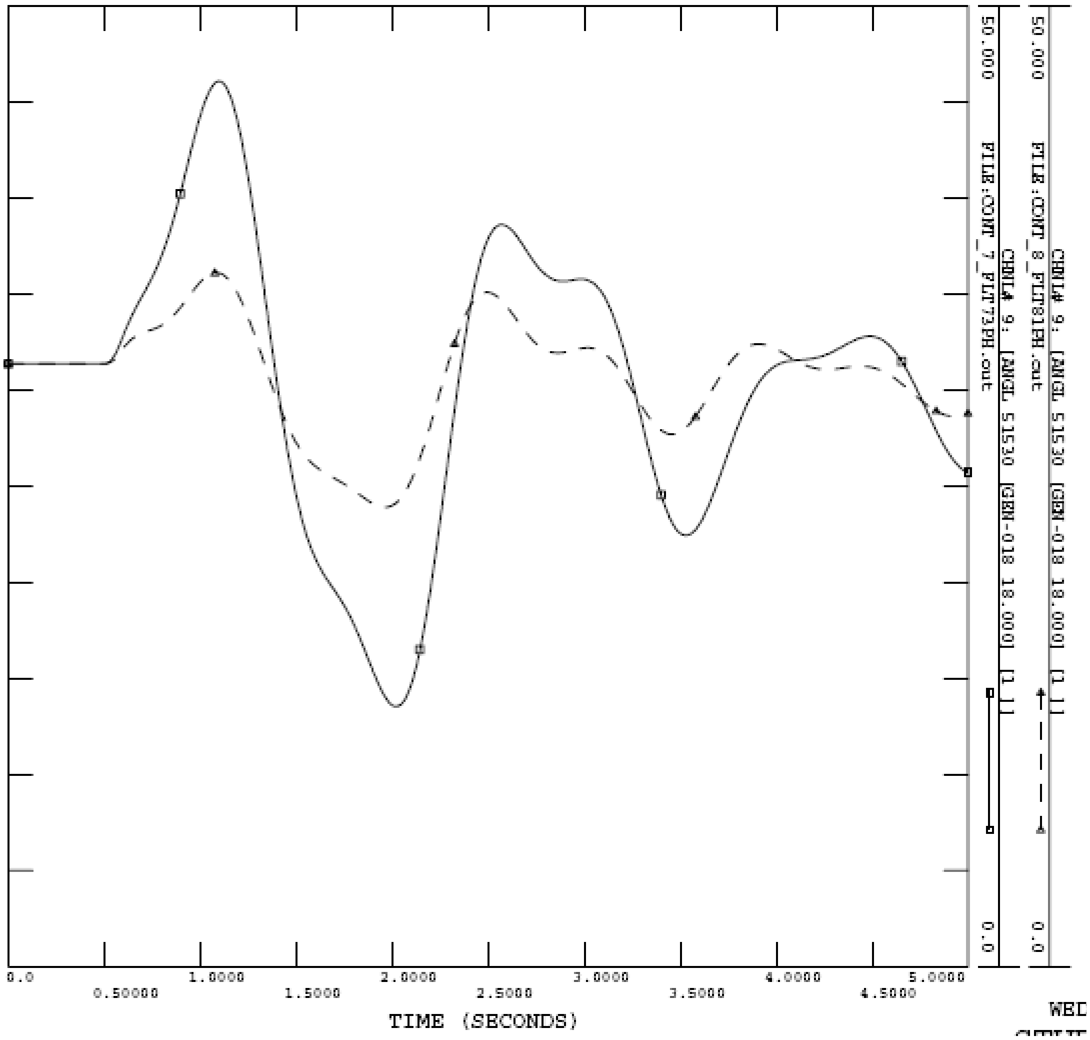

Figure 6 - Fault on Tolk – Tuco 230 kV line (Summer).

Cases 7 (three-phase fault) and 8 (phase-to-ground fault)

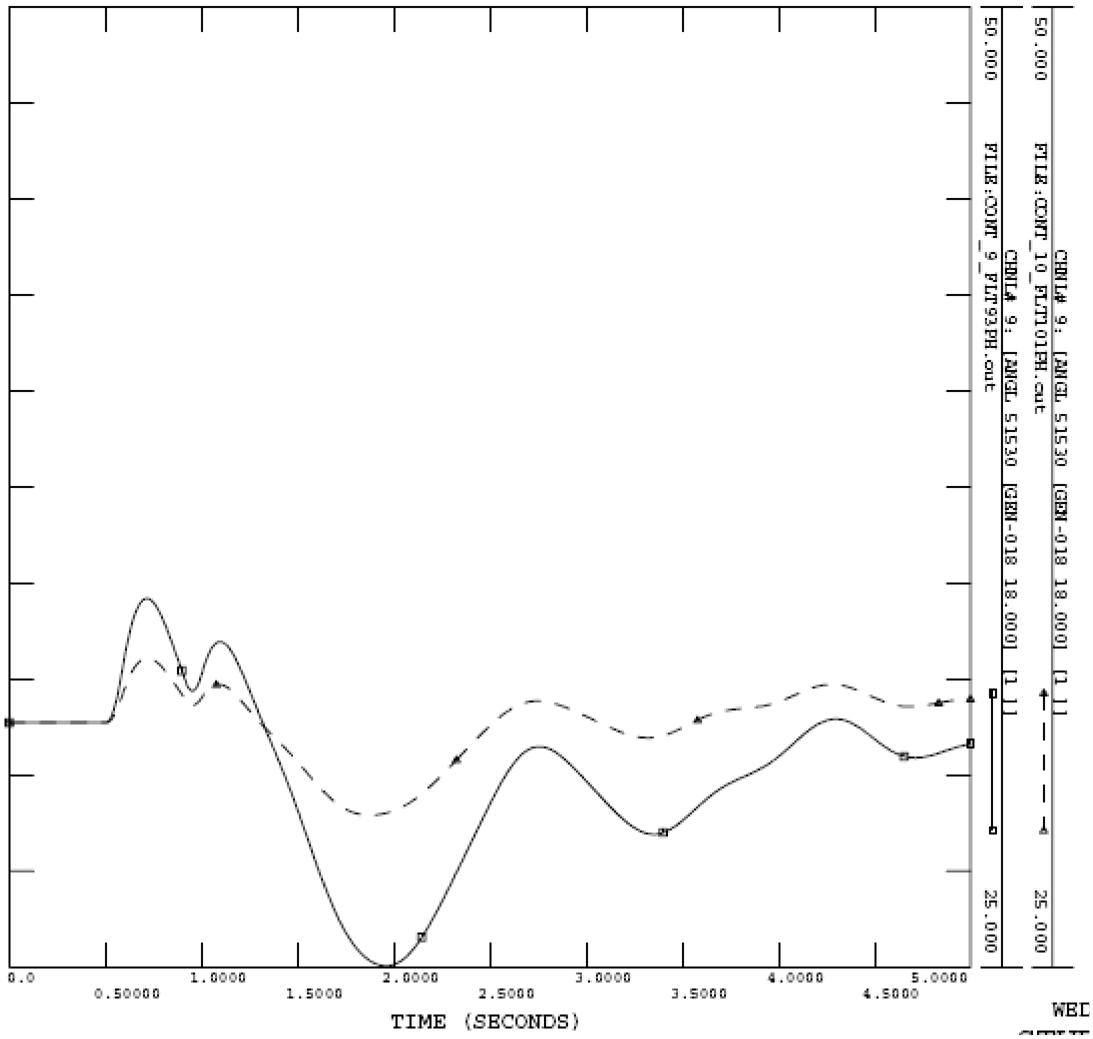

Figure 7 - Fault on Tuco – Swisher 230 kV line (Summer).

Cases 9 (three-phase fault) and 10 (phase-to-ground fault)

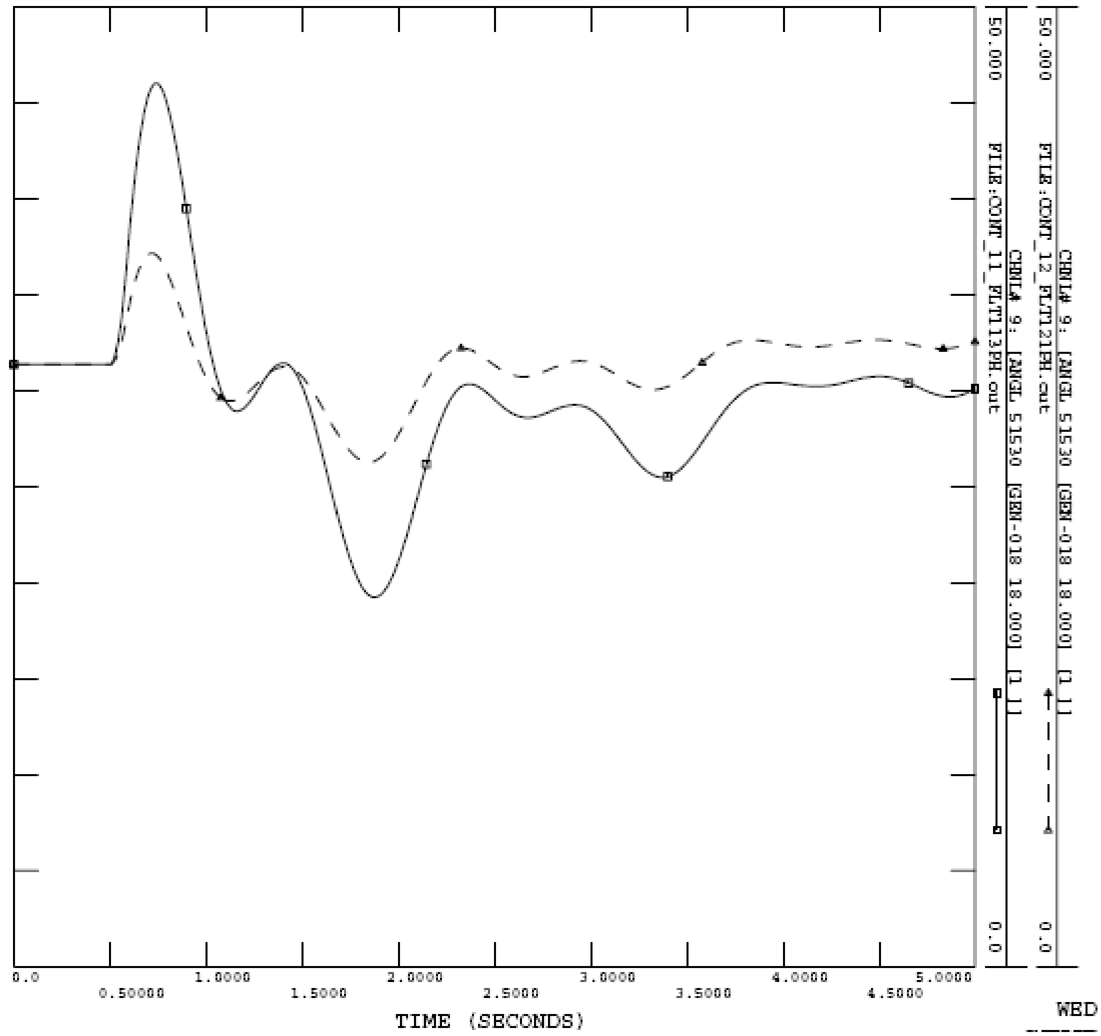

Figure 8 - Fault on Tuco – Jones 230 kV line (Summer).

Cases 11 (three-phase fault) and 12 (phase-to-ground fault)

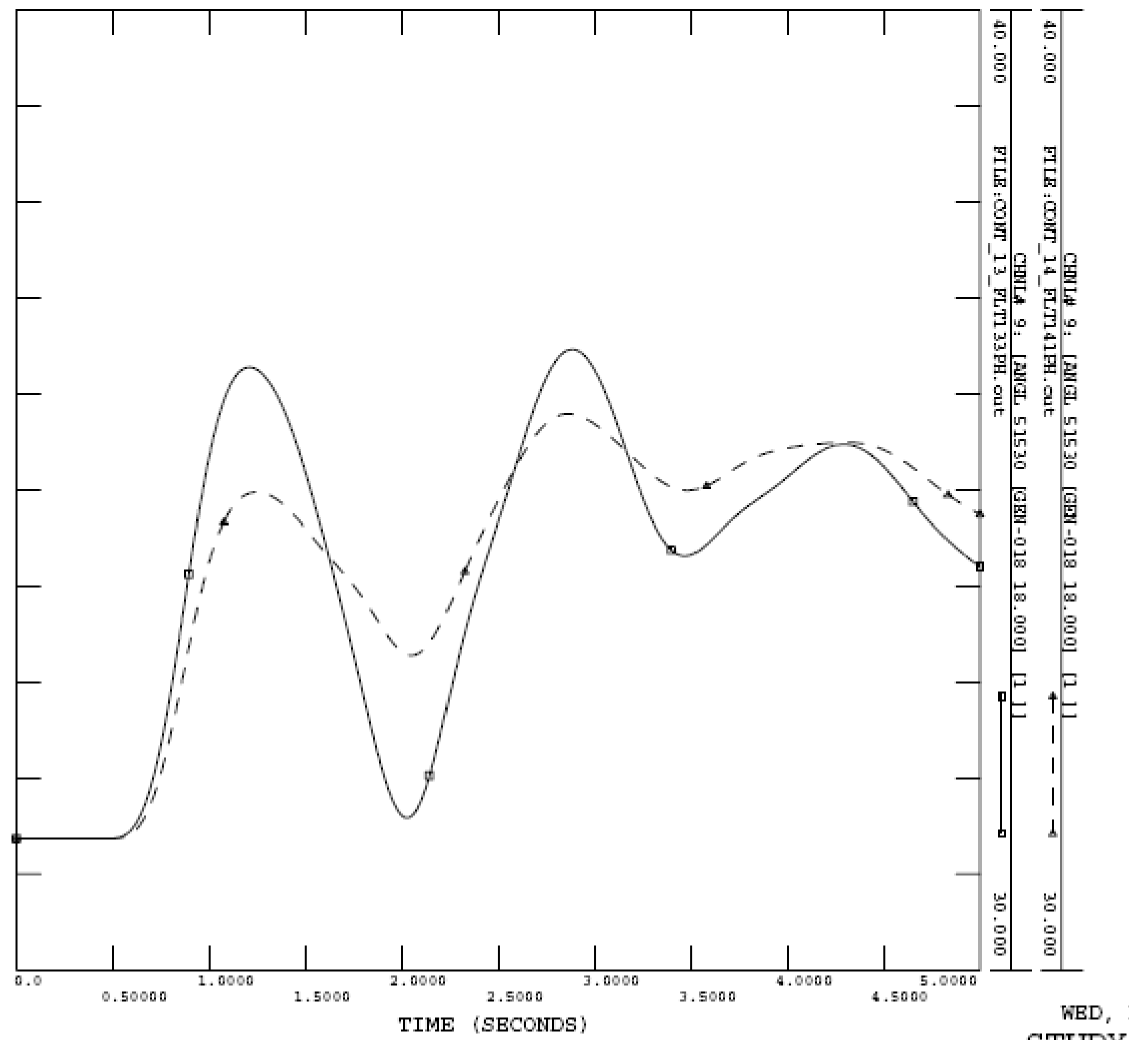

Figure 9 - Fault on Grapevine – Elk City 230 kV line (Summer).

Cases 13 (three-phase fault) and 14 (phase-to-ground fault)

4.2 Winter Cases

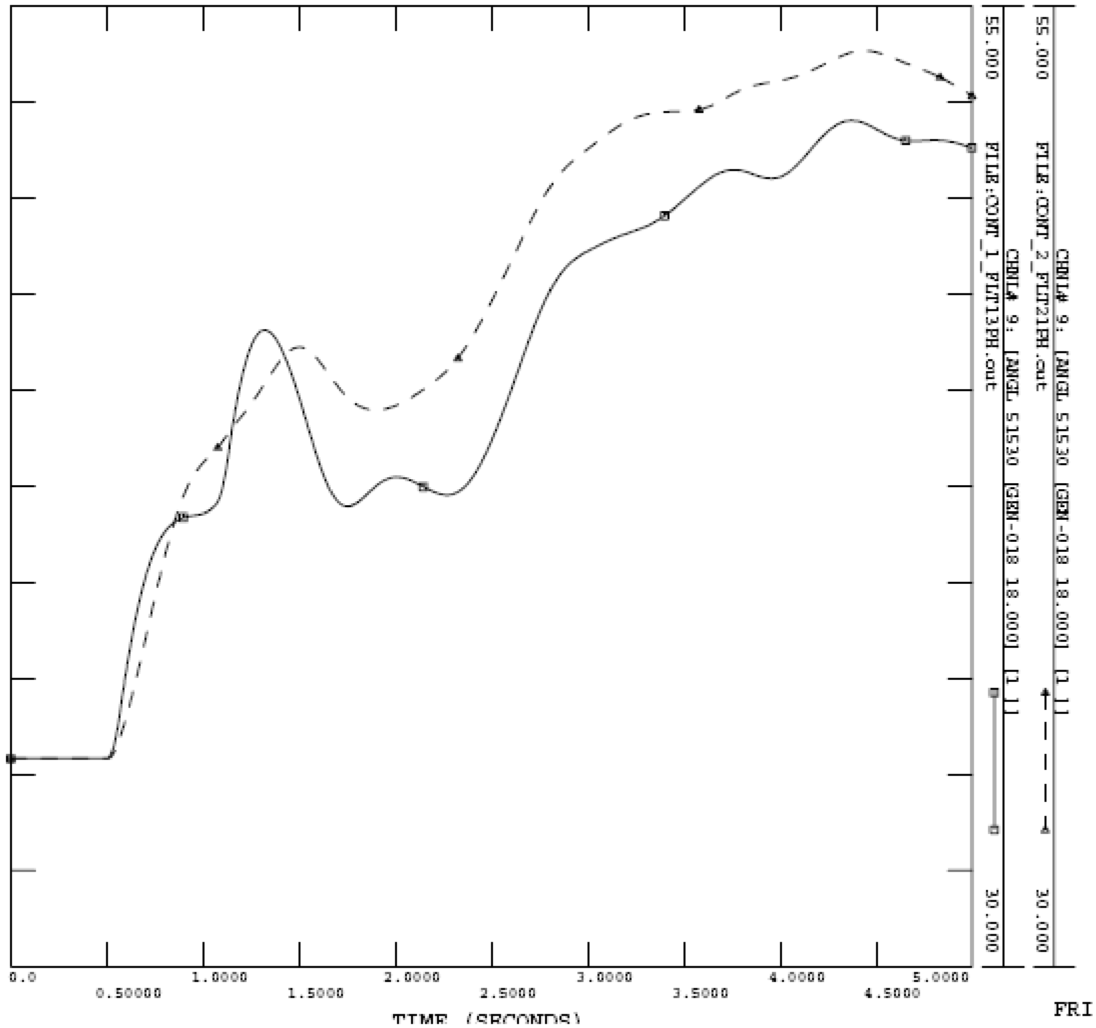

Figure 10 - Fault on Wind Farm – Oklaunion 345 kV line (Winter).
Cases 1 (Three-phase fault) and 2 (phase-to-ground fault)

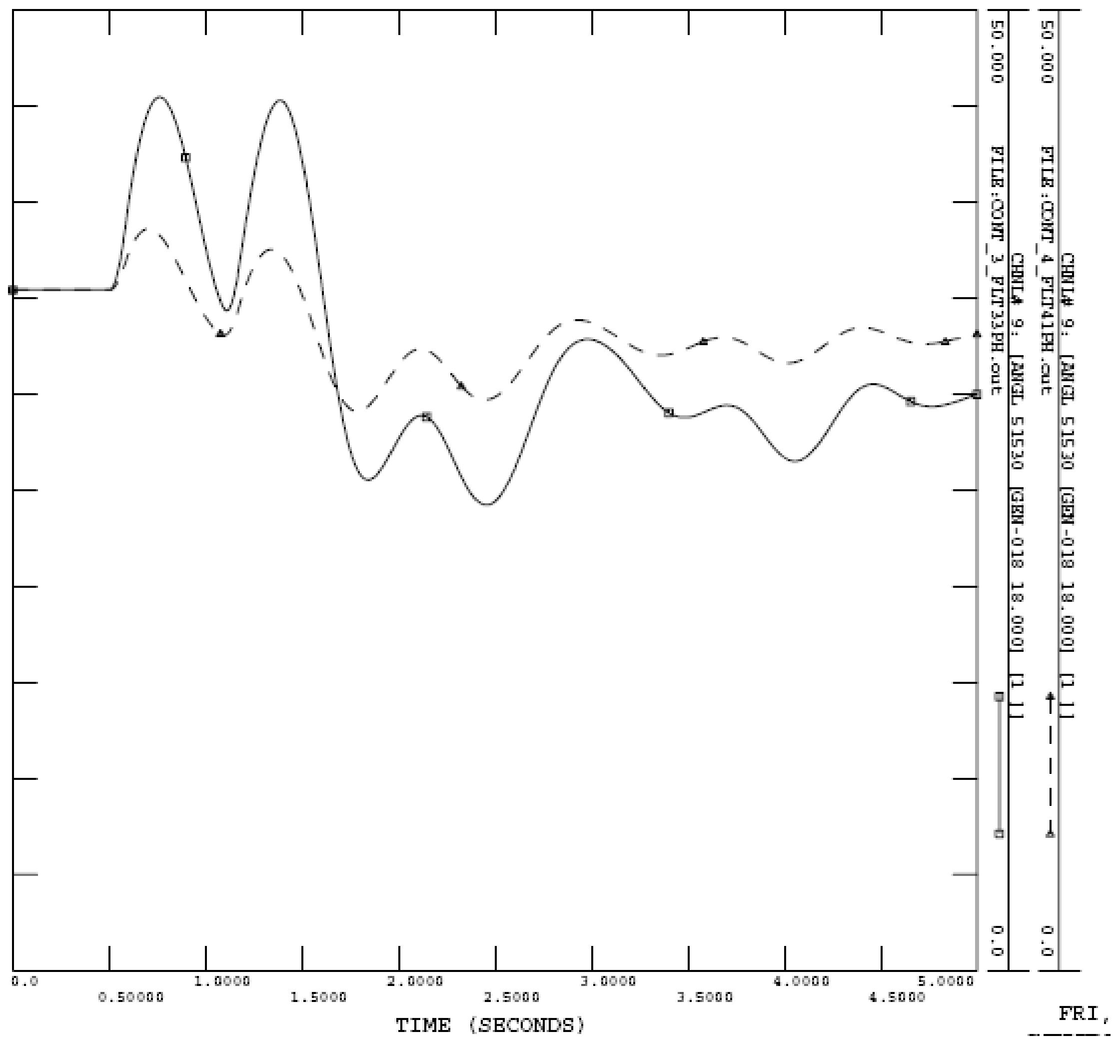

Figure 11 - Fault on Tuco – Wind Farm 345 kV line (Winter).
Cases 3 (three-phase fault) and 4 (phase-to-ground fault)

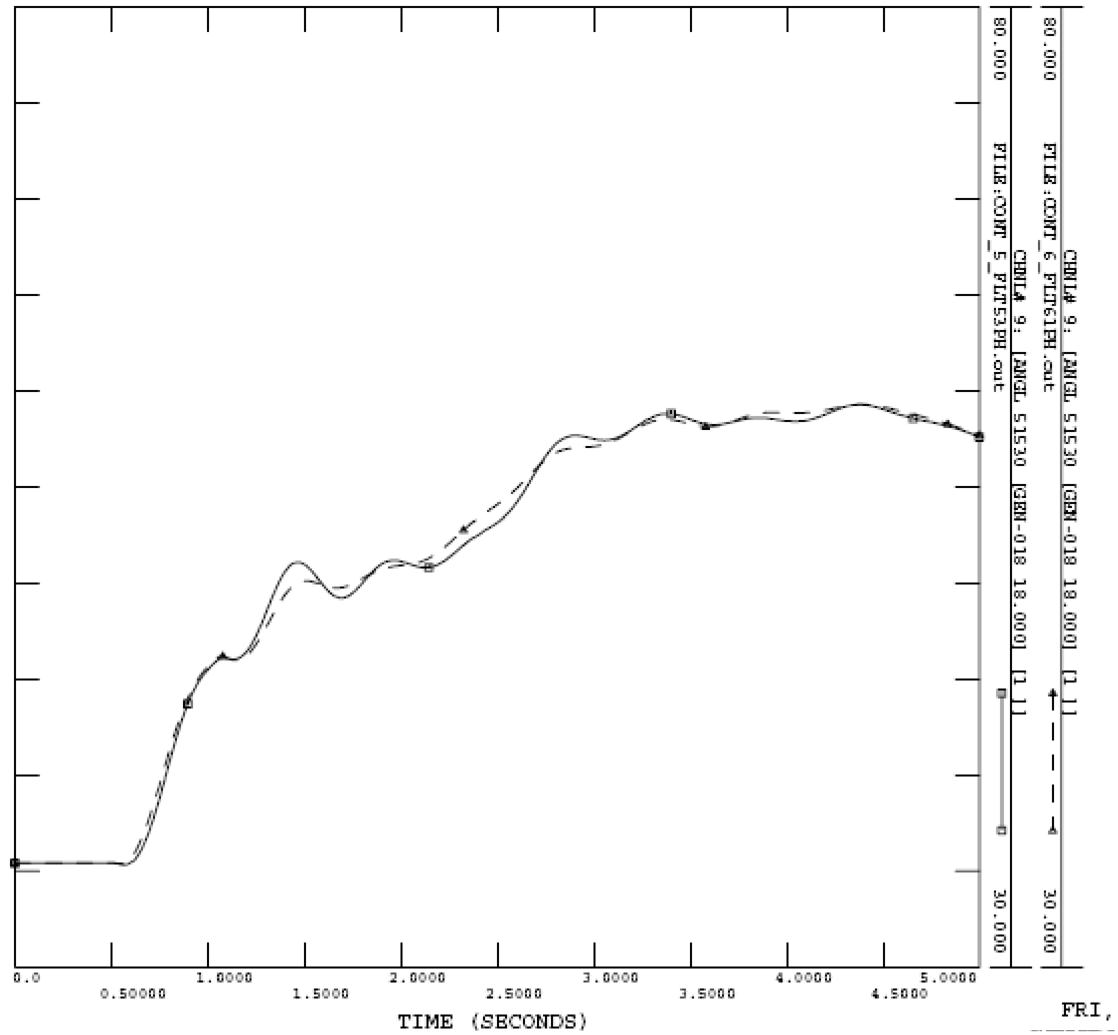

Figure 12 - Fault on Lawton – Oklaunion 345 kV line, also outaging Oklaunion DC Link and associated capacitor (Winter).
Cases 5 (three-phase fault) and 6 (phase-to-ground fault)

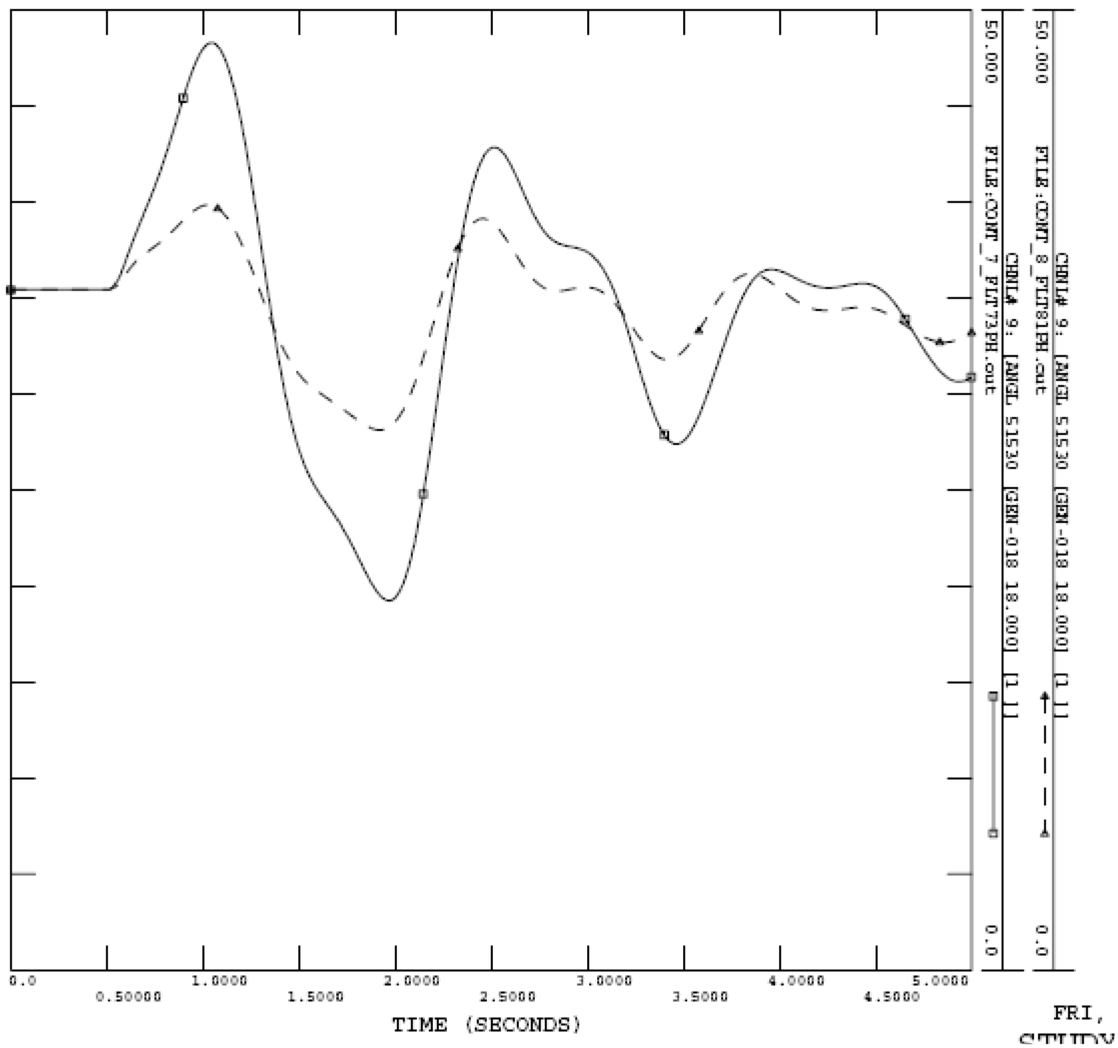

Figure 13 - Fault on Tolk – Tuco 230 kV line (Winter).
Cases 7 (three-phase fault) and 8 (phase-to-ground fault)

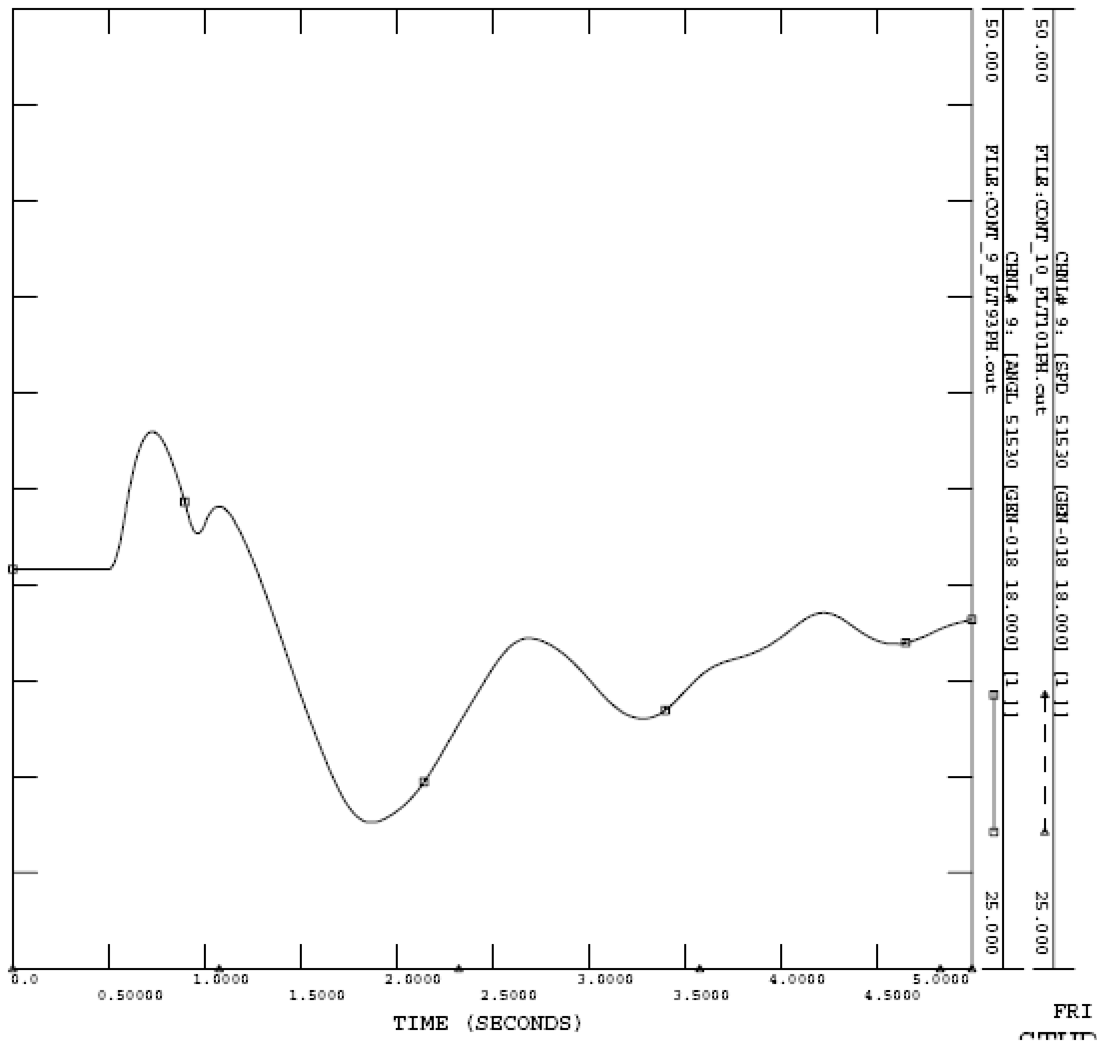

Figure 14 - Fault on Tuco – Swisher 230 kV line (Winter).
Cases 9 (three-phase fault) and 10 (phase-to-ground fault)

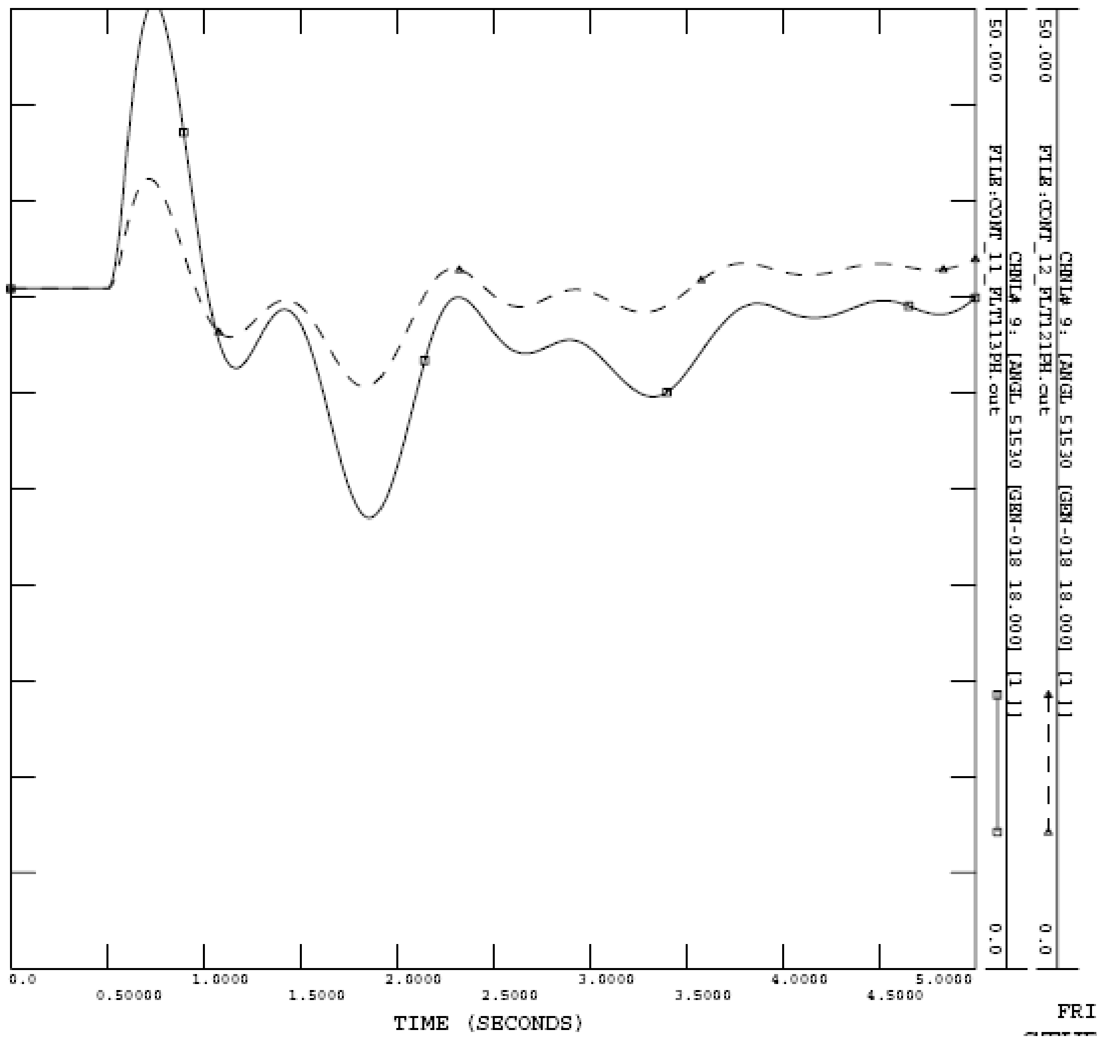

Figure 15 - Fault on Tuco – Jones 230 kV Line (Winter).
Cases 11 (three-phase fault) and 12 (phase-to-ground fault)

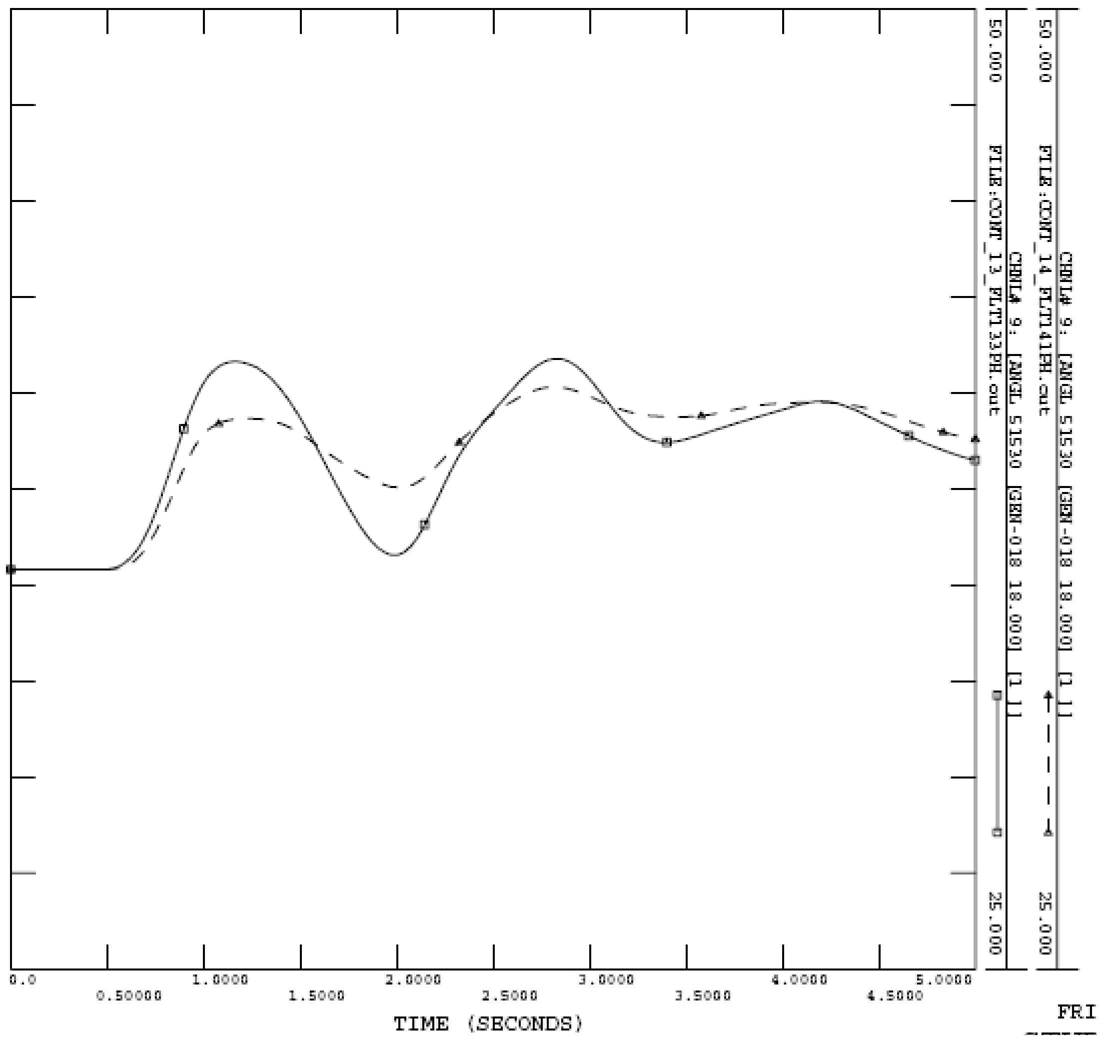

Figure 16 - Fault on Grapevine – Elk City 230 kV line (Winter).
Cases 13 (three-phase fault) and 14 (phase-to-ground fault)

5 Case Results and Conclusions

The proposed unit remained stable for all cases considered under both summer and winter loading conditions.

Appendix A
Modeling Details of Proposed GE Frame 7 Generating Unit

Note: Generator Data from GE drawing 378A8802;
Exciter and Stabilizer Data from GE drawing 378A5910)

<u>Generator</u>

Reactances (PU on 183.1 MVA base)	Direct Axis	Quadrature Axis
Synchronous	1.65	1.56
Transient	0.185	0.39
Subtransient	0.12	0.12
Leakage	0.105	
Field Time Constants (sec)		
Open Circuit	7.0	0.52
Open Circuit Subtransient	0.04	0.084
Inertia constant	6.2 kW-s/KVA	
Saturation		
At 1.0 PU voltage	0.068	
At 1.2 PU voltage	0.5806	

<u>EX2100 Busfed Exciter Model Parameters</u>
(IEEEE ST4B Model Format)

TR	0	Kc	0.08
KPR	3.49	KIR	3.49
Vrmax	1.00	Vrmin	-0.87
TA	0.01	KG	0
KPM	1.00	KIM	0
Vmmax	1.00	Vmmin	-0.87
KP	5.73	KI	0
Vbmax	7.16	XL	0

Power System Stabilizer Model
(IEEE Model type PSS2A)
Utilizing Speed Plus Power Input

T1 = 0.15	T2 = 003	T3 = 0.15	T4 = 0.03
KS1 = 10.	VSTmze = 0.1	VSTmin = -0.1	
TW1 = 2	TW2 = 2	T6 = 0	
TW3 = 2	TW4 = 0	T7 = 2	KS2 = 0.161
KS3 = 1/-	T8 = 0.5	T9 = 0.1	
M = 5		M = 1	
VSI1 = Speed (pu)		VSI2 = PE (pu)(Electrical Power)	

Turbine / Governor Model GAST
(Typical parameters)

R = 0.05	T1 = 0.4
T2 = 0.10000	T3 = 3.0
Ambient temperature Limit = 1.0	KT = 4.0
VMAX = 1.0	VMIN = 0.0
DTURB = 0.45	

Appendix B
Plots of Case Outputs

Part 1. Summer 2007 Conditions

Appendix B
Plots of Case Outputs

Part 2. Winter 2007 Conditions