SPP Southwest Power Pool

Impact Study for Generation Interconnection Request

GEN – 2003 – 002

SPP Coordinated Planning

(#GEN-2003-002)

September 2004

SUMMARY

Burns & McDonnell performed the following study at the request of the Southwest Power Pool (SPP) for SPP Generation Interconnection request Gen-2003-002. The request for interconnection was placed with SPP in accordance SPP's Open Access Transmission Tariff Attachment V, which covers new generation interconnections on SPP's transmission system.

Pursuant to the tariff, Burns & McDonnell was asked to perform a detailed stability analysis of the generation interconnection requests to satisfy the System Impact Study Agreement executed by the requesting customer and SPP.

Generation Interconnection Impact Study

for

SPP Queue Position GEN-2003-002

September 28, 2004

PROJECT NO. 37282

Burns & McDonnell
SINCE 1898

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EXECUTIVE SUMMARY

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Burns & McDonnell was retained by the Southwest Power Pool (SPP) to perform a stability study (Study) in order to evaluate the impact of a proposed wind farm (Gen-2003-002) project near Teterville, Kansas. The proposed wind farm will be interconnected to the mid point of the 345 kV line between Lang and Wichita, 41.05 miles from the Lang substation. <Omitted Text> requested a study of 100% MW generation case and a reduced generation case when stability problems occur. Two sets of load flow and stability database cases – 2010 Summer Peak and 2004 Fall – were provided by SPP. Three-phase and single-line-to-ground faults were simulated for the two cases using the fault definitions provided by SPP.

As the wind turbines are connected through feeders of different length and have different impedance from the interconnection point, the wind turbine generators may respond differently to disturbances. In order to simplify the model of the whole wind farm while capturing the effect of the different impedance, the wind turbines connected to the same feeder end points were aggregated into one equivalent unit. The impedances of the connection circuits were calculated taking the series connection of wind turbines into consideration. The wind farm was modeled with 24 equivalent wind turbine generators.

GE 1.5 MW wind turbine generators were modeled using the latest GE wind turbine model available from PTI. The GE wind turbine model package provides an IPLAN program to create the data for the wind turbine and GSU. It also generates a dynamic data file (*.dyr) for the machines including the controllers and voltage/frequency protection components. The current standard ride-through capability available from GE Wind Energy is reflected in the latest GE wind turbine model package.

Based on the results of the stability analysis, it is concluded that the wind farm does not adversely impact the stability of the SPP system. Therefore, system reinforcement due to dynamic stability is not required. The stability analysis results indicate that the wind farm will remain stable for all the faults away from the interconnection point. On the other hand, for the nearby faults on the lines emanating from the interconnection point, all the wind turbines in the wind farm will trip due to the low voltage.

The wind farm's capability to remain stable and connected to the system is largely determined by the low-voltage ride-through scheme. The over/under voltage protection scheme in the GE wind turbine generator appears to work well for this wind farm. Since the relay pickup time for an under voltage between 0.3 pu and 0.7 pu is 10 cycles, normal clearing of the fault allows the wind turbine to ride through the fault unless the voltage drops below 0.3 pu.

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PART I

INTRODUCTION

PART I
INTRODUCTION

STUDY SCOPE

Burns & McDonnell was retained by the Southwest Power Pool (SPP) to perform a stability study (Study) in order to evaluate the impact of a proposed wind farm (Gen-2003-002) project near Teterville, Kansas. The proposed wind farm will be interconnected to the mid point of the 345 kV line between Lang and Wichita, 41.05 miles from the Lang substation. <Omitted Text> requested a study of 100% MW generation case and a reduced generation case when stability problems occur. Two sets of load flow and stability database cases – 2010 Summer Peak and 2004 Fall – were provided by SPP. Three-phase and single-line-to-ground faults were simulated for the two cases using the fault definitions provided by SPP.

SYSTEM DESCRIPTION

The proposed wind farm will be interconnected to a new 345 kV three-breaker ring bus on the Lang to Wichita line within the service territory of Westar Energy (WERE). Figure I-1 shows the map of the wind farm area. Figure I-2 shows the connection of the wind farm to the 345 kV line. The rated output of the wind farm is 201 MW, comprised of 134 GE 1.5 MW wind turbine units. Southwest Power Pool provided Burns & McDonnell with the appropriate dispatch reduced by 201 MW to maintain area interchange totals.

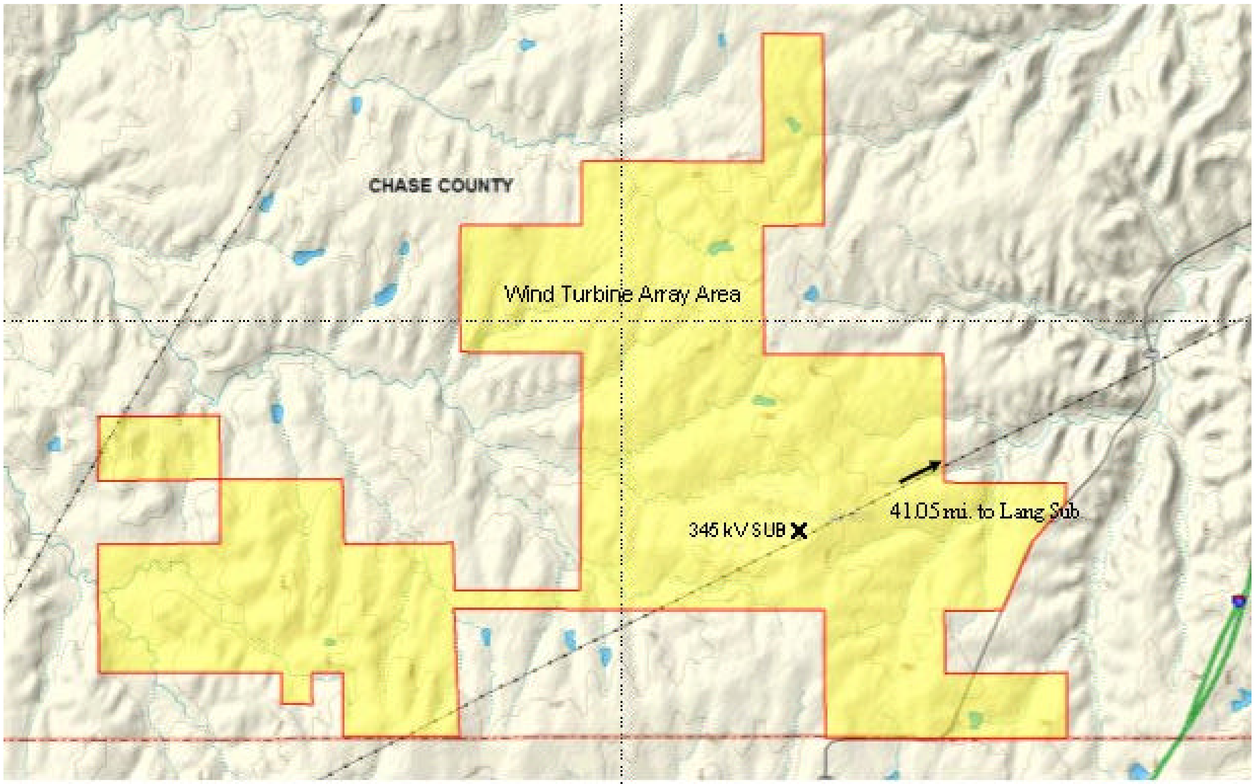

FIGURE I-1
MAP OF THE <OMITTED TEXT> WIND FARM AREA

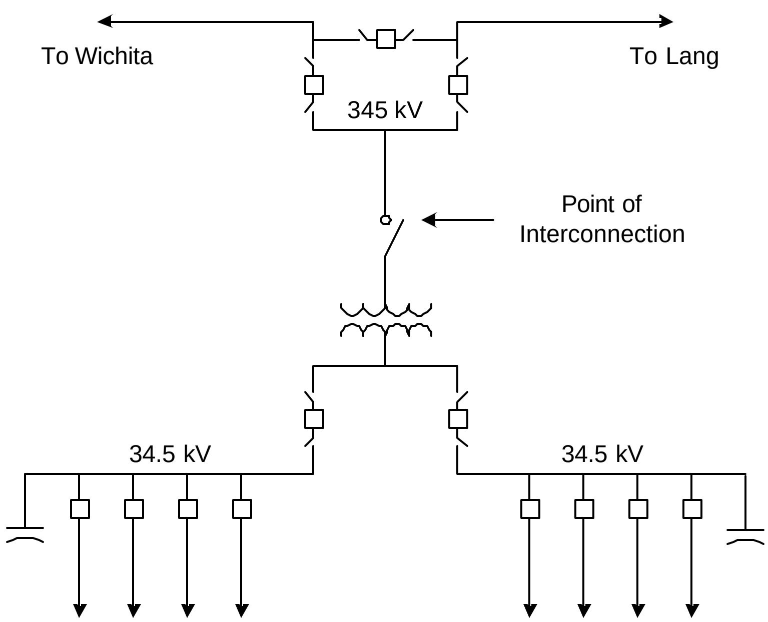

FIGURE I-2
PROPOSED INTERCONNECTION OF WIND FARM

LIMITATIONS

In the preparation of this report, the information provided to Burns & McDonnell by others was used by Burns & McDonnell to make certain assumptions with respect to conditions which may exist in the future. While Burns & McDonnell believes the assumptions made are reasonable for the purposes of this report, Burns & McDonnell makes no representation that the conditions assumed will, in fact, occur. In addition, while Burns & McDonnell has no reason to believe that the information provided by others, and on which this report is based, is inaccurate in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee its accuracy or completeness. To the extent that actual future conditions differ from those assumed herein or from the information provided to Burns & McDonnell, the actual results will vary from those presented.

The estimates and projections prepared by Burns & McDonnell relating to construction costs are based on our experience, qualifications, and judgment as a professional consultant. Since Burns & McDonnell has no control over weather, cost and availability of labor, materials, and equipment, labor productivity, construction contractor's procedures and methods, unavoidable delays, construction contractor's methods of determining prices, economic conditions, government regulations and laws (including the interpretation thereof), competitive bidding or market conditions and other factors affecting such estimates or projections, Burns & McDonnell does not guarantee that actual costs will not vary from the estimates and projections prepared by Burns & McDonnell.

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PART II

DATA PREPARATION

PART II
DATA PREPARATION

STUDY CASES

SPP provided the data for the 2004 Fall and 2010 Summer peak study cases in the form of PSS/E v29 load flow saved case and dynamic raw data files. The IDEV and IPLAN files to compile and link user-written models were also provided. Table II-1 is the summary of the load flow study cases.

The wind farm was modeled with 24 equivalent wind turbine generators as described in the following section. The wind turbine generators and the collector buses were added to the load flow cases, and the generation in the WERE area was scaled down to accommodate the increase of 201 MW generation from the <Omitted Text> wind farm. The Wolf Creek nuclear power plant and existing wind farms were maintained at their original dispatches.

TABLE II-1

LOAD FLOW STUDY CASE SUMMARY

Load Flow Case	Unit	From Generation	To Load	To Bus Shunt	To Line Shunt	From Charging	To Net Interface	Losses
2004 Fall								
WERE	MW	4693.5	4087.2	0.0	5.0	0.0	448.3	142.0
	MVar	707.6	719.6	-535.9	31.3	1006.2	-169.5	1640.7
TOTAL	MW	475691.8	463674.5	100.5	482.4	0.0	0.0	11429.5
	MVar	64073.7	142243.4	-90124.8	5142.5	161919.1	0.0	168703.3
2010 Summer								
WERE	MW	6605.7	5837.9	0.0	5.3	0.0	586.4	167.9
	MVar	1123.8	983.6	-735.0	30.6	1141.0	-129.9	2088.4
TOTAL	MW	688976.4	670383.2	161.4	904.1	0.0	0.0	17518.9
	MVar	172082.8	203729.5	-128125.0	5242.8	162775.5	0.0	254013.9

MODELING WIND FARM

As the wind turbines are all identical units, the wind farm could be modeled as a single equivalent unit representing of the combined capacity of grouped units. The detailed connection diagram of the wind farm provided by SPP is included in Appendix A. The line parameters (R, X, and B) of the 34.5 kV collector circuits were provided by <Omitted Text>. The variations of feeder length and conductor size result in different impedance from the interconnection point, which slightly affect the wind turbine generators' response to disturbances on the high voltage system. In order to simplify the model of the wind farm while capturing the effect of the different impedance, the wind turbines connected to the same feeder end points were aggregated into one equivalent unit. The impedances of the connection feeder circuits were calculated taking the series connection of wind turbines into consideration. As a result, the wind farm was modeled with 24 equivalent units as shown in Figure II-1. The number in the circle represents the number of individual units aggregated at the bus.

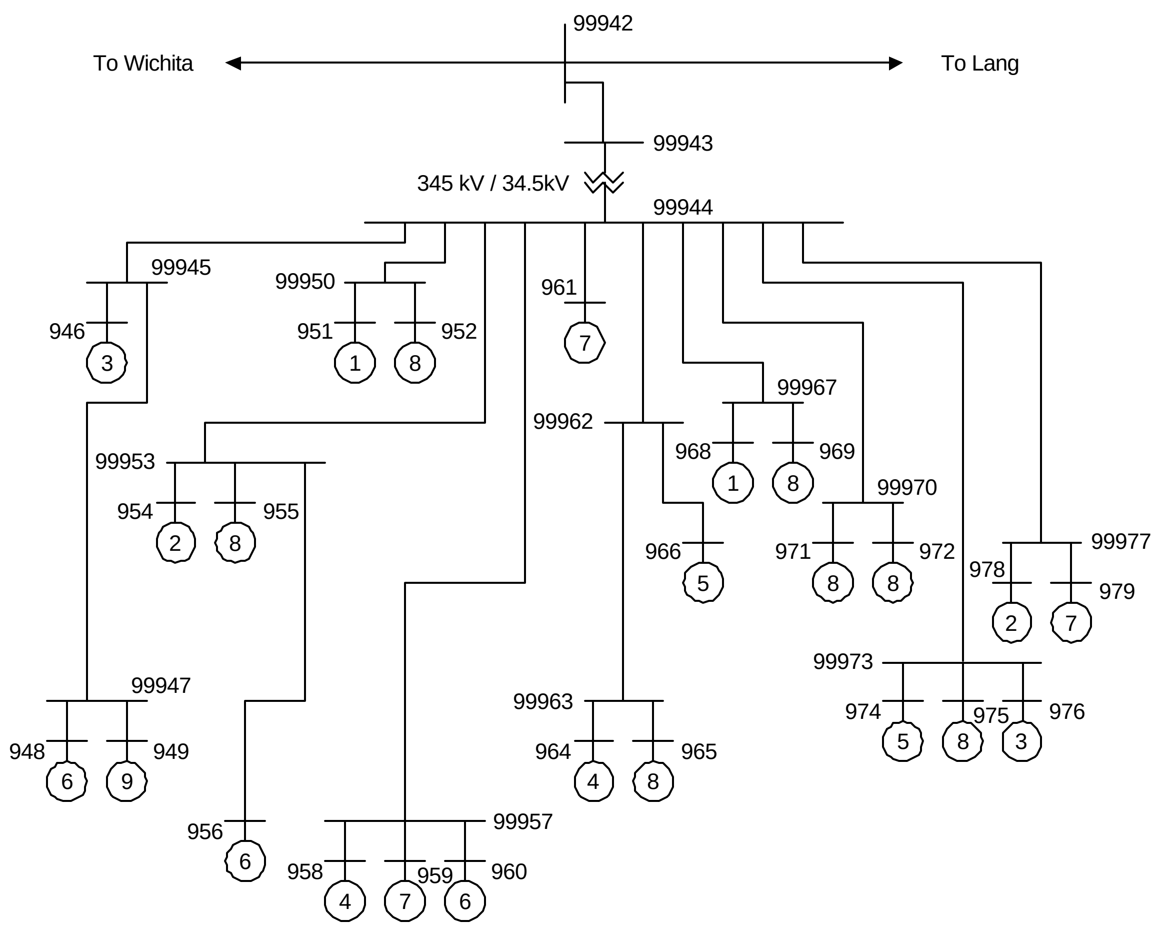

FIGURE II-1
EQUIVALENT WIND FARM MODEL FOR SIMULATION

WIND TURBINE MODEL

GE 1.5 MW wind turbine generators were modeled using the latest GE wind turbine model available from PTI. The wind turbine generator model is comprised of several user models for dynamic simulation listed below.

DFIGPQ	doubly fed induction generator model
CGENCN2	machine control
GEAERO	aerodynamic energy conversion
TGPTCH	pitch control
TWIND1	wind gusts and ramps simulation
TSHAFT	two-mass shaft system
VTGTRP	over/under-voltage protection
FRQTRP	over/under-frequency protection

The GE wind turbine model package provides an IPLAN program to create the data for the wind turbine and GSU. It also generates a dynamic data file (*.dyr) for the machines including the controllers and voltage/frequency protection components. Since the wind turbine generators have ride-through capability for voltage and frequency, detailed relay settings for voltage/frequency protection schemes are included in the model. The current standard ride-through capability available from GE Wind Energy is reflected in the latest GE wind turbine model package as shown in Table II-2 and Table II-3.

TABLE II-2

OVER/UNDER VOLTAGE PROTECTION SCHEME FOR GE WIND TURBINES

Voltage (pu)	Relay Pickup (Second)	Breaker Time (Second)
$V \leq 0.3$	0.02	0.15
$0.3 < V \leq 0.7$	0.1	0.15
$0.7 < V \leq 0.75$	1.0	0.15
$0.75 < V \leq 0.85$	10.0	0.15
$1.1 \leq V < 1.15$	1.0	0.15
$1.15 \leq V < 1.3$	0.1	0.15
$V \geq 1.3$	0.02	0.15

TABLE II-3

FREQUENCY PROTECTION SCHEME FOR GE WIND TURBINES

Frequency (pu)	Relay Pickup (Second)	Breaker Time (Second)
f ≤ 56.5	0.02	0.15
56.5 < f ≤ 57.5	10.0	0.15
61.5 < f ≤ 62.5	30.0	0.15
f ≥ 62.5	0.02	0.15

* * * * *

PART III

STABILITY ANALYSIS

PART III
STABILITY ANALYSIS

METHODOLOGY AND ASSUMPTIONS

Stability analysis was performed using PTI's PSS/E dynamic simulation program version 29. The GE wind turbine generators were modeled using the GE wind turbine model available from PTI.

Sixteen fault definitions were provided by SPP for the stability analysis, which are shown in Table III-1. Single-line-to-ground faults were simulated by applying a fault impedance to the positive sequence network to represent the effect of the negative and zero sequence networks on the positive sequence network. Since the actual fault MVA's at the faulted substations were not available, fault impedances were chosen such that the voltage at the bus with the SLG fault dropped to below 0.5 pu during the fault. Each simulation was performed with a 0.1-second steady-state run followed by the disturbance.

TABLE III-1

DISTURBANCE DEFINITIONS

Fault ID	Description
FLT13PH	3-phase fault Fault on the Lang (56769) - <Omitted Text> Wind Farm (99942), 345 kV line, near Lang a. Apply Fault near Lang (56769). b. Clear fault after 4 cycles by removing the line 56769 – 99942. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT21PH	1-phase fault Same as FLT13ph above
FLT33PH	3-phase fault Fault on the Lang (56769) - <Omitted Text> Wind Farm (99942), 345 kV line, near Wind Farm a. Apply Fault near Wind Farm (99942). b. Clear fault after 4 cycles by removing the line 56769 – 99942. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT41PH	1-phase fault Same as FLT13ph above

TABLE III-1

DISTURBANCE DEFINITIONS (CONTINUED)

FLT53PH	3-phase fault Fault on the Wichita (56796) - <Omitted Text> Wind Farm (99942), 345 kV line, near Wichita a. Apply Fault near Wichita (56796). b. Clear fault after 4 cycles by removing the line 56796 – 99942. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT61PH	1-phase fault Same as FLT13ph above
FLT73PH	3-phase fault Fault on the Wichita (56796) - <Omitted Text> Wind Farm (99942), 345 kV line, near Wind Farm a. Apply Fault near Wind Farm (99942). b. Clear fault after 4 cycles by removing the line 56796 – 99942. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT81PH	1-phase fault Same as FLT13ph above
FLT93PH	3-phase fault Fault on the Morris Co. (56770) - Lang (56769), 345 kV line, near Lang a. Apply Fault near Lang (56769). b. Clear fault after 4 cycles by removing the line 56770 – 56769. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT101PH	1-phase fault Same as FLT13ph above
FLT113PH	3-phase fault Fault on the Swissvale (56774) – Lang (56769), 345 kV line, near Lang a. Apply Fault near Lang (56769). b. Clear fault after 4 cycles by removing the line 56774 – 56769. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT121PH	1-phase fault Same as FLT13ph above
FLT133PH	3-phase fault Fault on the Benton (56791) – Wichita (56796), 345 kV line, near Wichita a. Apply Fault near Wichita (56796). b. Clear fault after 4 cycles by removing the line 56791 – 56796. c. Wait 26 cycles, and then re-close the line in (b) into the fault. a. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT141PH	1-phase fault Same as FLT13ph above
FLT153PH	3-phase fault Fault on the Woodring (54715) - Wichita (56796), 345 kV line, near Wichita a. Apply Fault near Wichita (56796). b. Clear fault after 4 cycles by removing the line 54715 – 56796. c. Wait 26 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
FLT161PH	1-phase fault Same as FLT13ph above

ANALYSIS RESULTS

Simulations were run for a 10-second duration to check for proper machine damping. The results of the 16 fault simulations for each of the two study cases showed no instability problem. Table III-2 is the summary of the simulation results. The wind turbines remained stable for most of the faults except two disturbances – faults on the lines emanating from the interconnection point. For these two faults, all the wind turbines were tripped, and the system remained stable.

TABLE III-2

STABILITY SIMULATION RESULTS

Fault ID	Fault Location	Stability Result	
		2004 Fall	2010 Summer
FLT13PH	Wichita (56769) - Wind Farm (99942), 345 kV line, near Wichita	Stable	Stable
FLT21PH	Wichita (56769) - Wind Farm (99942), 345 kV line, near Wichita	Stable	Stable
FLT33PH	Lang (56769) - Wind Farm (99942), 345 kV line, near Wind Farm	WT, SS	WT, SS
FLT41PH	Lang (56769) - Wind Farm (99942), 345 kV line, near Wind Farm	Stable	Stable
FLT53PH	Wichita (56796) - Wind Farm (99942), 345 kV line, near Wichita	Stable	Stable
FLT61PH	Wichita (56796) - Wind Farm (99942), 345 kV line, near Wichita	Stable	Stable
FLT73PH	Wichita (56796) - Wind Farm (99942), 345 kV line, near Wind Farm	WT, SS	WT, SS
FLT81PH	Wichita (56796) - Wind Farm (99942), 345 kV line, near Wind Farm	Stable	Stable
FLT93PH	Morris Co. (56770) - Lang (56769), 345 kV line, near Lang	Stable	Stable
FLT101PH	Morris Co. (56770) - Lang (56769), 345 kV line, near Lang	Stable	Stable
FLT113PH	Swissvale (56774) – Lang (56769), 345 kV line, near Lang	Stable	Stable
FLT121PH	Swissvale (56774) – Lang (56769), 345 kV line, near Lang	Stable	Stable
FLT133PH	Benton (56791) – Wichita (56796), 345 kV line, near Wichita	Stable	Stable
FLT141PH	Benton (56791) – Wichita (56796), 345 kV line, near Wichita	Stable	Stable
FLT153PH	Woodring (54715) - Wichita (56796), 345 kV line, near Wichita	Stable	Stable
FLT161PH	Woodring (54715) - Wichita (56796), 345 kV line, near Wichita	Stable	Stable

WT: wind farm tripped, SS: system stable

PART IV

CONCLUSIONS

PART IV
CONCLUSIONS

STUDY CONCLUSION

Based on the results of the stability analysis, it is concluded that the wind farm does not adversely impact the stability of the SPP system. Therefore, system reinforcement due to dynamic stability is not required. The stability analysis results indicate that the wind farm will remain stable for all the faults away from the interconnection point. For the nearby faults on the line emanating from the interconnection point, all the wind turbines in the wind farm will trip due to low voltage during the fault.

The wind farm's capability to remain stable and connected to the system is largely determined by the low-voltage ride-through scheme. The over/under voltage protection scheme in the GE wind turbine generator appears to work well for this wind farm. Since the relay pickup time for an under voltage between 0.3 pu and 0.7 pu is 10 cycles, normal clearing of the fault allows the wind turbine to ride through the fault unless the voltage drops below 0.3 pu.

COST ESTIMATE

The estimated cost for building a new 345 kV switching station with three breakers is $ 3,545,000. The estimated cost for the interconnection metering at the project substation is $276,000. This makes the total estimated cost for the interconnection substation $ 3,821,000. See Table IV-1 below to determine the Network Upgrade and the Direct Assignment cost breakdowns.

TABLE IV-1

COST ESTIMATES

ITEM	DESCRIPTION	ESTIMATE
	NETWORK UPGRADES	
1	New Three breaker 345 kV interconnection substation	$3,545,000
2	Interconnection metering at project interconnection substation	$276,000
	TOTAL NETWORK UPGRADE SUBTOTAL	**$3,821,000**
	DIRECT ASSIGNMENT FACILITIES	
1	Extension of 345 kV line, to wind farm (if required)	*
2	345/34.5 kV Substation, relay & metering systems	*
3	345/34.5 kV 3-winding transformer	*
	DIRECT ASSIGNMENT FACILITIES SUBTOTAL	*
	TOTAL	**$3,821,000**

* TO BE ESTIMATED BY CUSTOMER

If any previously queued projects that were included in this study are not constructed, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on WERE transmission facilities. In accordance with FERC and SPP procedures, the study cost for restudy shall be borne by the Interconnection Customer. **The costs do not include any 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.**

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APPENDIX A

WIND FARM COLLECTOR SYSTEM DIAGRAM

CUSTOMER SUPPLIED DRAWINGS

Southwest Power Pool provided the Customer provided detailed collection system one-line and cable impedance spread sheet to Burns & McDonnell to be used to build the specific wind farm (GEN-2003-002) project model.

APPENDIX B

DYNAMIC MODEL DATA FOR WIND FARM

APPENDIX B
DYNAMIC MODEL DATA FOR WIND FARM

DFIGPQ - GE WIND TURBINE DOUBLY-FED INDUCTION GENERATOR

CONs	#	Value	Description
J		0.00706	Ra, Stator resistance, pu
J+1		0.1714	La, Stator Inductance, pu
J+2		2.904	Lm, Mutual Inductance, pu
J+3		0.005	R1, Rotor Resistance, pu
J+4		0.1563	L1, Rotor Inductance, pu
J+5		0.57	H, total drive train inertia, sec.
J+6		0.0	D, Damping Factor, pu
J+7		0.2	-SLIP, initial rotor negative slip

CGENCN2 - GE WIND TURBINE GENERATOR CONTROL

CONs	#	Value	Description
J		0.15	Tfv, Delay in sending the signal to local WTs (sec)
J+1		20.0	Kpv, Proportional gain in Voltage regulator(pu)
J+2		2.0	Kiv, Integrator gain in Voltage regulator (pu)
J+3		0.0	Rc, Line drop compensation resistance (pu)
J+4		0.0	Xc, Line drop compensation reactance (pu)
J+5		0.05	Tfp, Filter time constant in Torque regulator (sec)
J+6		3.0	Kpp, Proportional gain in Torque regulator(pu)
J+7		0.6	Kip, Integrator gain in Torque regulator (pu)
J+8		1.12	PMX, Max limit in Torque regulator)pu)
J+9		0.09	PMN, Min limit in Torque regulator)pu)
J+10		0.3	QMX, Max limit in Voltage regulator (pu)
J+11		-0.43	QMN, Min limit in Voltage regulator (pu)
J+12		1.11	IQmax, Max reactive current limit (pu)
J+13		0.05	Trv, voltage sensor time constant (sec.)
J+14		0.45	RPMX, maximum power order drrivative (pu)
J+15		-0.45	RPMN, minimum power order derivative (pu)
J+16		5.0	T_Power, Power reference filter time constant, sec.
J+17		0.025	KQV, MVAR/ Volt gain
J+18		0.9	VMINCL, min. voltage limit
J+19		1.1	VMAXCL, max. voltage limit
J+20		50.0	KVQ, Volt/MVAR gain

GEAERO - GE WIND TURBINE AERODYNAMICS

CONs	#	Value	Description
J		12.0	Vwinit, Initial eff. wind speed from load flow, m/sec
J+1		20.0	Lambda_Max, Max. Lambda from Cp curves
J+2		0.0	Lambda_Min, Min. Lambda from Cp curves
J+3		27.0	PITCH_MAX, Upper limit of pitch angle
J+4		-4.0	PITCH_MIN, Lower Limit of pitch angle
J+5		0.0	Ta, time constant of the conversion smoothing
J+6		1.225	Rho, Air desity, kg/m3
J+7		35.25	Radius, Blade radius, m
J+8		72.0	GB_ratio, Gear box ratio
J+9		1200.0	Synchr, Synchronous rpm
J+10		1500.0	Power_Rate, Rated power of the original WTG, kW
J+11		1.667	MBASE1, MBASE of the original WTG, MVA

TGPTCH - GE PITCH CONTROL

CONs	#	Value	Description
J		0.2	Tp, Time constant of the output lag (sec)
J+1		150.0	Kpp, Proportional gain of PI rgulator (pu)
J+2		25.0	Kip, Integrator gain of PI regulator (pu)
J+3		3.0	Kpc, Proportional gain of the compensator (pu)
J+4		30.0	Kic, Integrator gain of the compensator (pu)
J+5		-4.0	BetaMin, Lower pitch angle limit (degrees)
J+6		27.0	BetaMax, Upper pitch angle limit (degrees)
J+7		-10.0	RBetaMin, Lower pitch angle rate limit (degrees/sec.)
J+8		10.0	RBetaMax, Upper pitch angle rate limit (degrees/sec.)
J+9		0.91	PMX, power reference

TWIND1 - WIND GUST AND RAMP

CONs	#	Value	Description
J		12.0	Vwb, Base wind speed from load flow, m/sec
J+1		9999.0	T1g, Gust start time, sec.
J+2		5.0	Tg, Gust duration, sec.
J+3		30.0	MAXG, Gust peak over Vwb, m/sec
J+4		9999.0	T1r, Ramp start time, sec.
J+5		9999.0	T2r, Ramp Max time, sec.
J+6		30.0	MAXR, Ramp maximum over Vwb, m/sec.

TSHAFT - TWO-MASS SHAFT

CONs	#	Value	Description
J		1.5	D12, Shaft damping (pu)
J+1		1.246	K12, Shaft stiffness (pu)
J+2		7.64	Ta1, Turbine rotor inertia (sec.)
J+3		3	POL, a number of generator pole pairs
J+4		72.0	Rq, Gear box ratio

VTGTRP - UNDERVOLTAGE/OVERVOLTAGE GENERATOR RELAY MODEL

CONs	#	1	2	3	4	5	6	7	Description
J		0.3	0.7	0.75	0.85	0.0	0.0	0.0	VL, lower voltage threshold (pu)
J+1		5.0	5.0	5.0	5.0	1.1	1.15	1.3	VU, upper voltage threshold (pu)
J+2		0.02	0.1	1.0	10.0	1.0	0.1	0.02	TP, relay pickup time (sec)
J+3		0.15	0.15	0.15	0.15	0.15	0.15	0.15	TB, breaker time (sec)

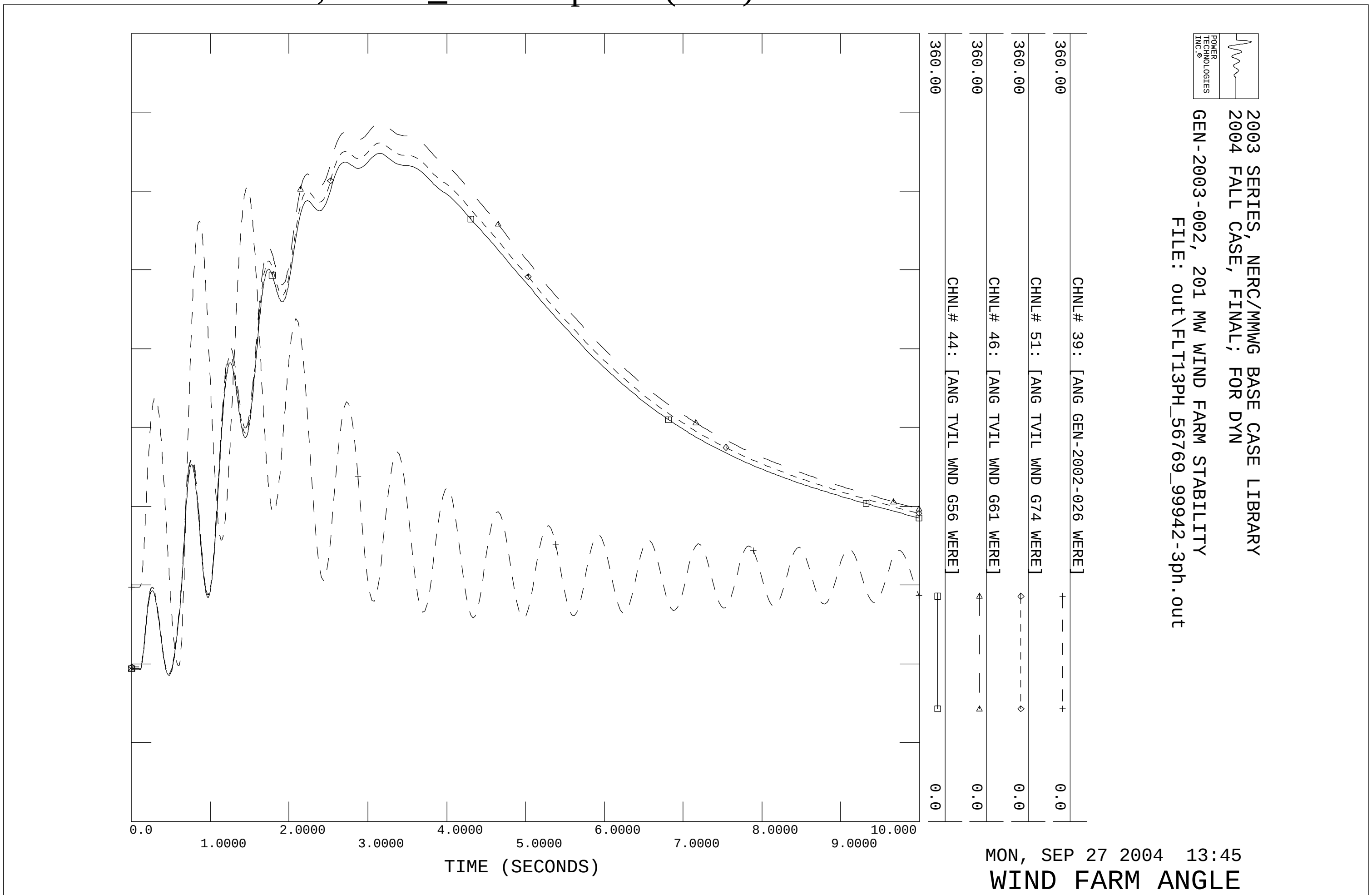
FRQTRP - UNDERFREQUENCY/OVERFREQUENCY GENERATOR RELAY MODEL

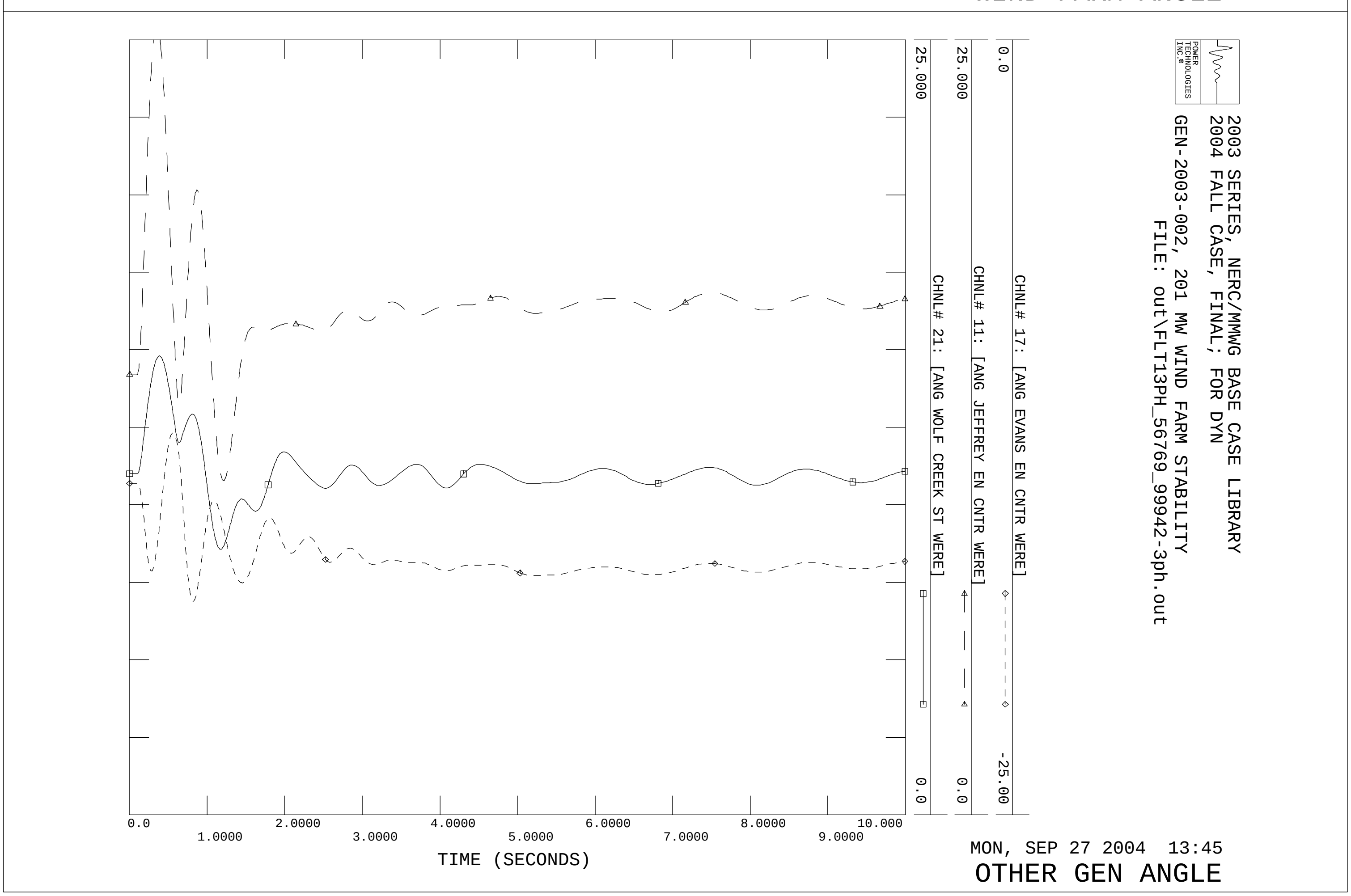
CONs	#	1	2	3	4	Description
J		56.5	57.5	54.0	54.0	FL, lower frequency threshold (pu)
J+1		66.0	66.0	61.5	62.5	FU, upper frequency threshold (pu)
J+2		0.02	10.0	30.0	0.02	TP, relay pickup time (sec)
J+3		0.15	0.15	0.15	0.15	TB, breaker time (sec)

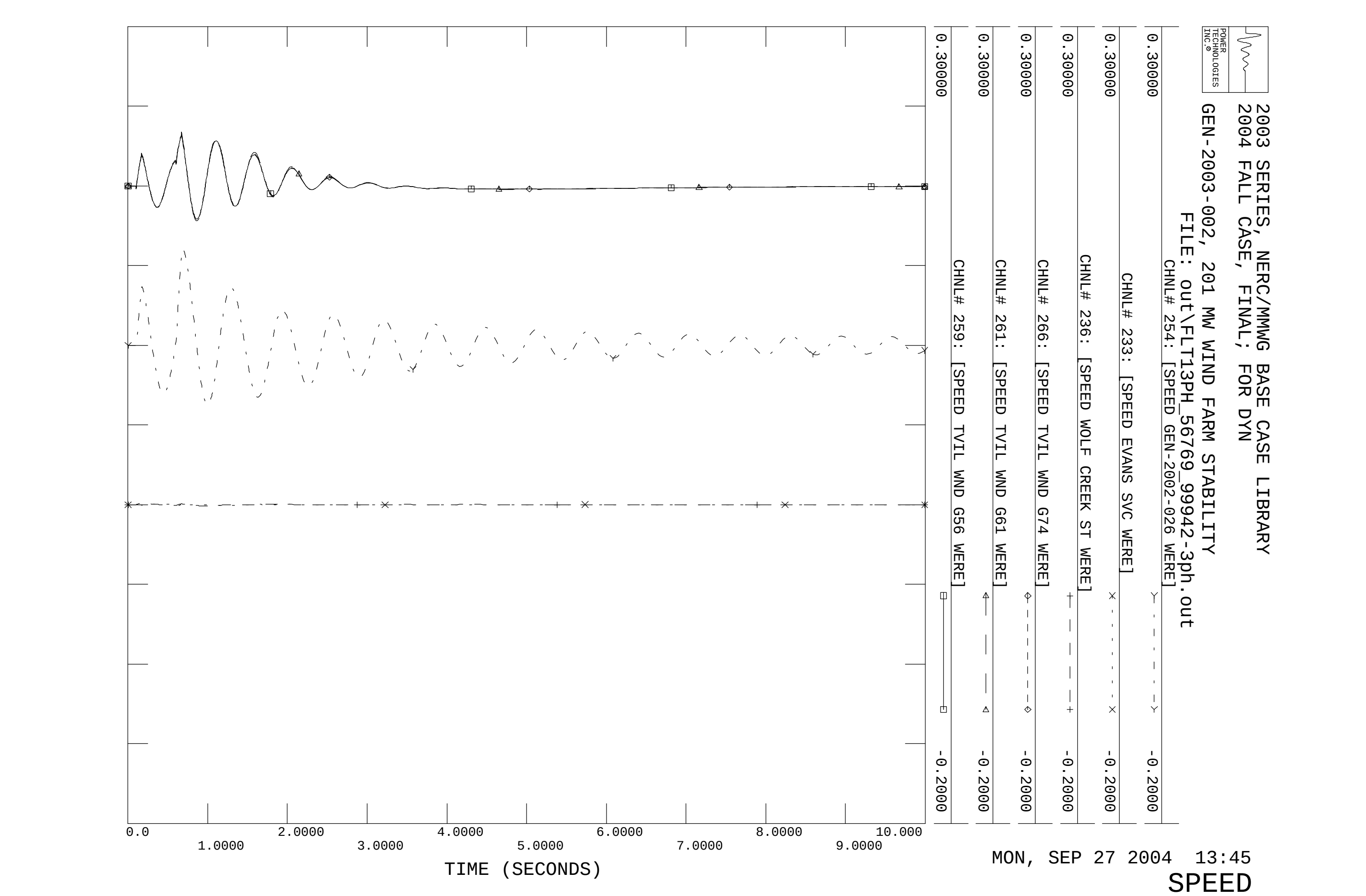
APPENDIX C

STABILITY RESULT PLOTS

CASE ID: FLT13PH, 56769_99942-3ph (1 / 2)






2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 236: [SPEED WOLF CREEK ST WERE] 0.30000 -0.2000
CHNL# 266: [SPEED TVIL WND G74 WERE] 0.30000 -0.2000
CHNL# 261: [SPEED TVIL WND G61 WERE] 0.30000 -0.2000
CHNL# 259: [SPEED TVIL WND G56 WERE] 0.30000 -0.2000
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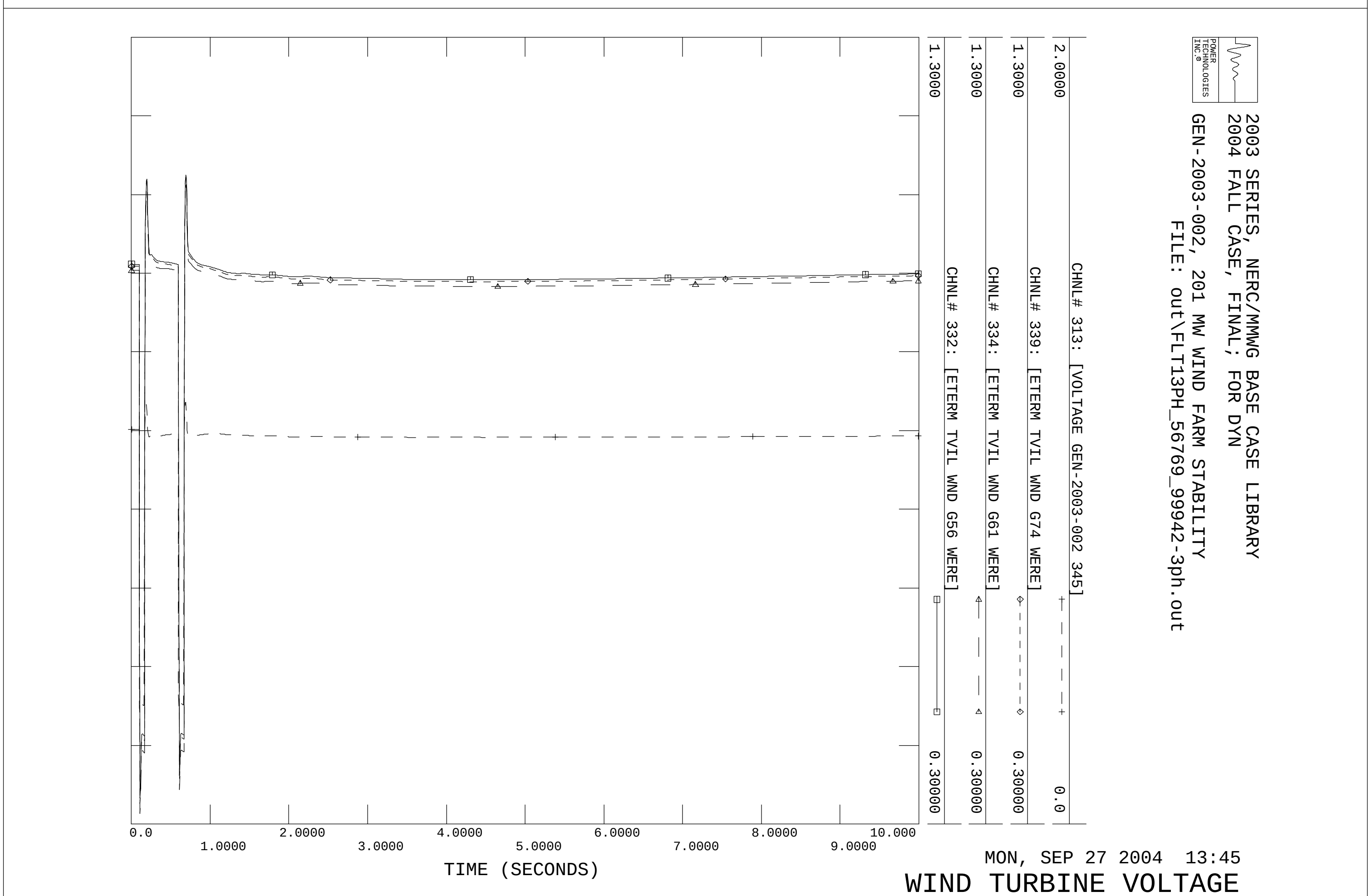
TIME (SECONDS)
MON, SEP 27 2004 13:45
SPEED


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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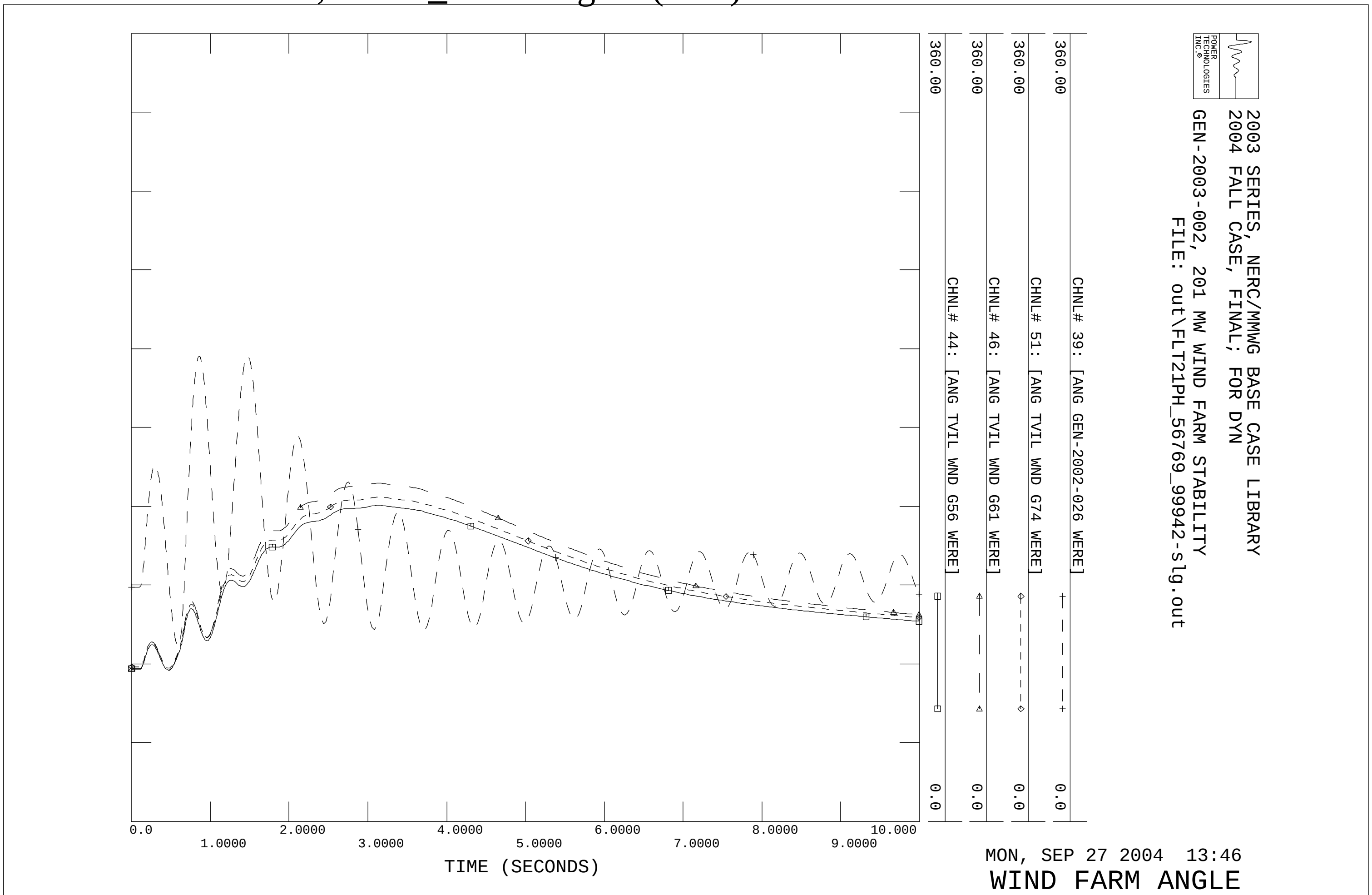
TIME (SECONDS)
MON, SEP 27 2004 13:45
WIND TURBINE VOLTAGE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GEN-2003-002, 201 MW WIND FARM STABILITY
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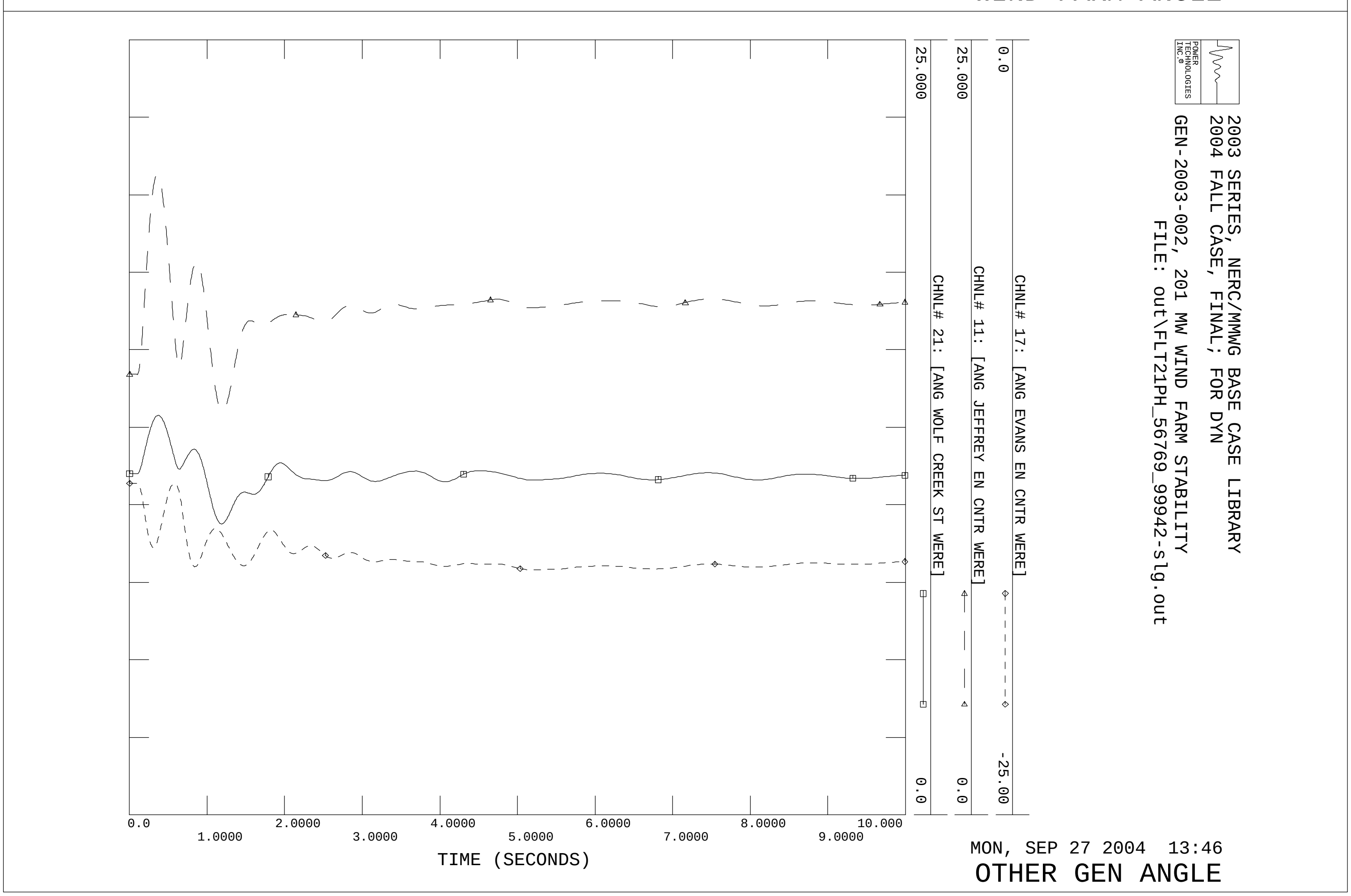
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND FARM ANGLE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2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 11: [ANG JEFFREY EN CNTR WERE]
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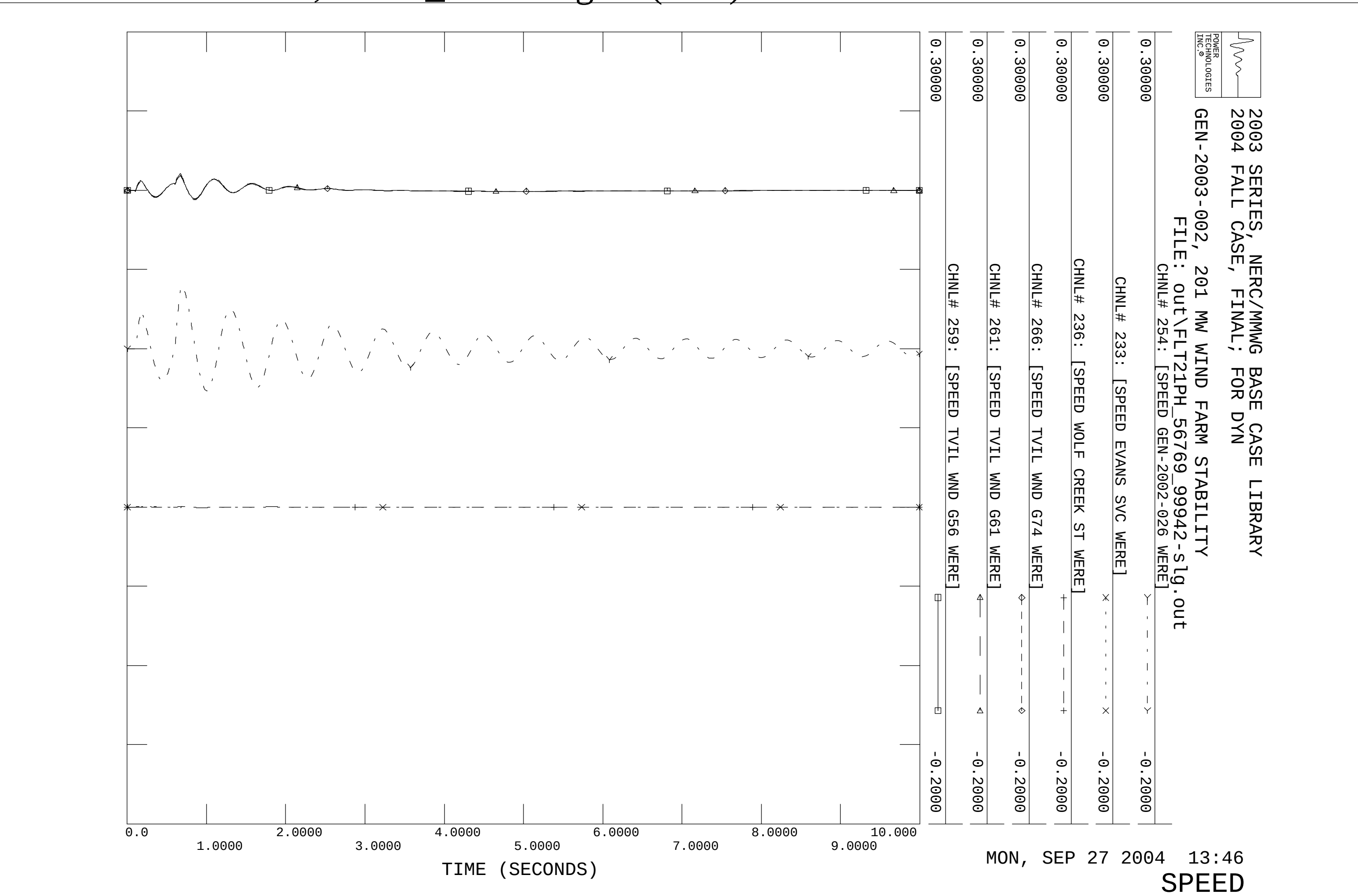
TIME (SECONDS)
MON, SEP 27 2004 13:46
OTHER GEN ANGLE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GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 266: [SPEED TVIL WND G74 WERE] 0.30000 -0.2000
CHNL# 261: [SPEED TVIL WND G61 WERE] 0.30000 -0.2000
CHNL# 259: [SPEED TVIL WND G56 WERE] 0.30000 -0.2000
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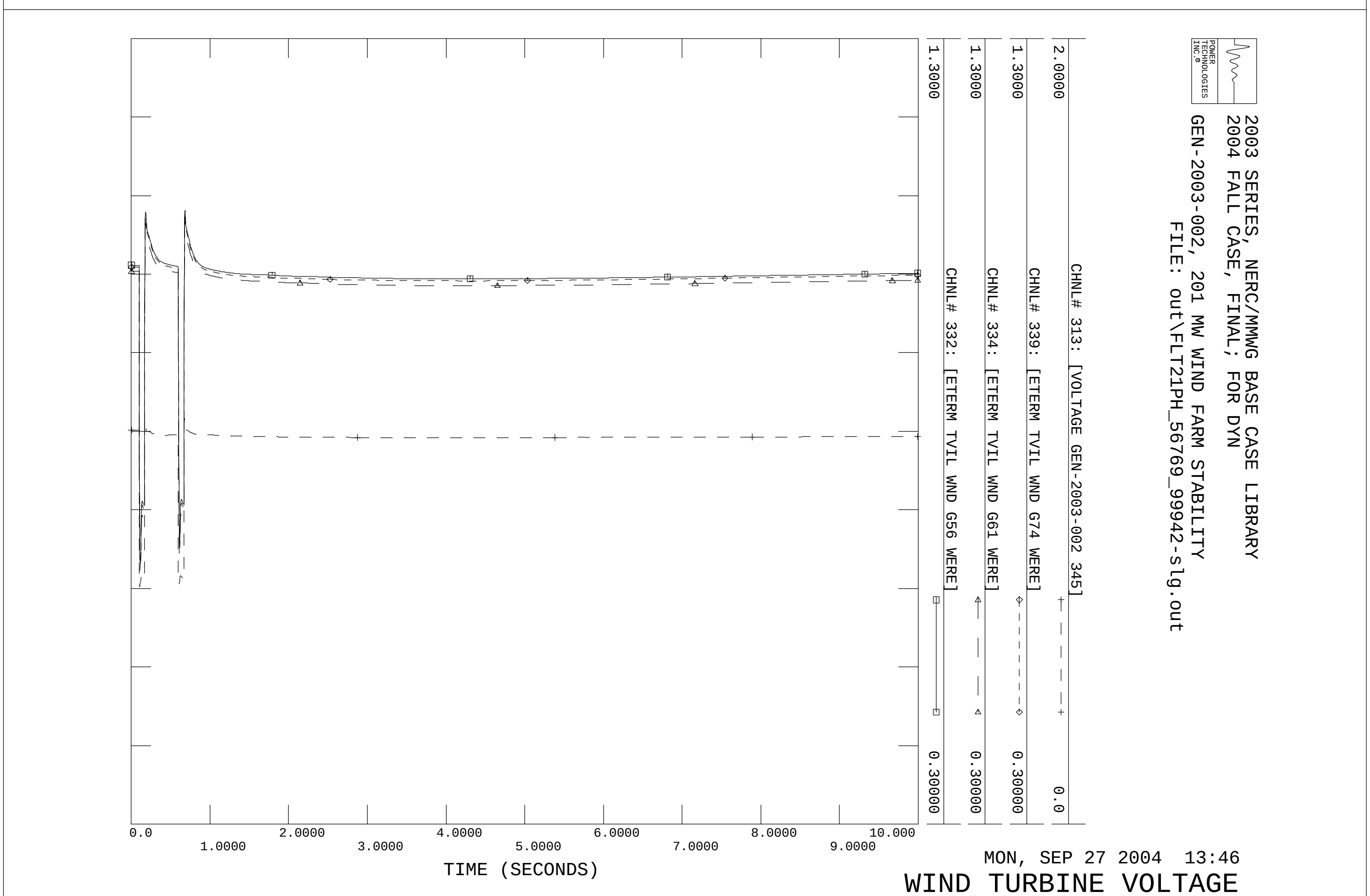
TIME (SECONDS)
MON, SEP 27 2004 13:46
SPEED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2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 334: [ETERM TVIL WND G61 WERE] 1.3000 0.30000
CHNL# 332: [ETERM TVIL WND G56 WERE] 1.3000 0.30000
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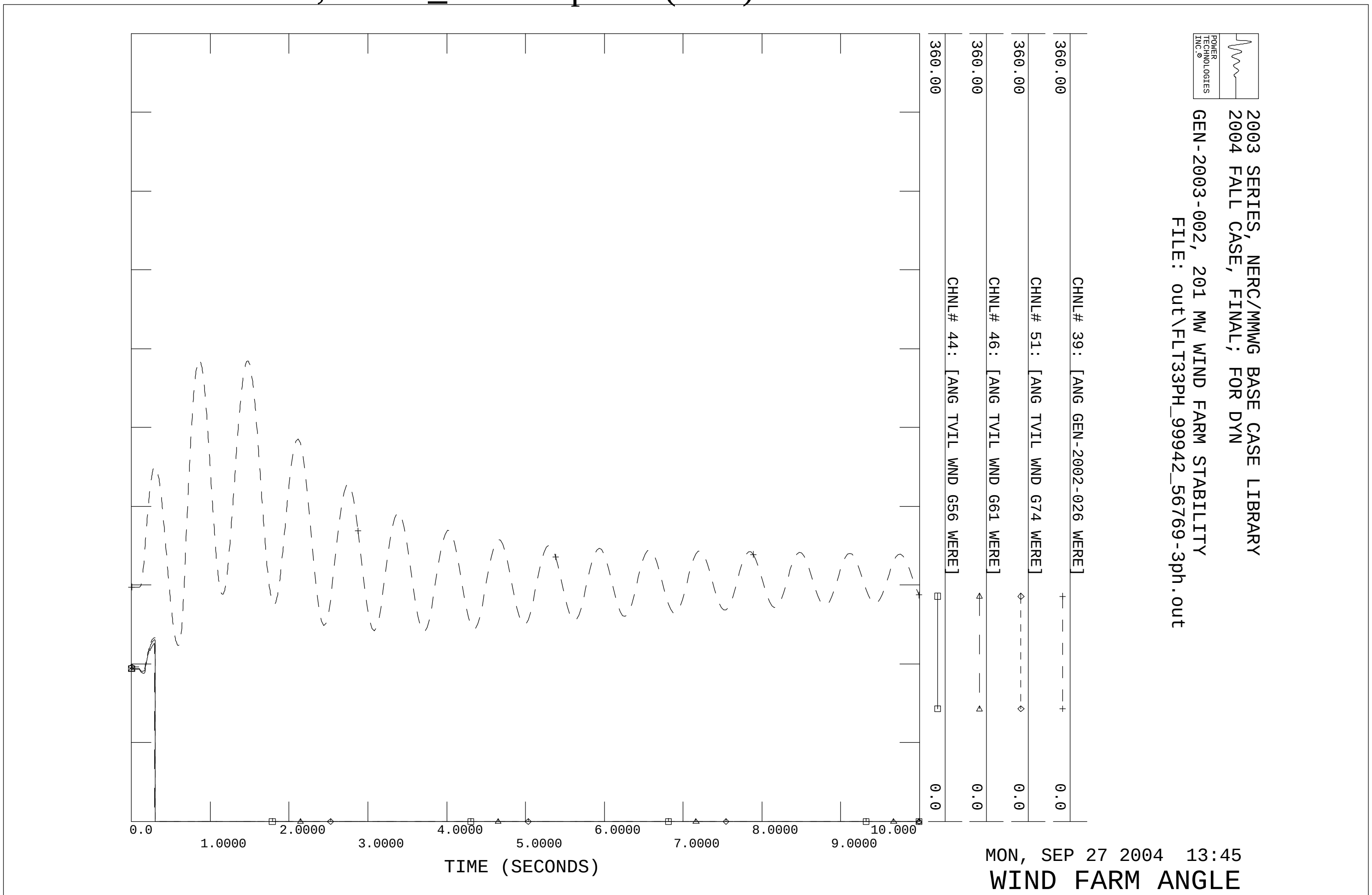
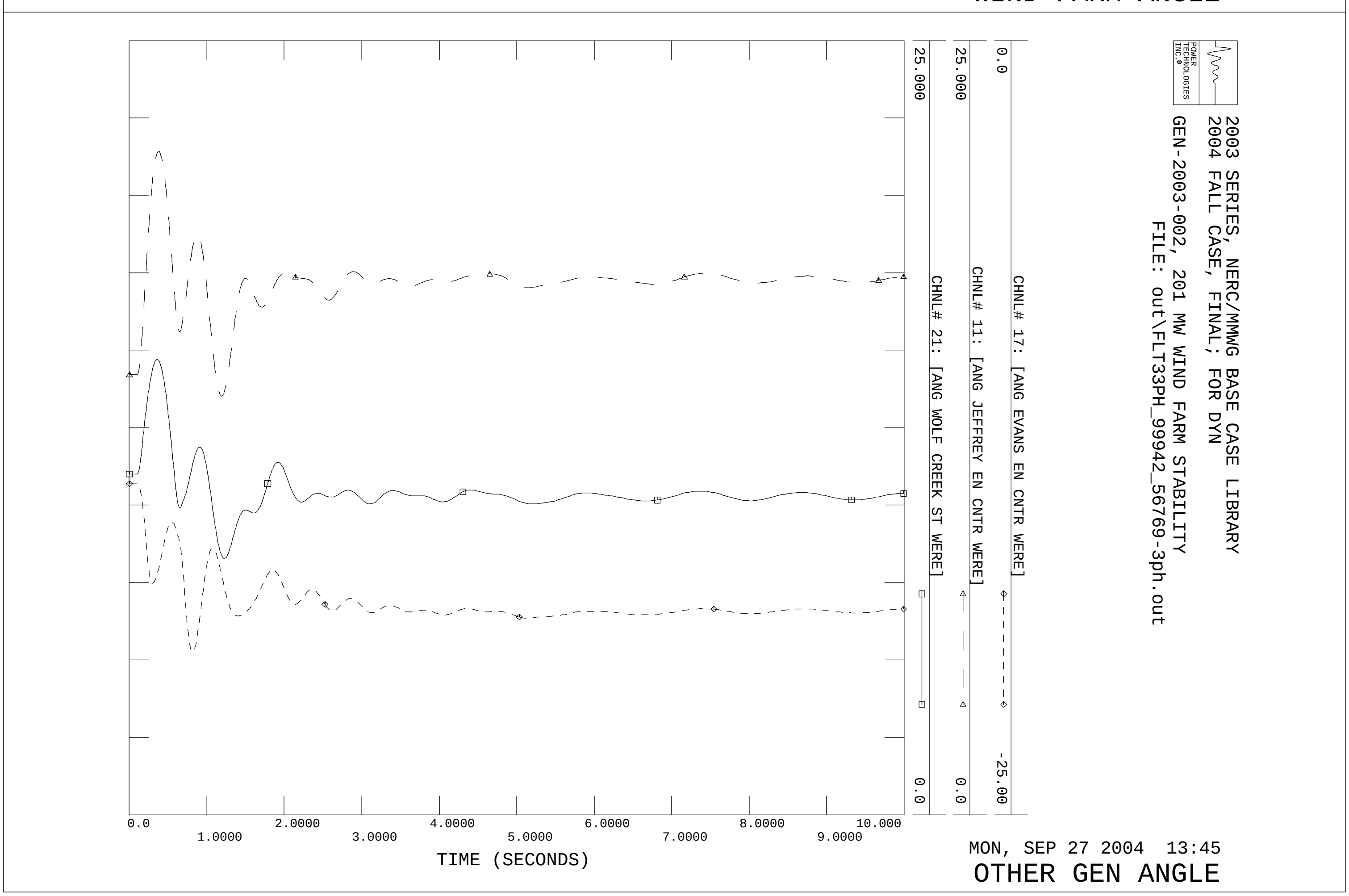
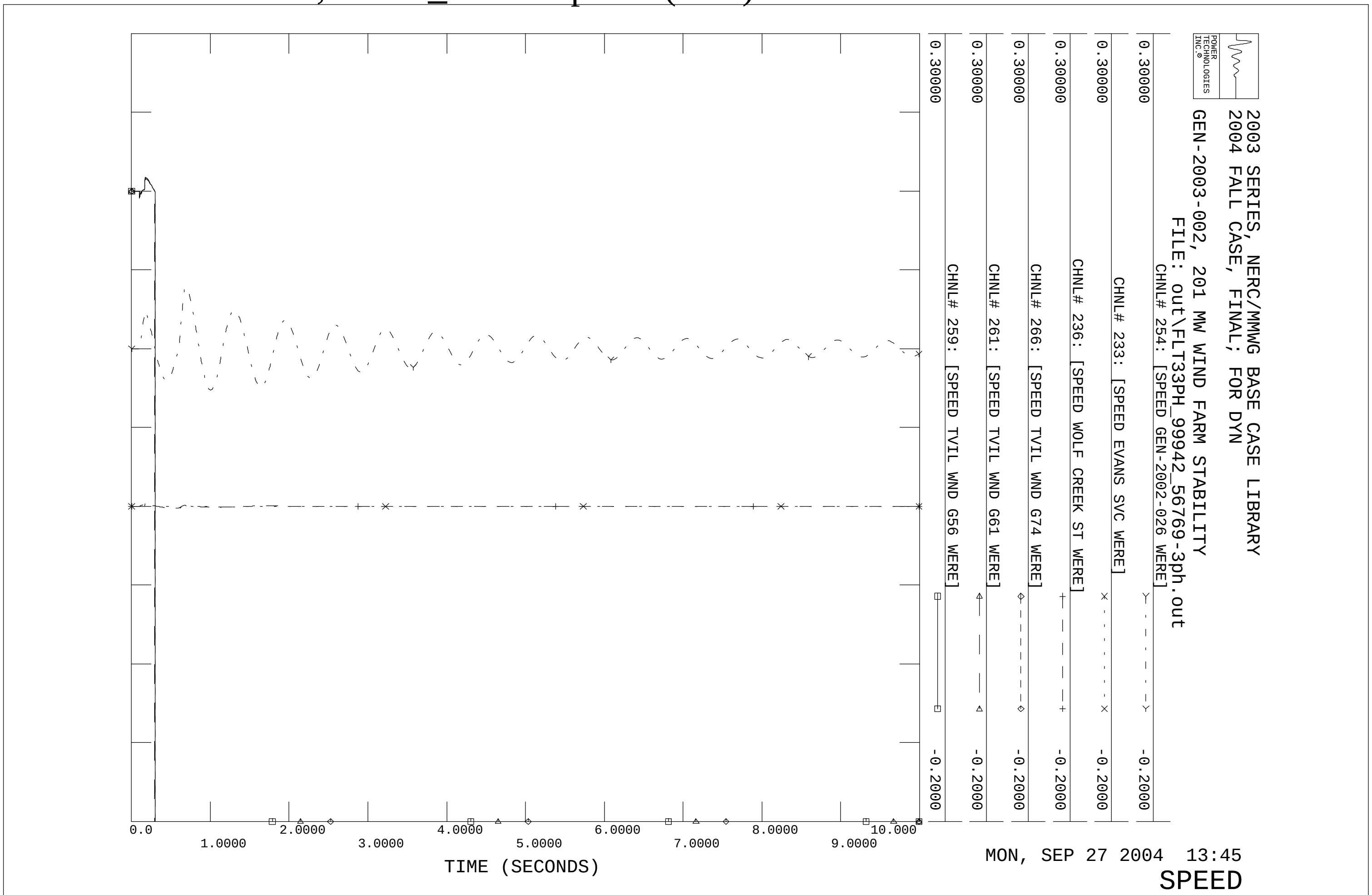
MON, SEP 27 2004 13:46
WIND TURBINE VOLTAGE

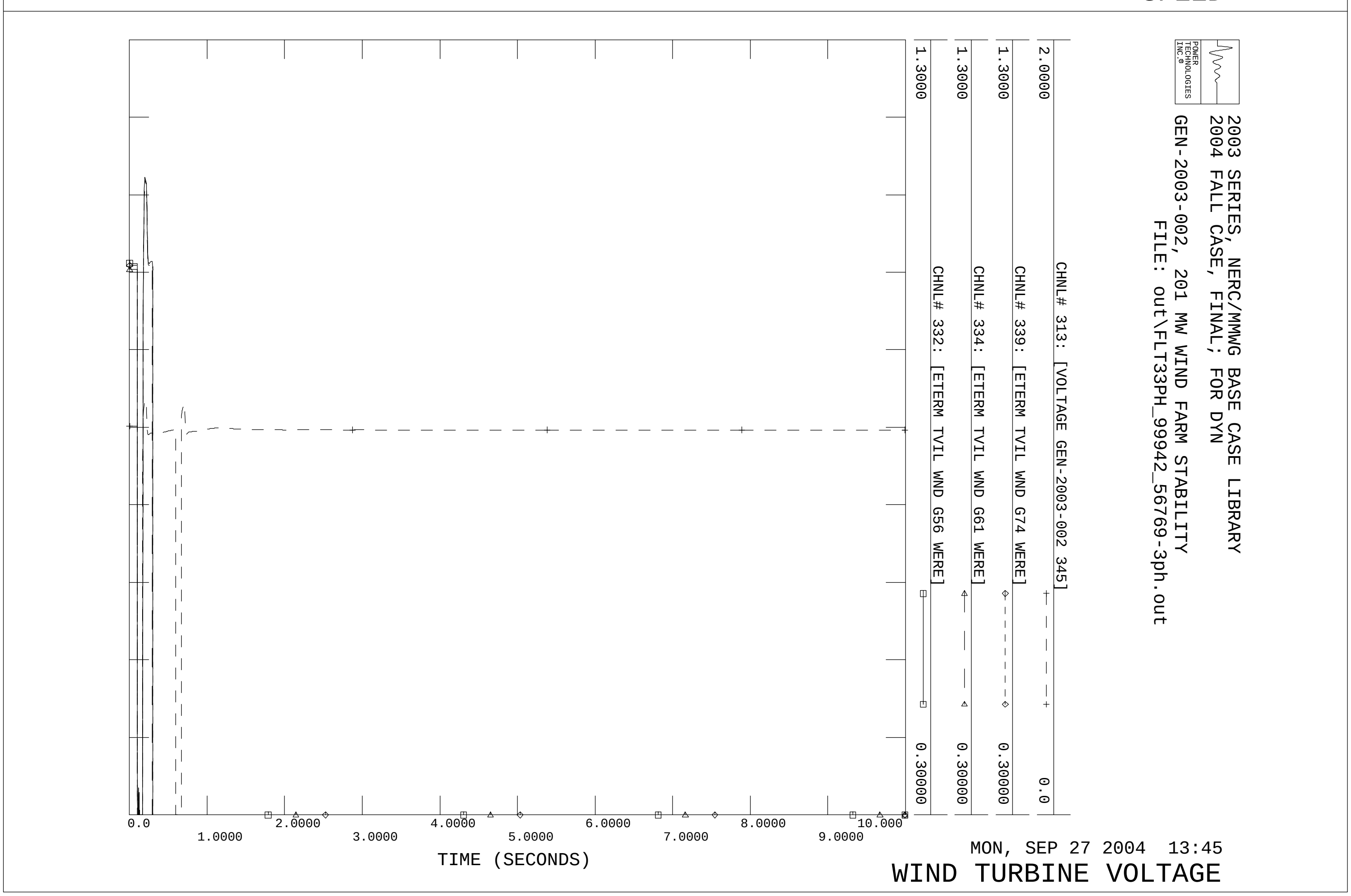
CASE ID: FLT33PH, 99942_56769-3ph (1 / 2)



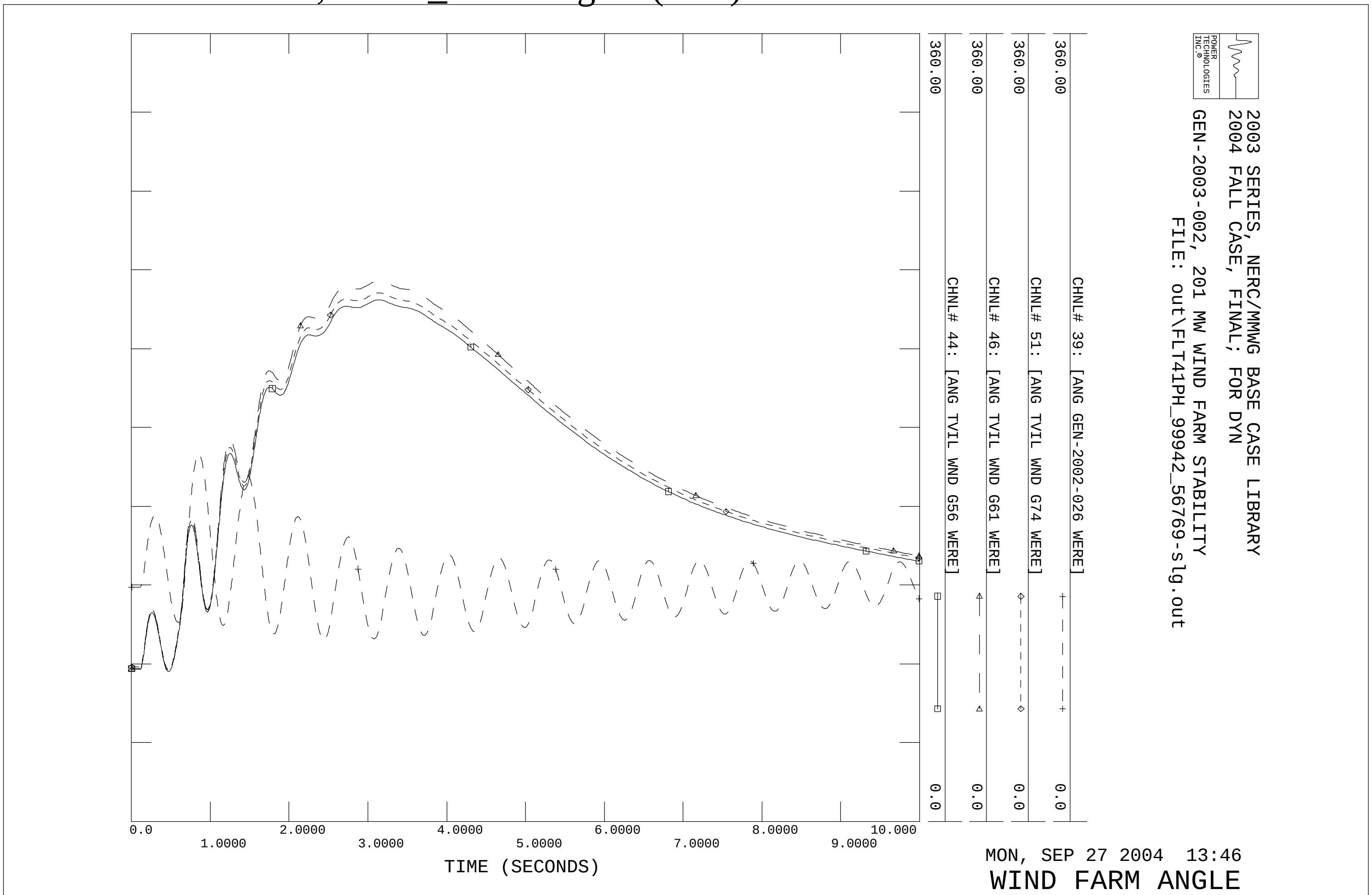


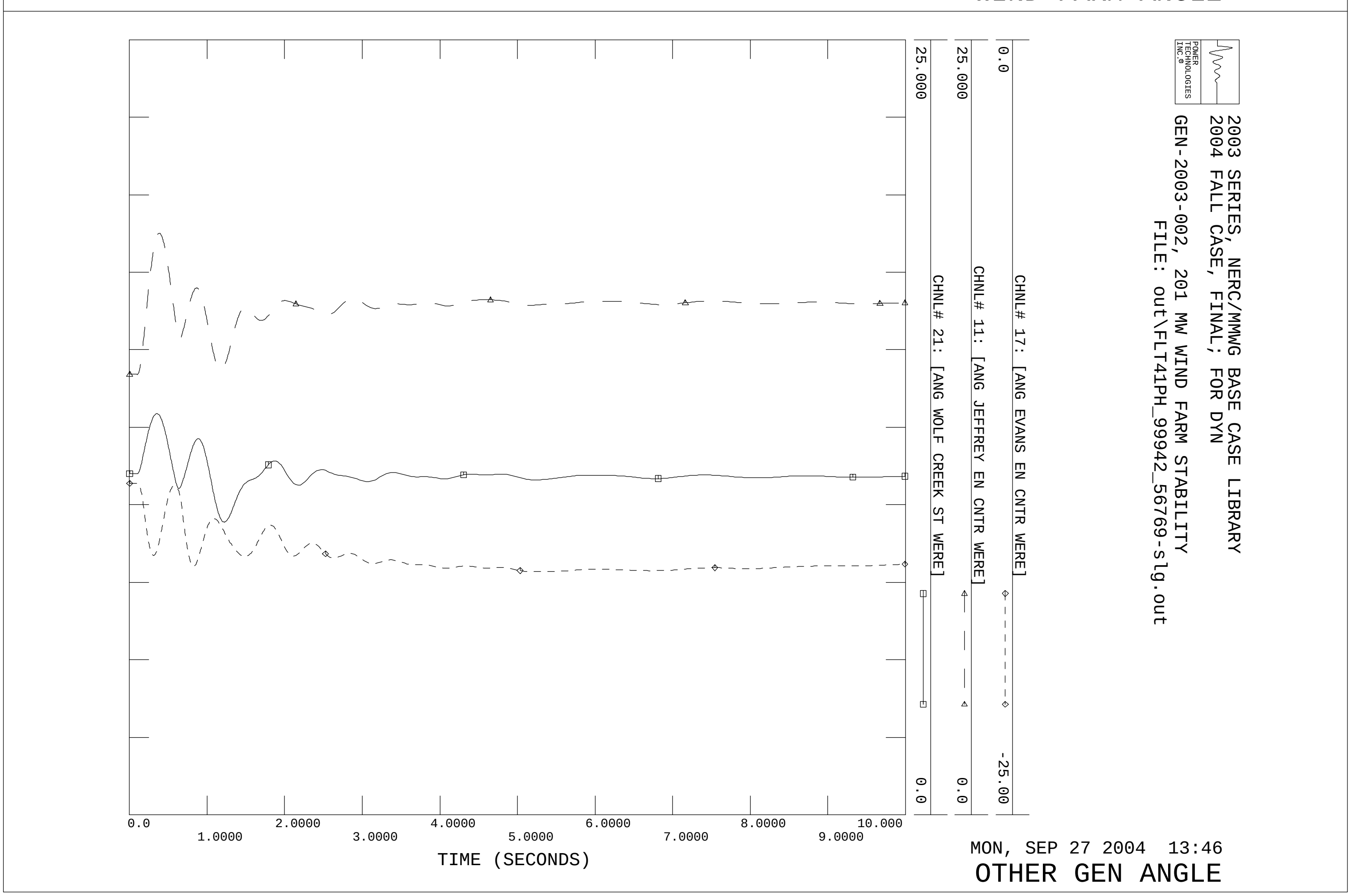
CASE ID: FLT33PH, 99942_56769-3ph (2 / 2)

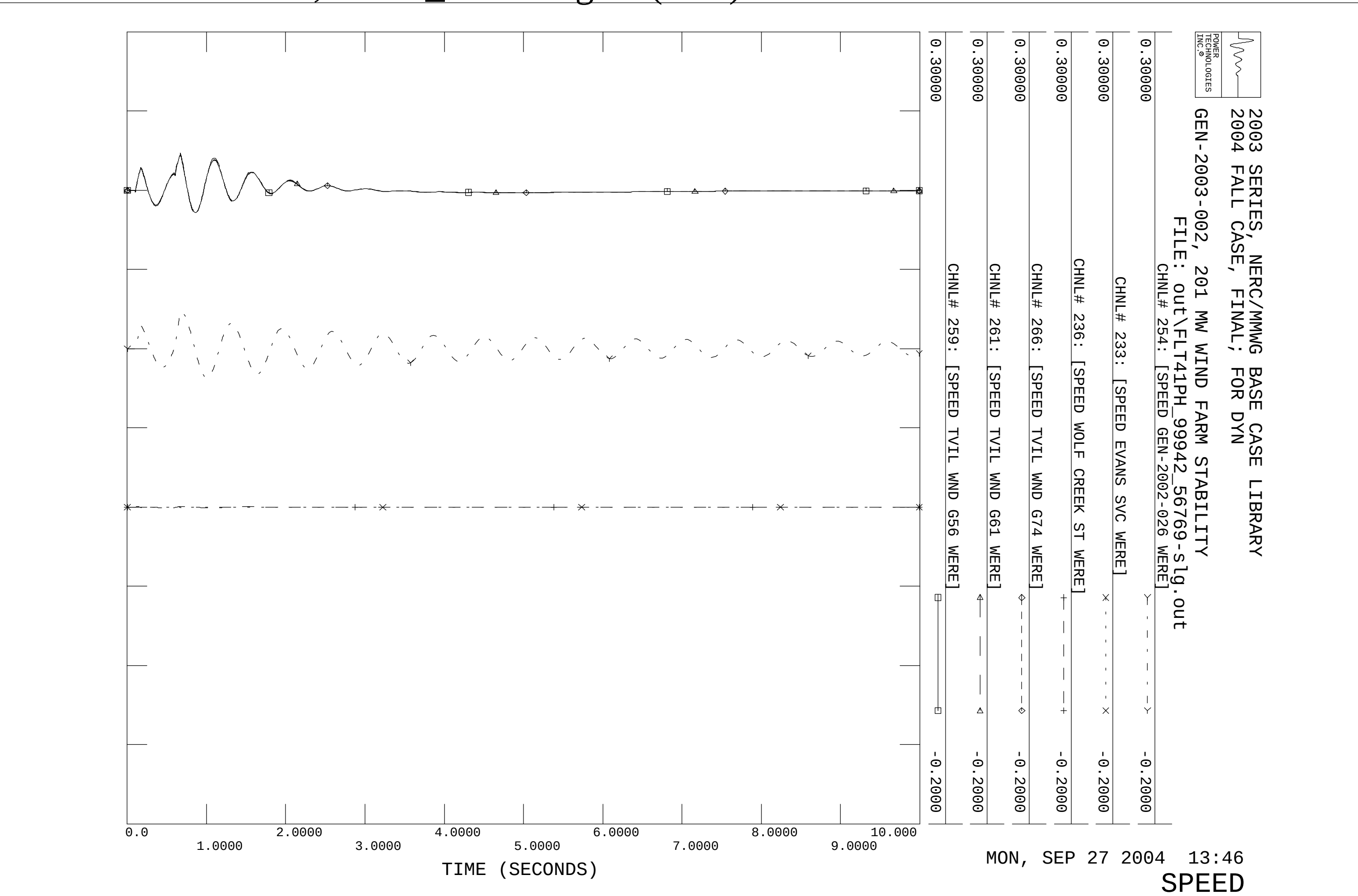




CASE ID: FLT41PH, 99942_56769-slg (1 / 2)






2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 233: [SPEED EVANS SVC WERE]
CHNL# 236: [SPEED WOLF CREEK ST WERE]
CHNL# 266: [SPEED TVIL WND G74 WERE]
CHNL# 261: [SPEED TVIL WND G61 WERE]
CHNL# 259: [SPEED TVIL WND G56 WERE]
0.30000
-0.2000
0.0
1.0000
2.0000
3.0000
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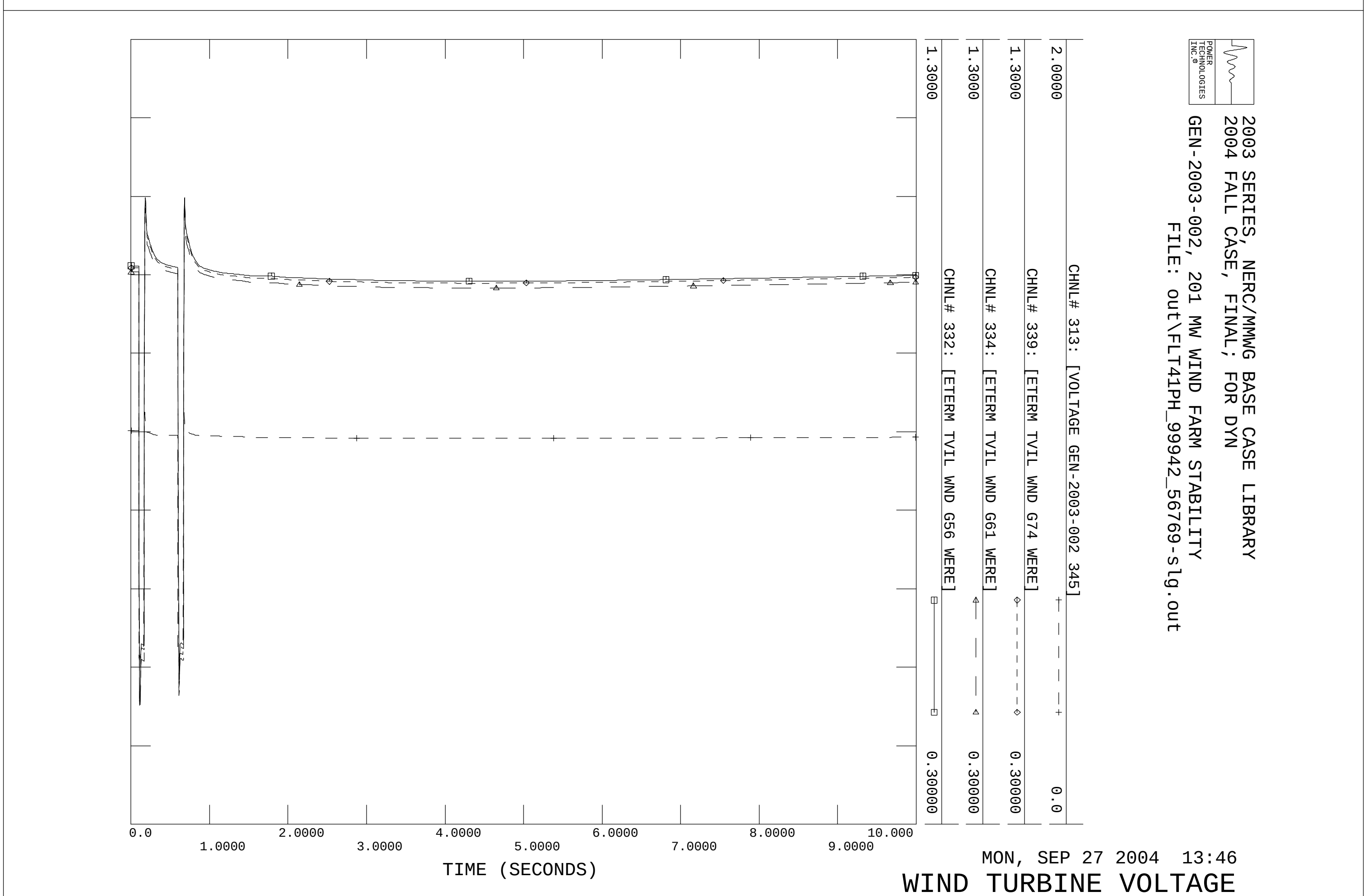
10.000
TIME (SECONDS)
MON, SEP 27 2004 13:46
SPEED


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT41PH_99942_56769-slg.out
CHNL# 313: [VOLTAGE GEN-2003-002 345]
CHNL# 339: [ETERM TVIL WND G74 WERE]
CHNL# 334: [ETERM TVIL WND G61 WERE]
CHNL# 332: [ETERM TVIL WND G56 WERE]
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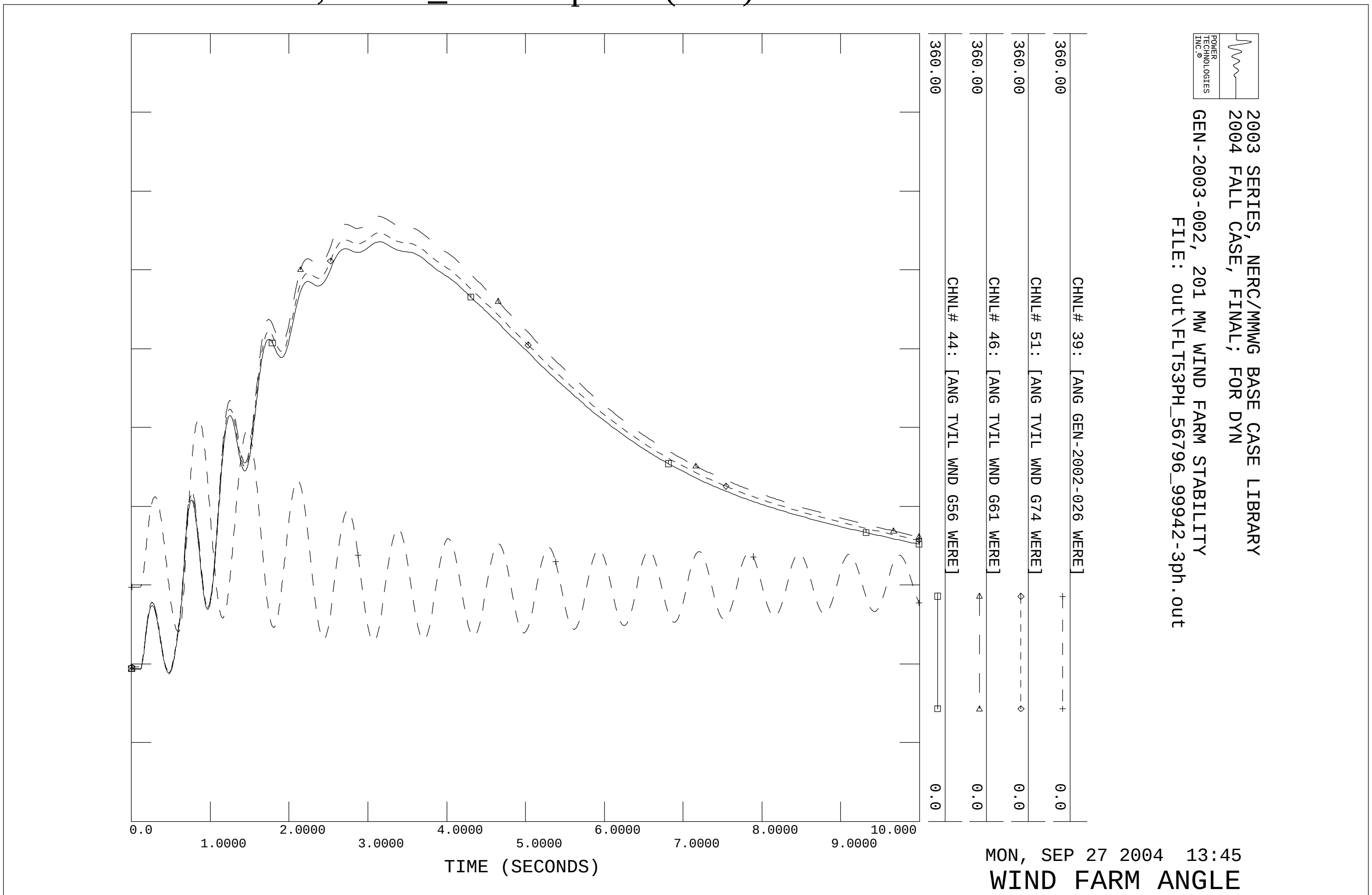
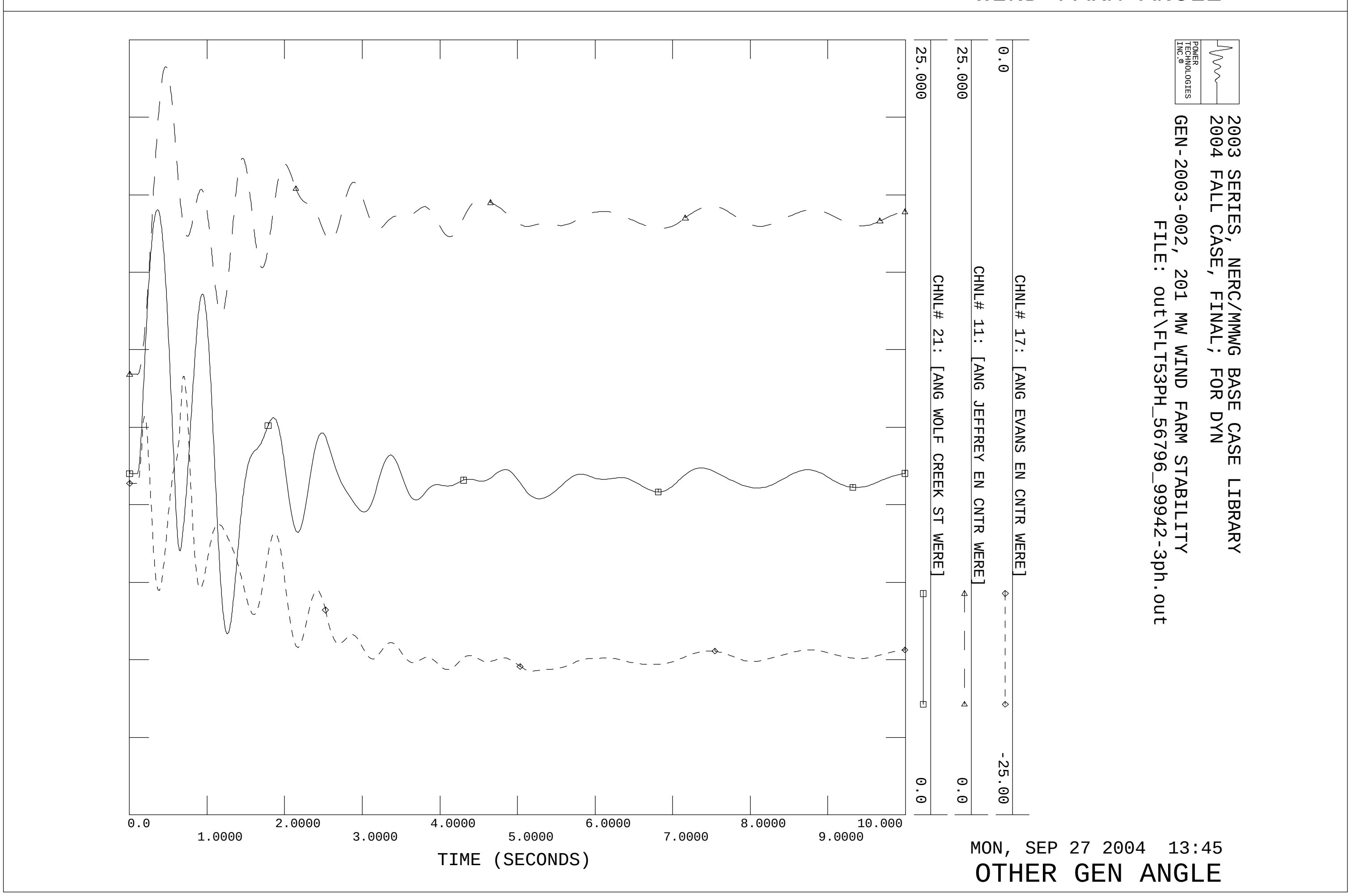
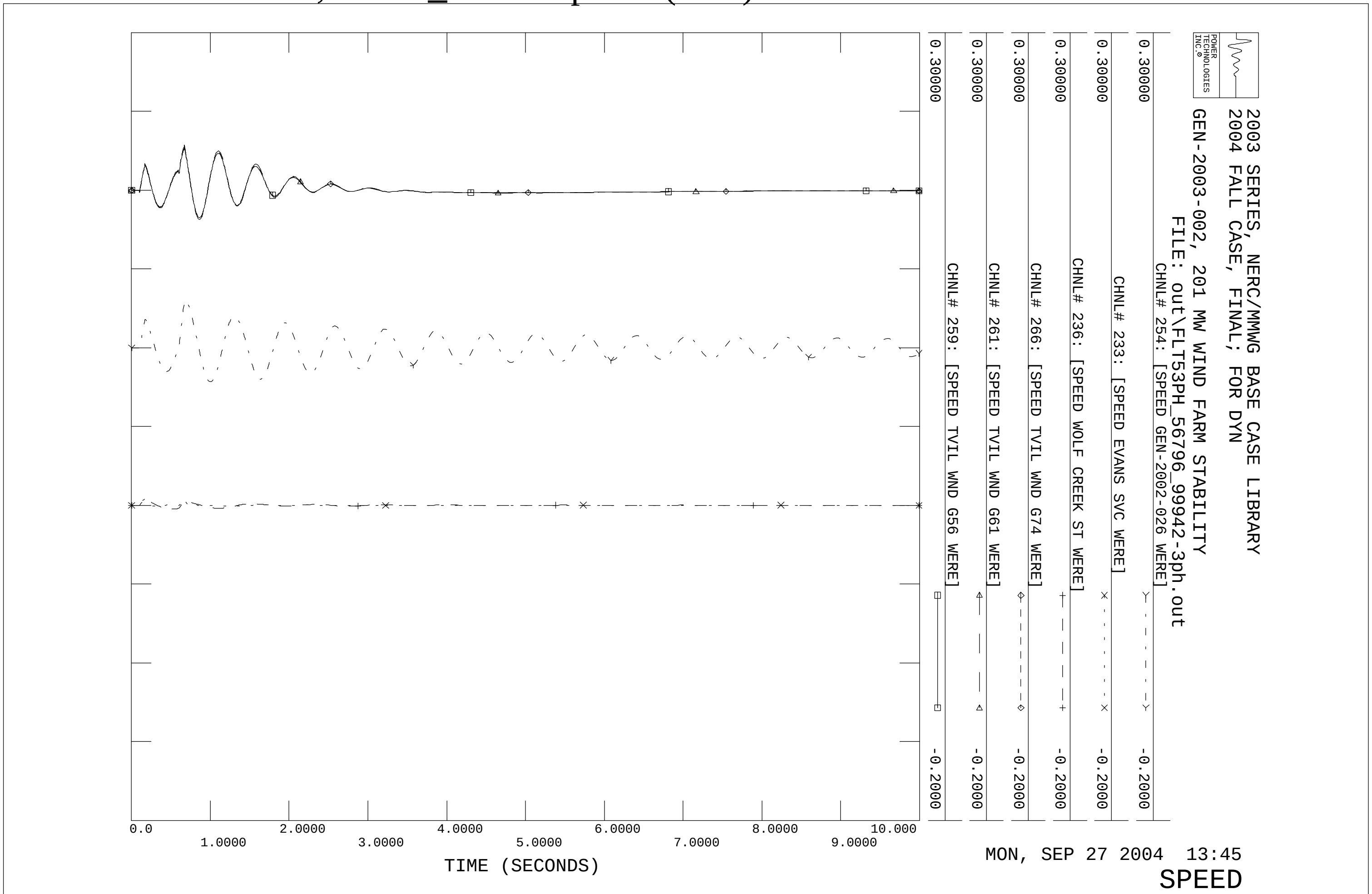
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND TURBINE VOLTAGE

CASE ID: FLT53PH, 56796_99942-3ph (1 / 2)






POWER TECHNOLOGIES INC.®
2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT53PH_56796_99942-3ph.out
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CHNL# 233: [SPEED EVANS SVC WERE] 0.30000 -0.2000
CHNL# 236: [SPEED WOLF CREEK ST WERE] 0.30000 -0.2000
CHNL# 266: [SPEED TVIL WND G74 WERE] 0.30000 -0.2000
CHNL# 261: [SPEED TVIL WND G61 WERE] 0.30000 -0.2000
CHNL# 259: [SPEED TVIL WND G56 WERE] 0.30000 -0.2000
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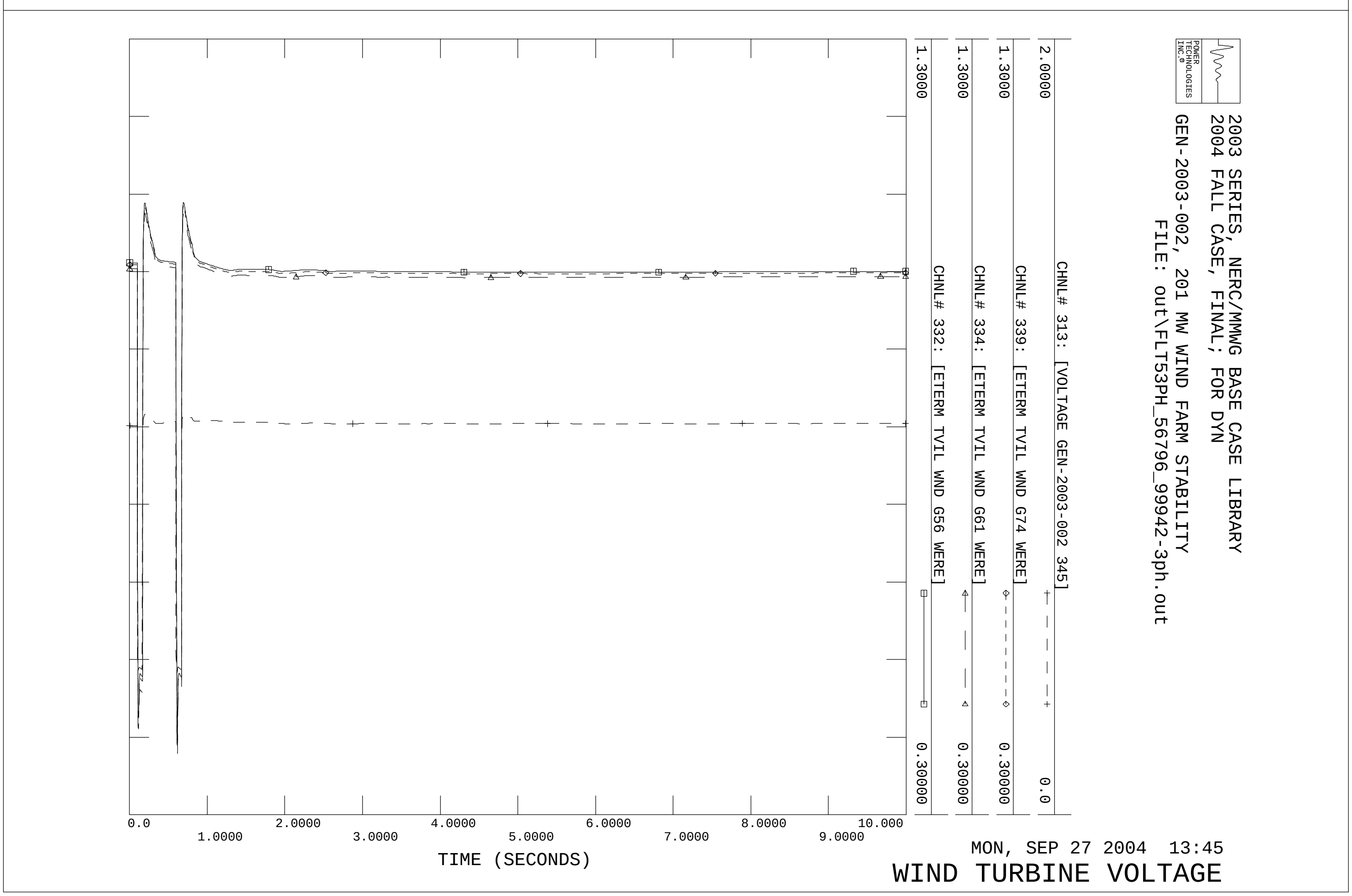
TIME (SECONDS)
MON, SEP 27 2004 13:45
SPEED


POWER TECHNOLOGIES INC.®
2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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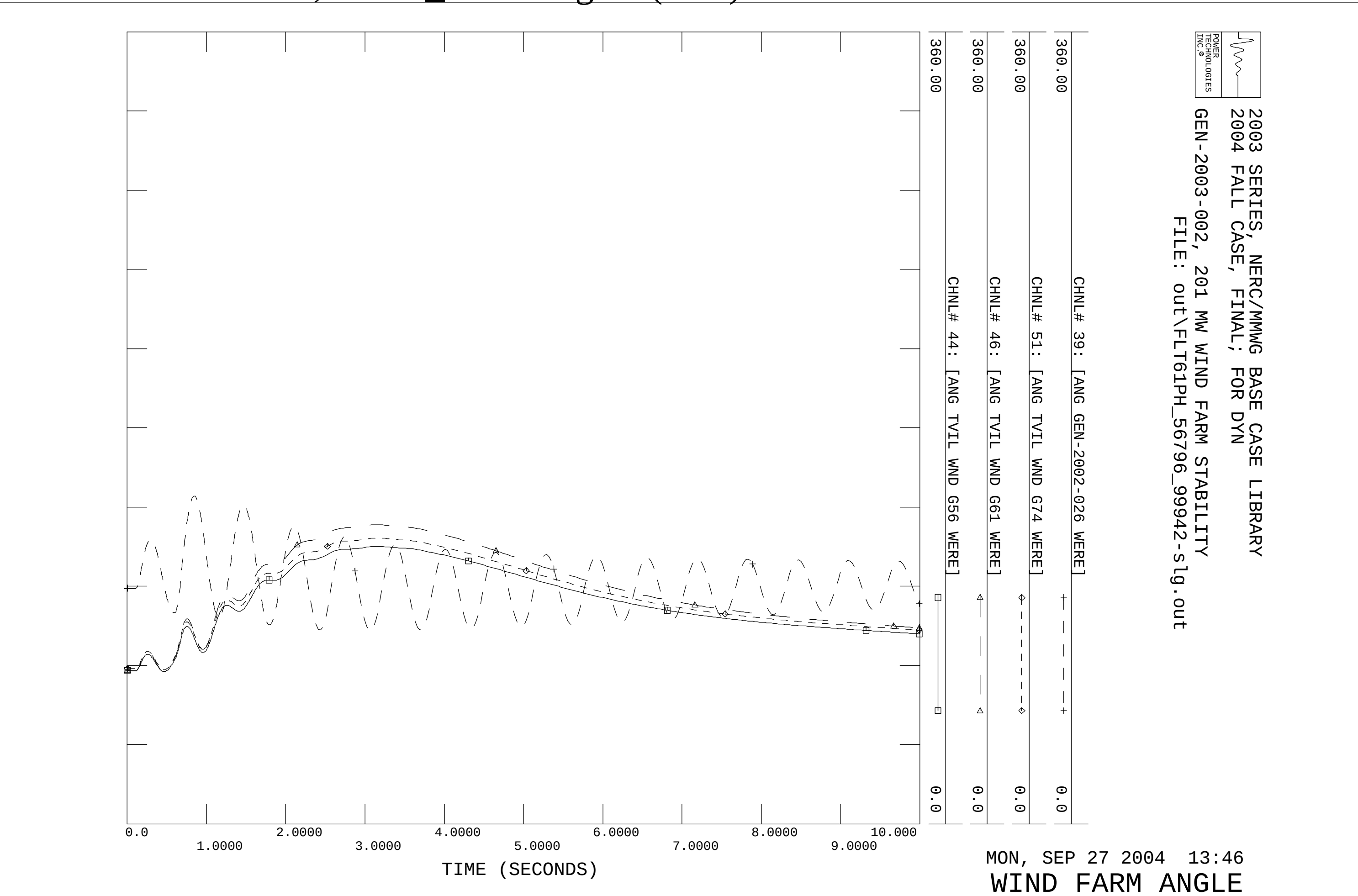
CHNL# 339: [ETERM TVIL WND G74 WERE] 1.3000 0.30000
CHNL# 334: [ETERM TVIL WND G61 WERE] 1.3000 0.30000
CHNL# 332: [ETERM TVIL WND G56 WERE] 1.3000 0.30000
0.0 1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000 10.000
TIME (SECONDS)
MON, SEP 27 2004 13:45
WIND TURBINE VOLTAGE


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT61PH_56796_99942-slg.out
CHNL# 39: [ANG GEN-2002-026 WERE]
CHNL# 51: [ANG TVIL WND G74 WERE]
CHNL# 46: [ANG TVIL WND G61 WERE]
CHNL# 44: [ANG TVIL WND G56 WERE]
360.00
0.0
0.0
1.0000
2.0000
3.0000
4.0000
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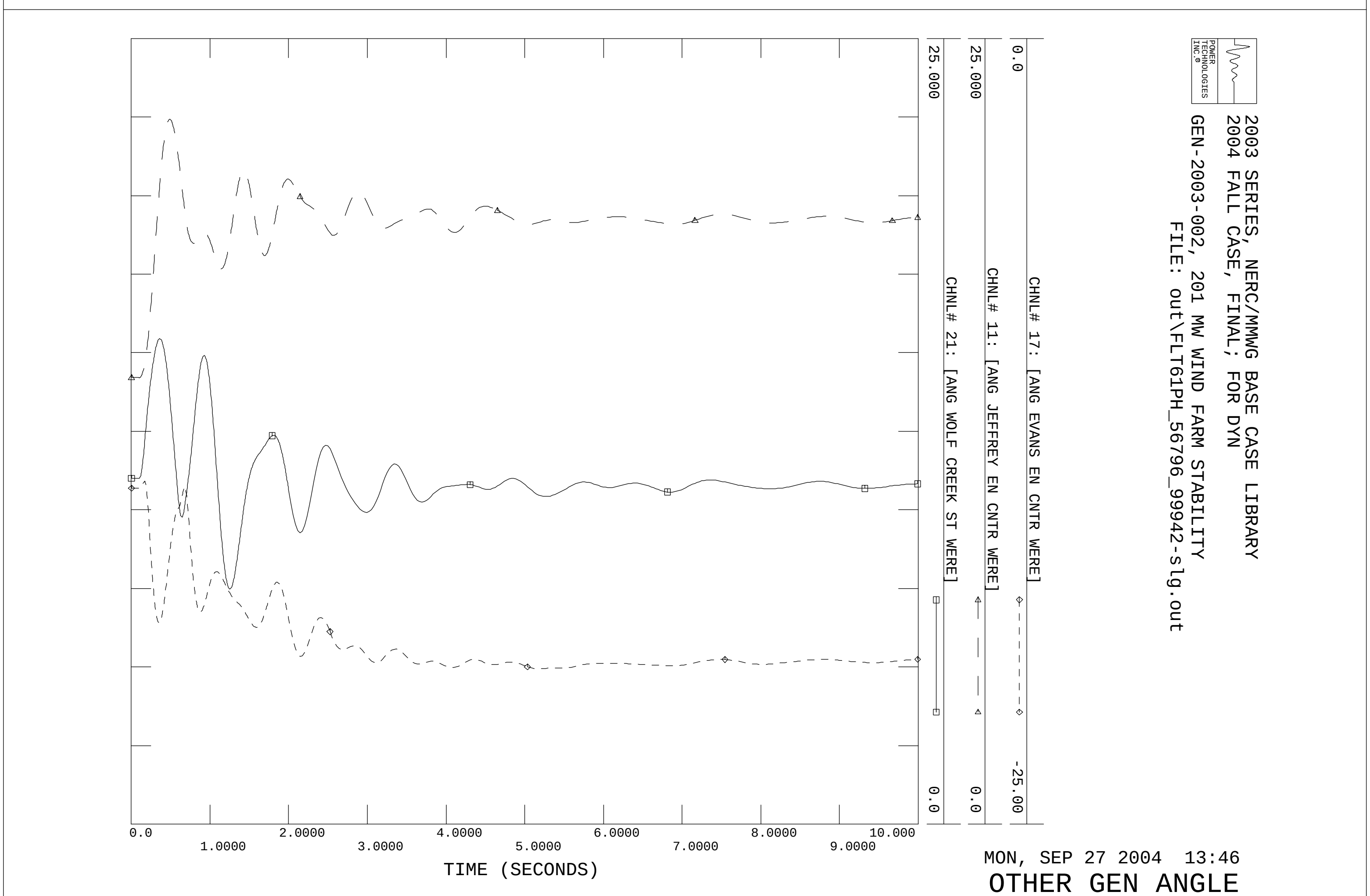
10.000
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND FARM ANGLE


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT61PH_56796_99942-slg.out
CHNL# 17: [ANG EVANS EN CNTR WERE]
CHNL# 11: [ANG JEFFREY EN CNTR WERE]
CHNL# 21: [ANG WOLF CREEK ST WERE]
0.0
-25.00
25.000
0.0
1.0000
2.0000
3.0000
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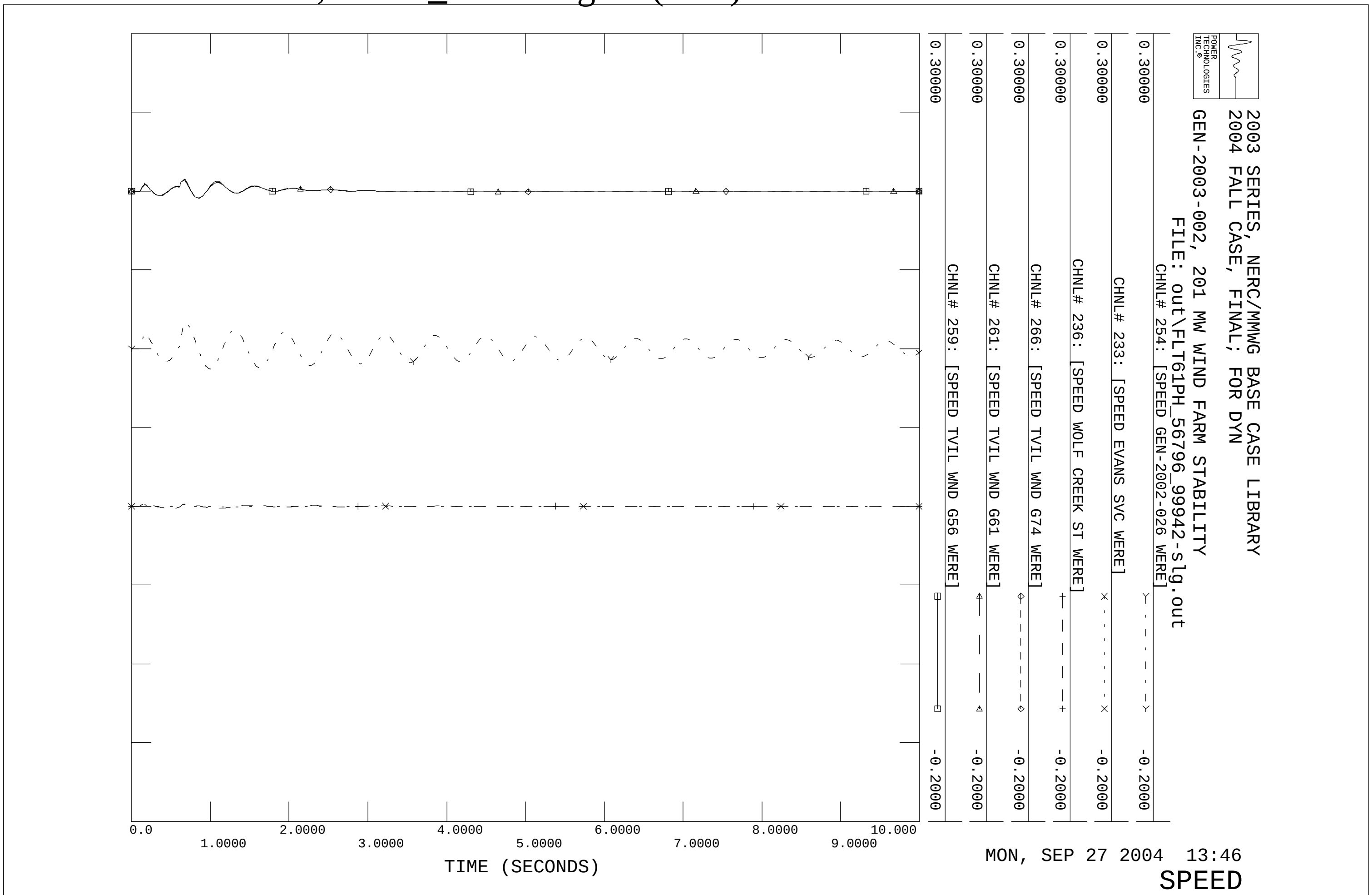
TIME (SECONDS)
MON, SEP 27 2004 13:46
OTHER GEN ANGLE


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT61PH_56796_99942-slg.out
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CHNL# 233: [SPEED EVANS SVC WERE]
CHNL# 236: [SPEED WOLF CREEK ST WERE]
CHNL# 266: [SPEED TVIL WND G74 WERE]
CHNL# 261: [SPEED TVIL WND G61 WERE]
CHNL# 259: [SPEED TVIL WND G56 WERE]
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-0.2000
0.0
1.0000
2.0000
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7.0000
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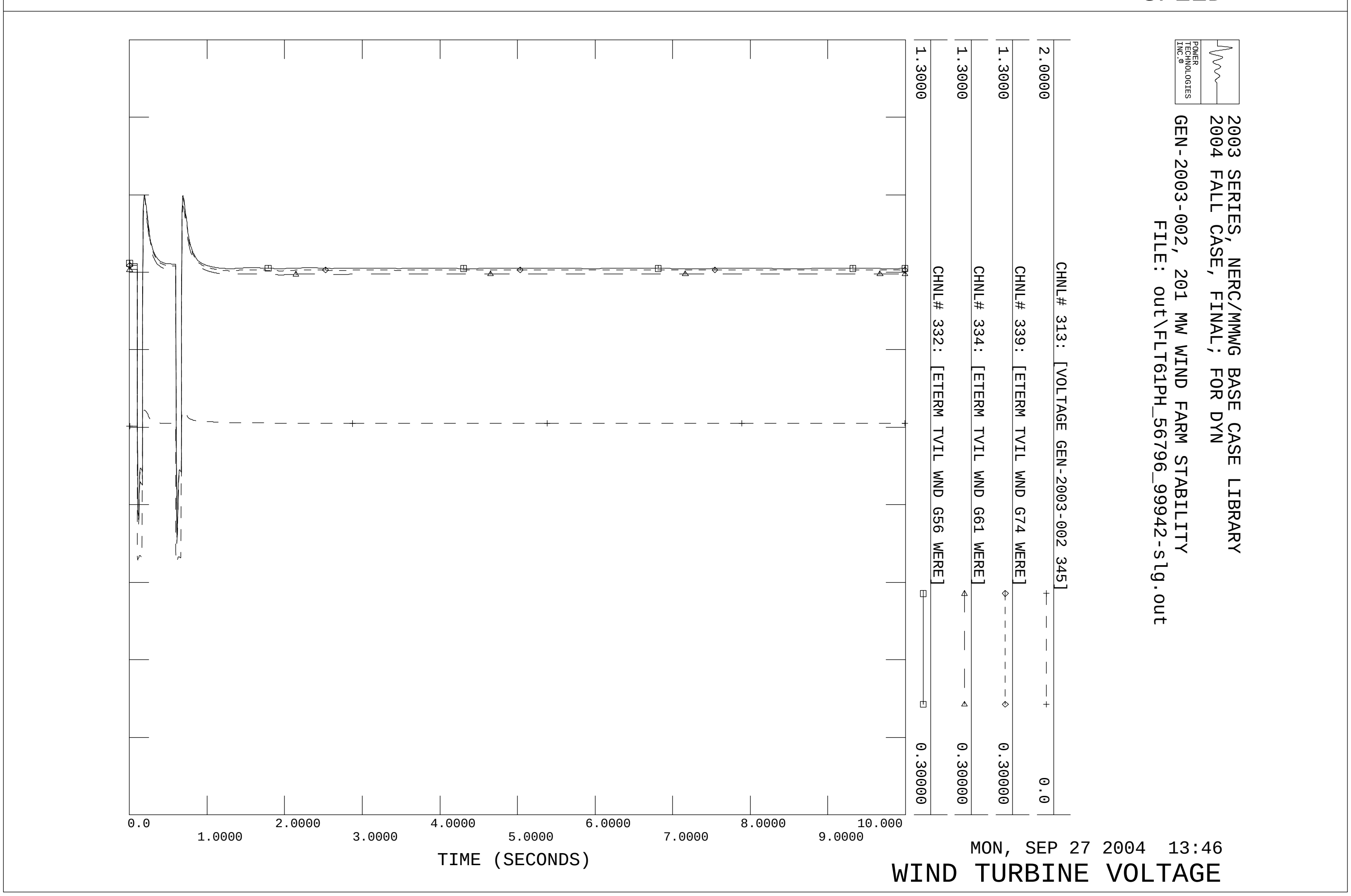
TIME (SECONDS)
MON, SEP 27 2004 13:46
SPEED


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 339: [ETERM TVIL WND G74 WERE]
CHNL# 334: [ETERM TVIL WND G61 WERE]
CHNL# 332: [ETERM TVIL WND G56 WERE]
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1.3000
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1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
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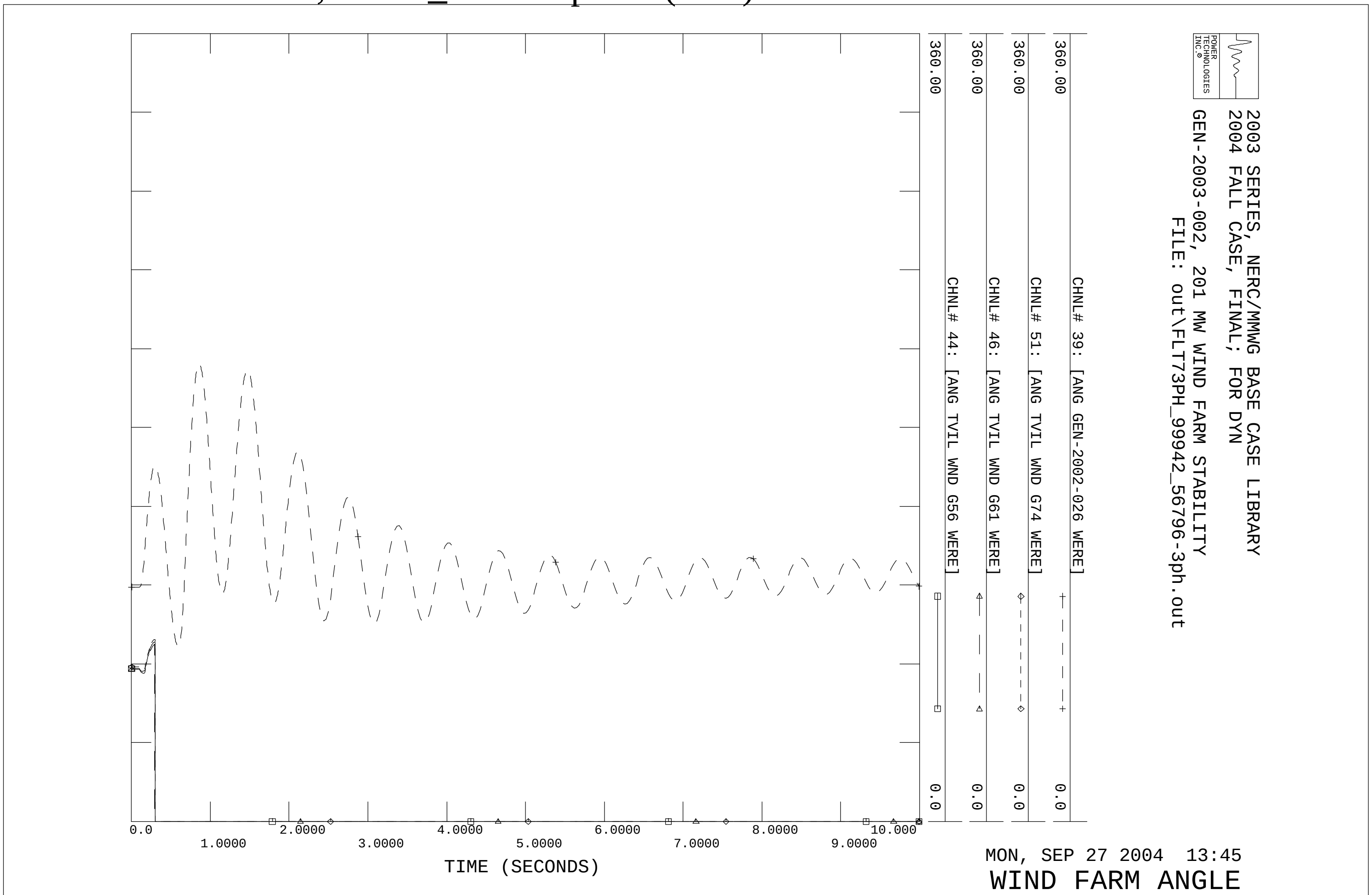
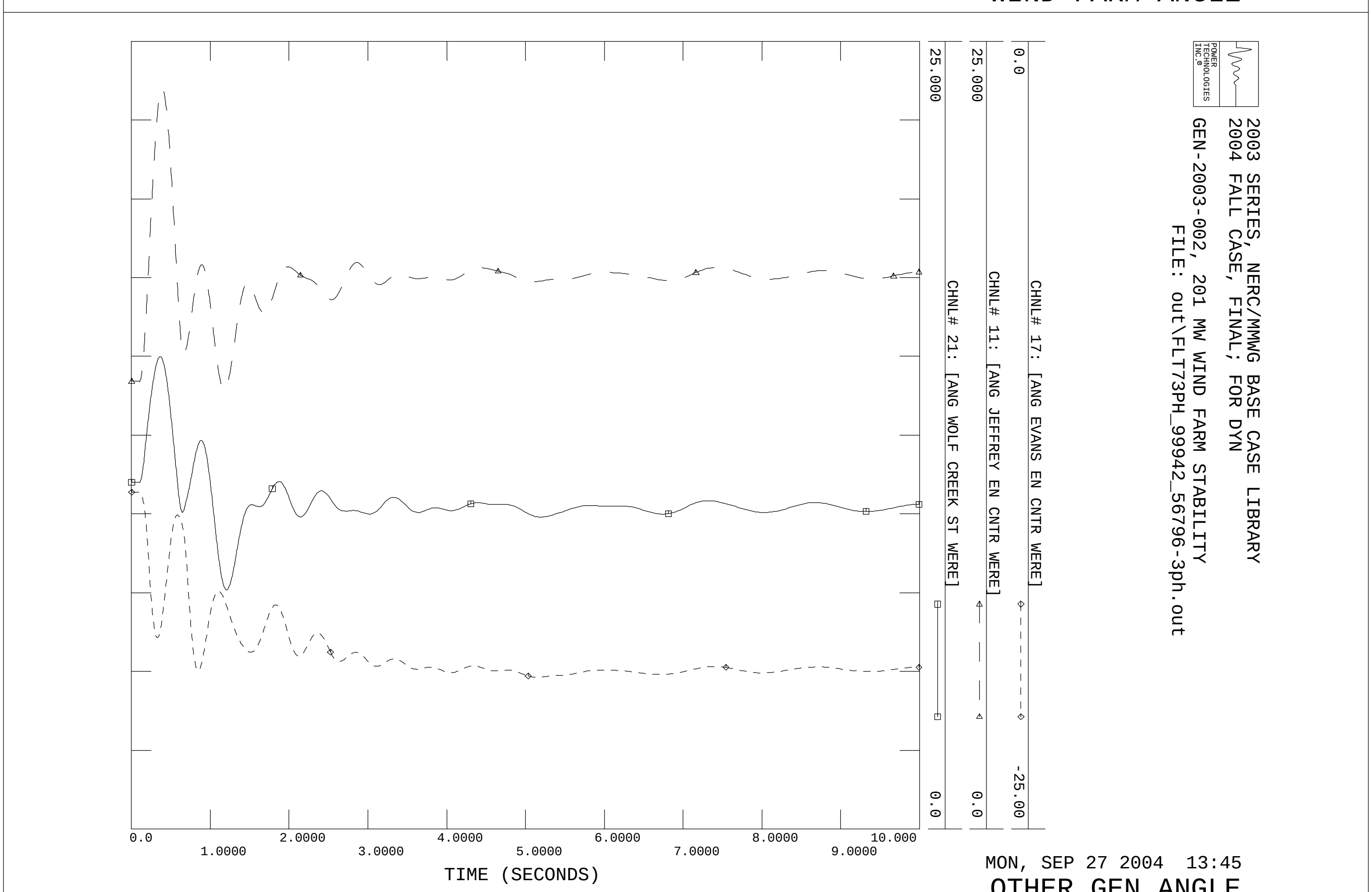
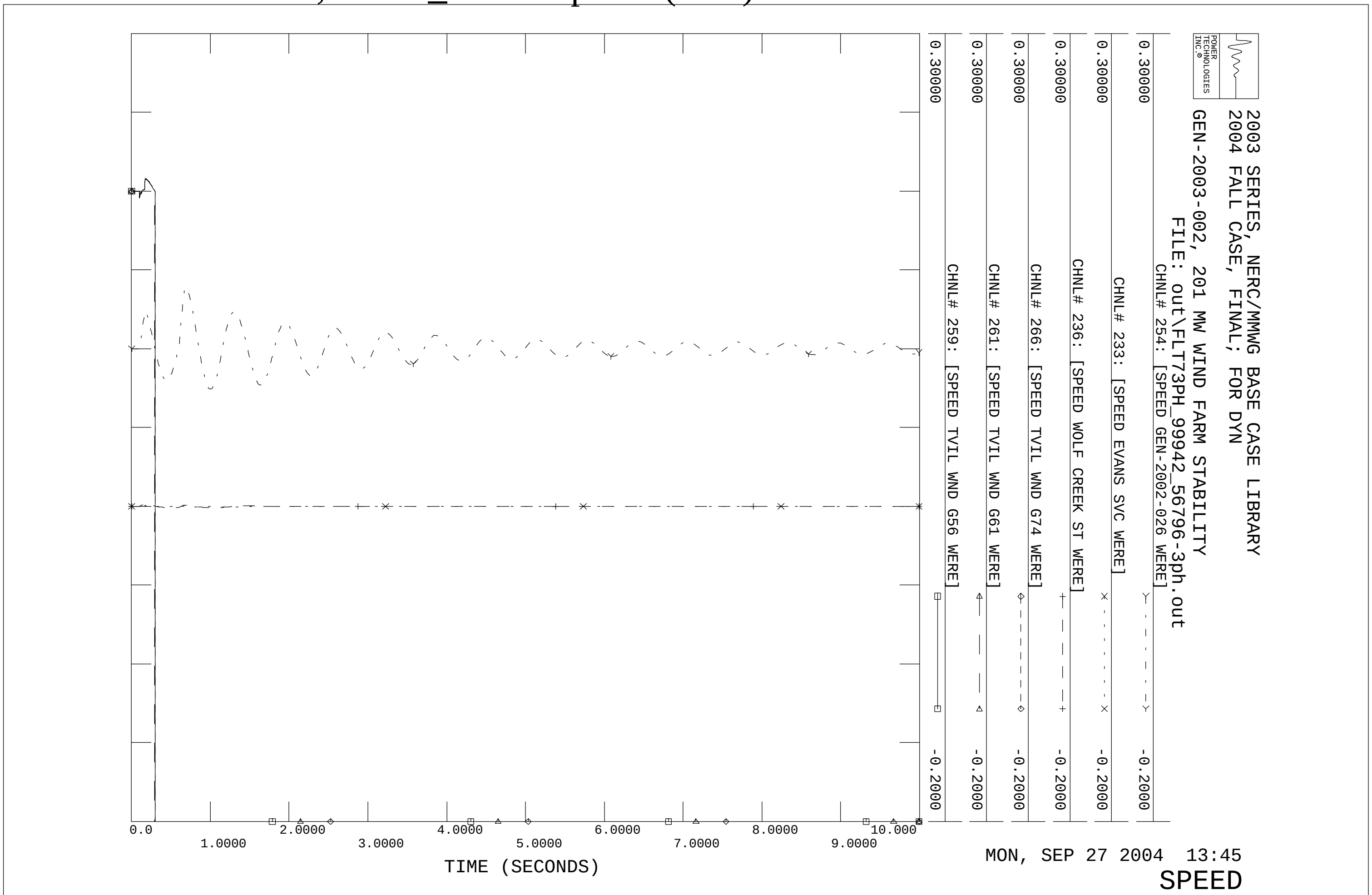
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND TURBINE VOLTAGE

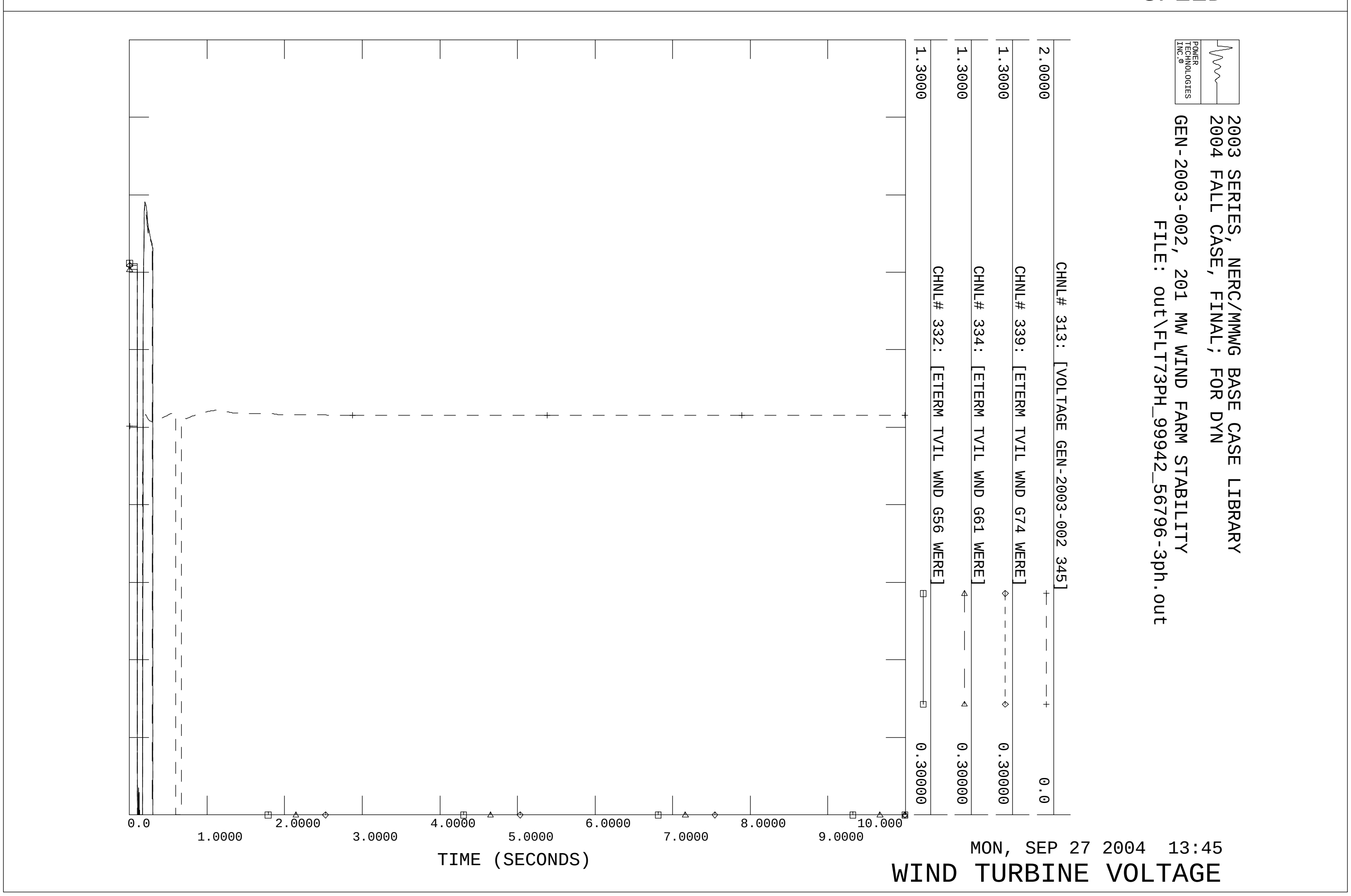
CASE ID: FLT73PH, 99942_56796-3ph (1 / 2)



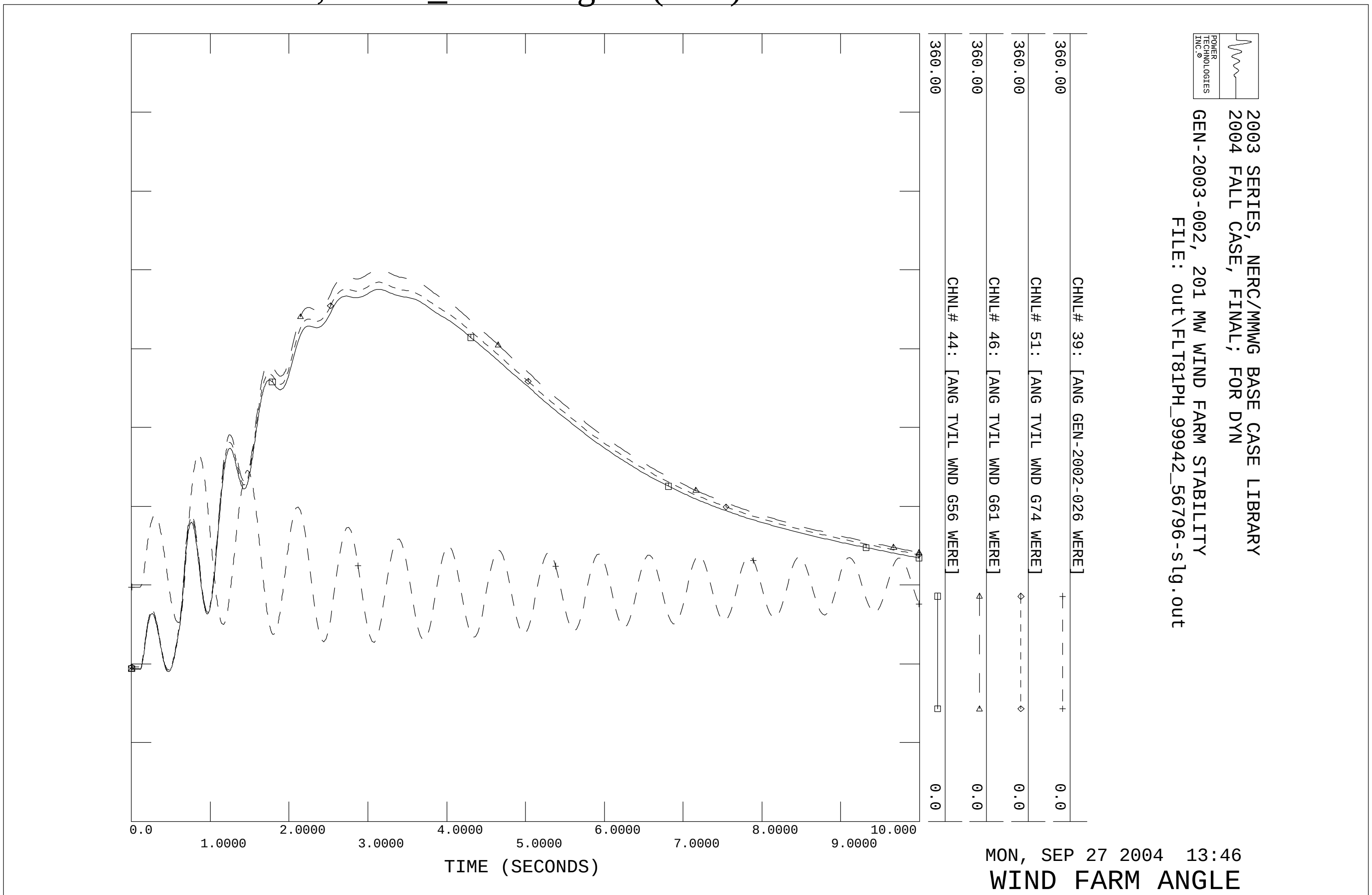


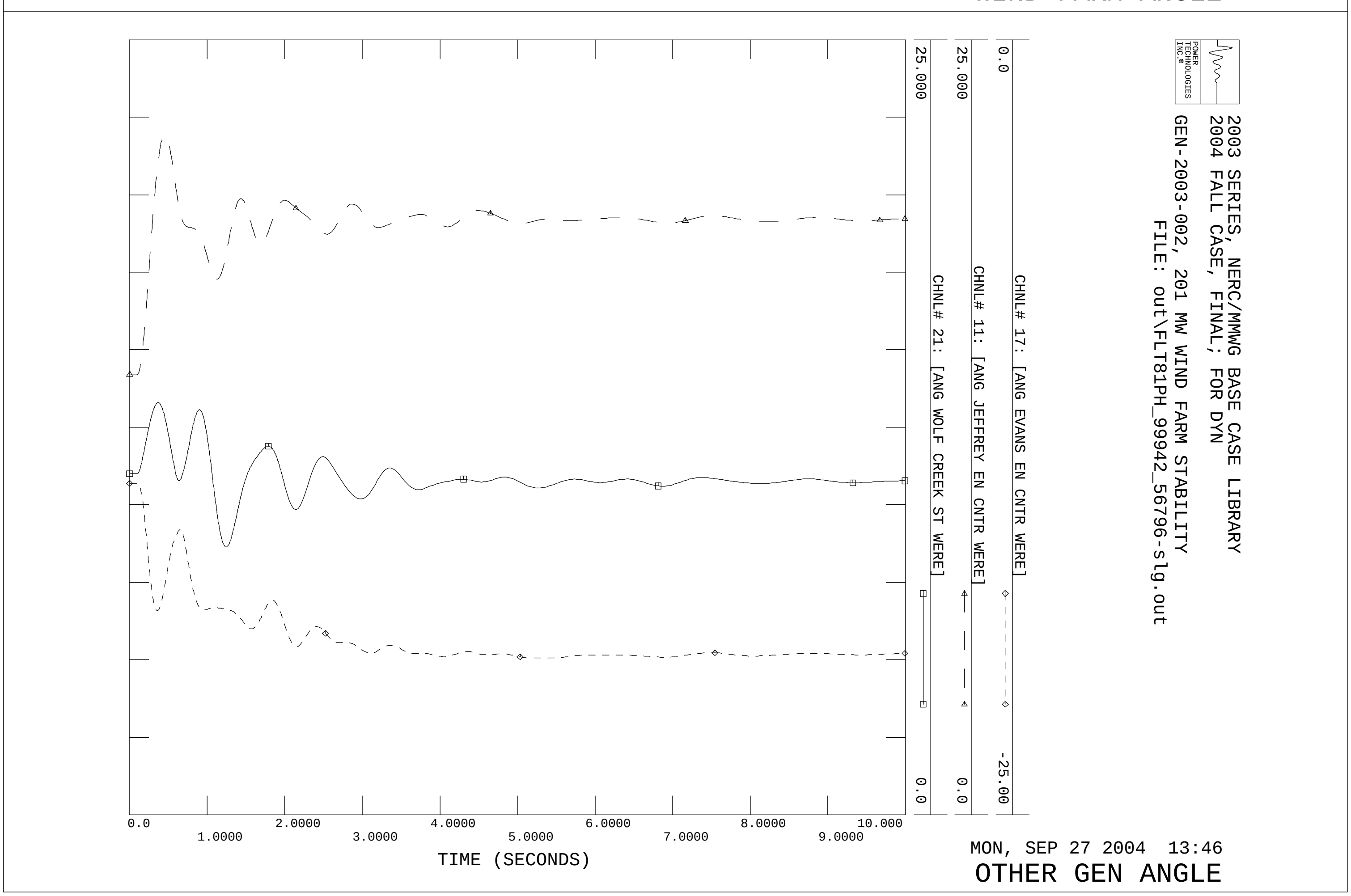
CASE ID: FLT73PH, 99942_56796-3ph (2 / 2)

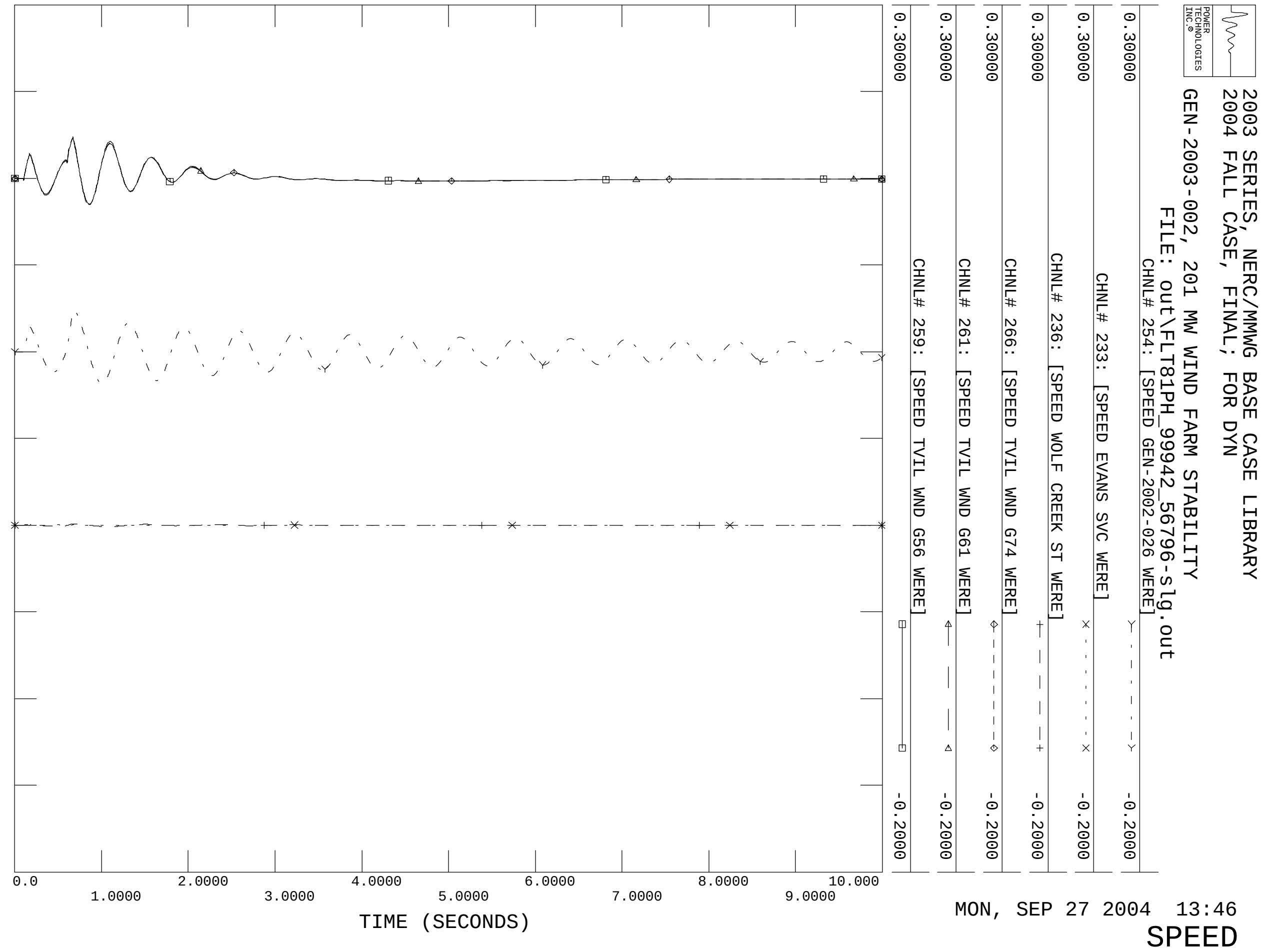




CASE ID: FLT81PH, 99942_56796-slg (1 / 2)






2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 233: [SPEED EVANS SVC WERE]
CHNL# 236: [SPEED WOLF CREEK ST WERE]
CHNL# 266: [SPEED TVIL WND G74 WERE]
CHNL# 261: [SPEED TVIL WND G61 WERE]
CHNL# 259: [SPEED TVIL WND G56 WERE]
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-0.2000
0.0
1.0000
2.0000
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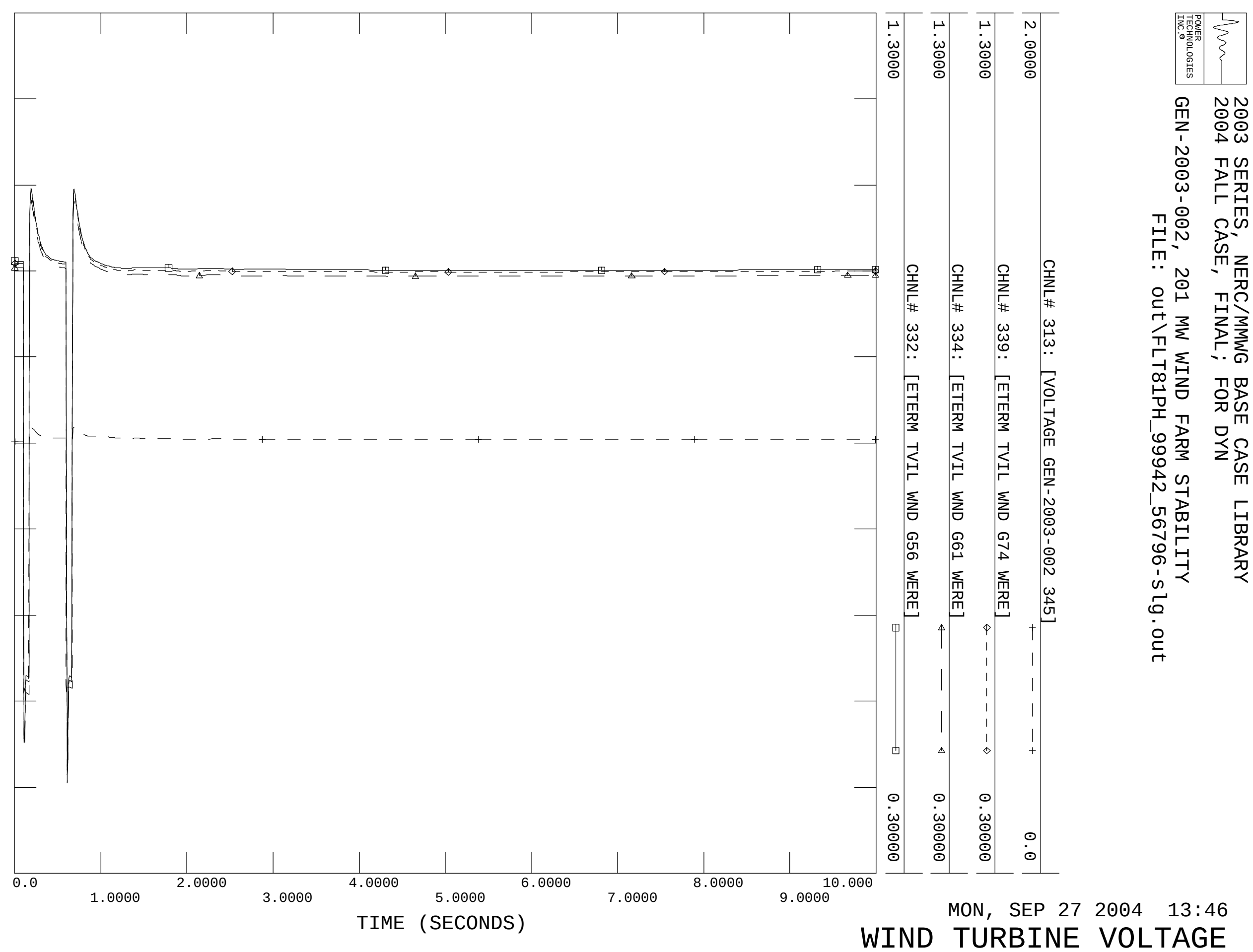
TIME (SECONDS)
MON, SEP 27 2004 13:46
SPEED


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT81PH_99942_56796-slg.out
CHNL# 313: [VOLTAGE GEN-2003-002 345]
CHNL# 339: [ETERM TVIL WND G74 WERE]
CHNL# 334: [ETERM TVIL WND G61 WERE]
CHNL# 332: [ETERM TVIL WND G56 WERE]
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0.0
1.3000
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0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
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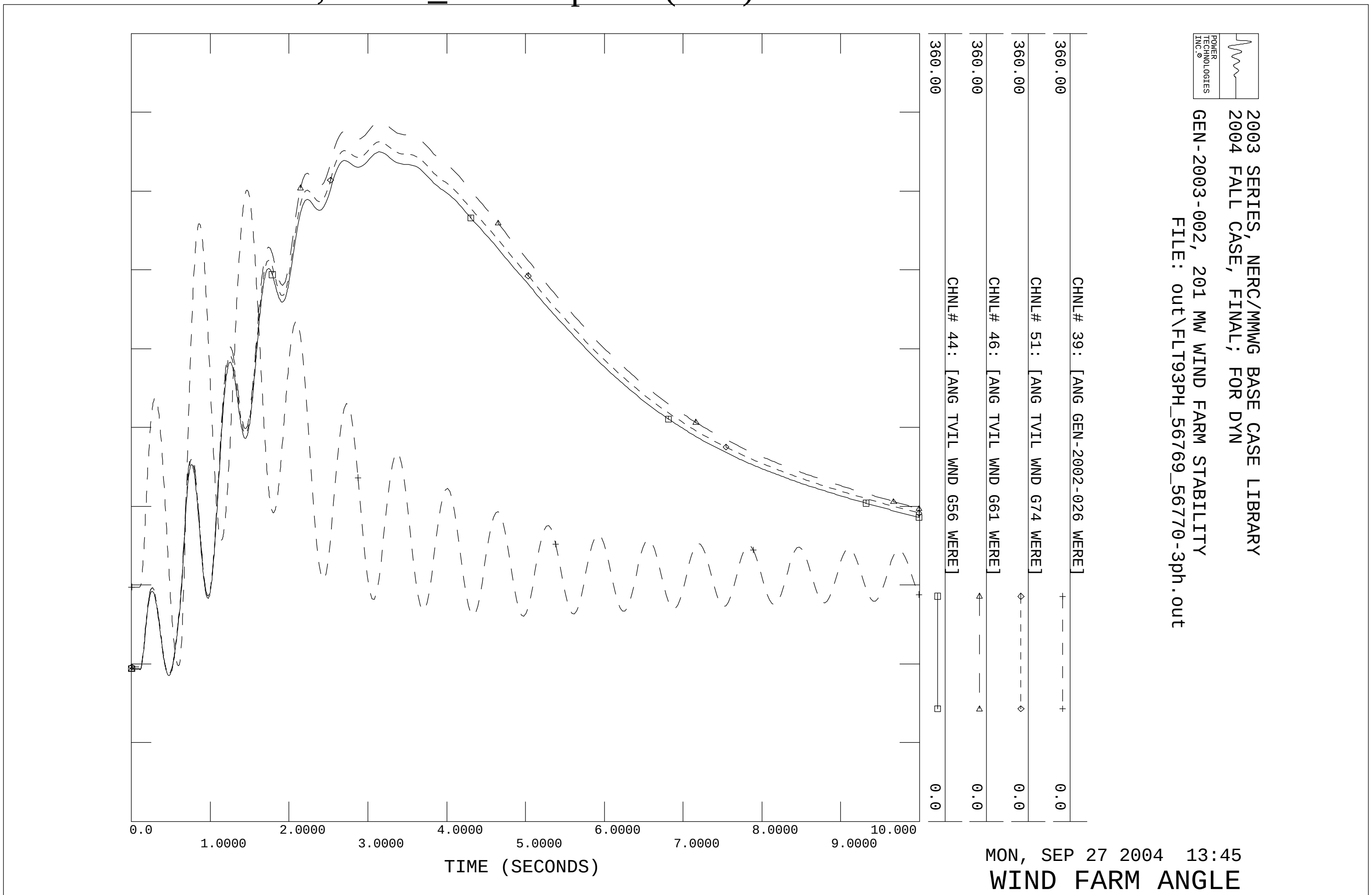
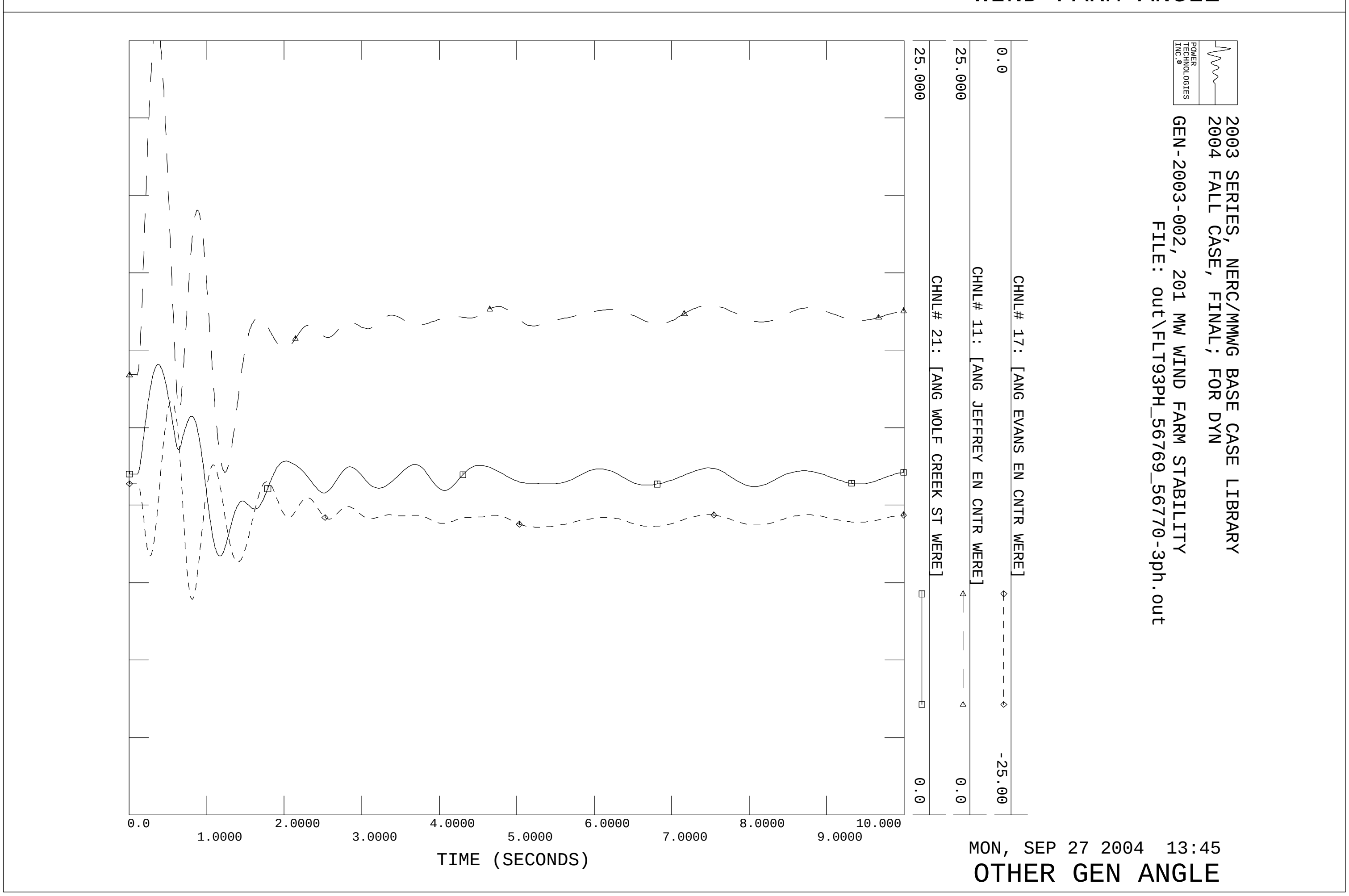
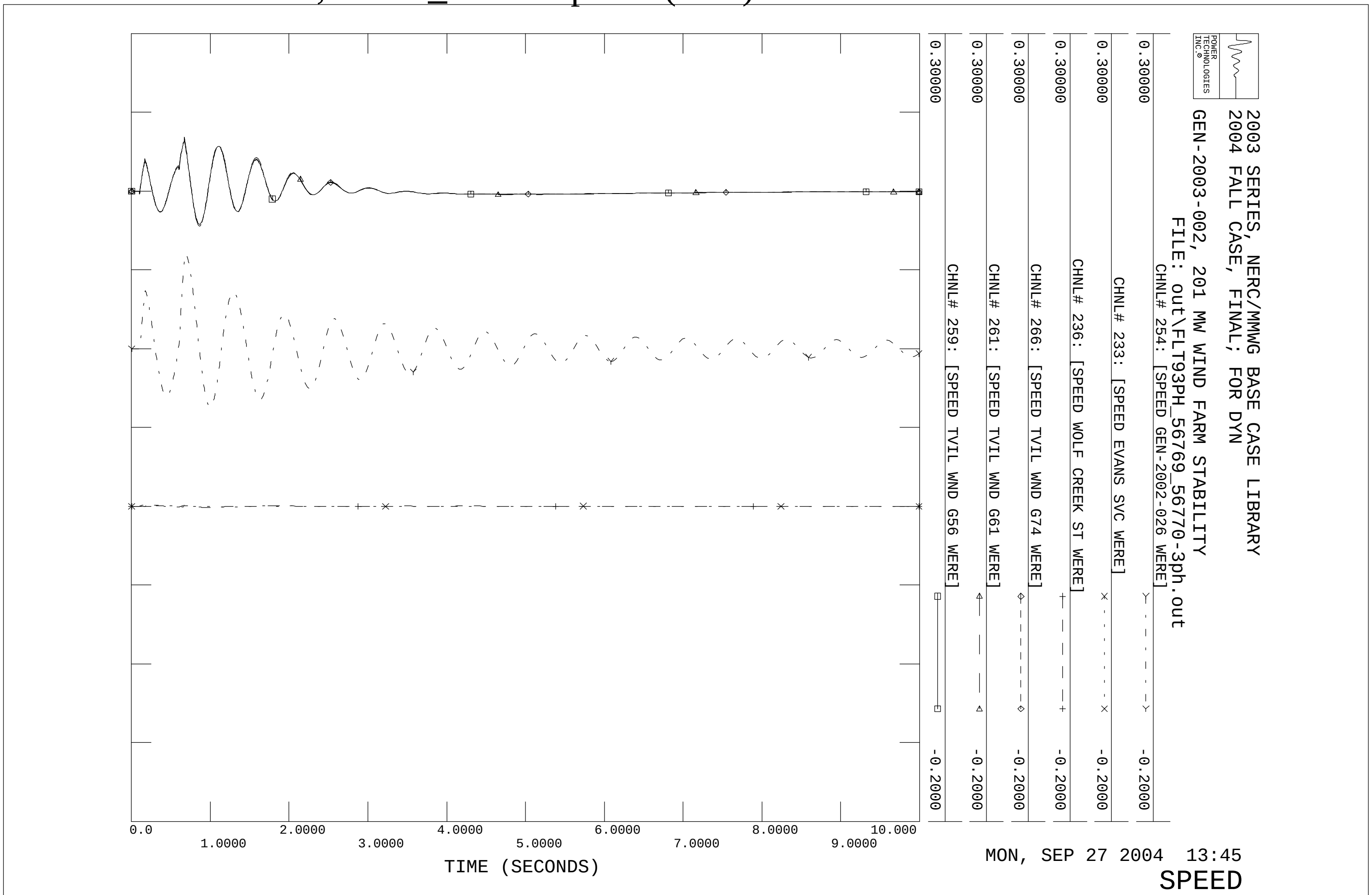
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND TURBINE VOLTAGE

CASE ID: FLT93PH, 56769_56770-3ph (1 / 2)






2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 233: [SPEED EVANS SVC WERE]
CHNL# 236: [SPEED WOLF CREEK ST WERE]
CHNL# 266: [SPEED TVIL WND G74 WERE]
CHNL# 261: [SPEED TVIL WND G61 WERE]
CHNL# 259: [SPEED TVIL WND G56 WERE]
0.30000
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0.0
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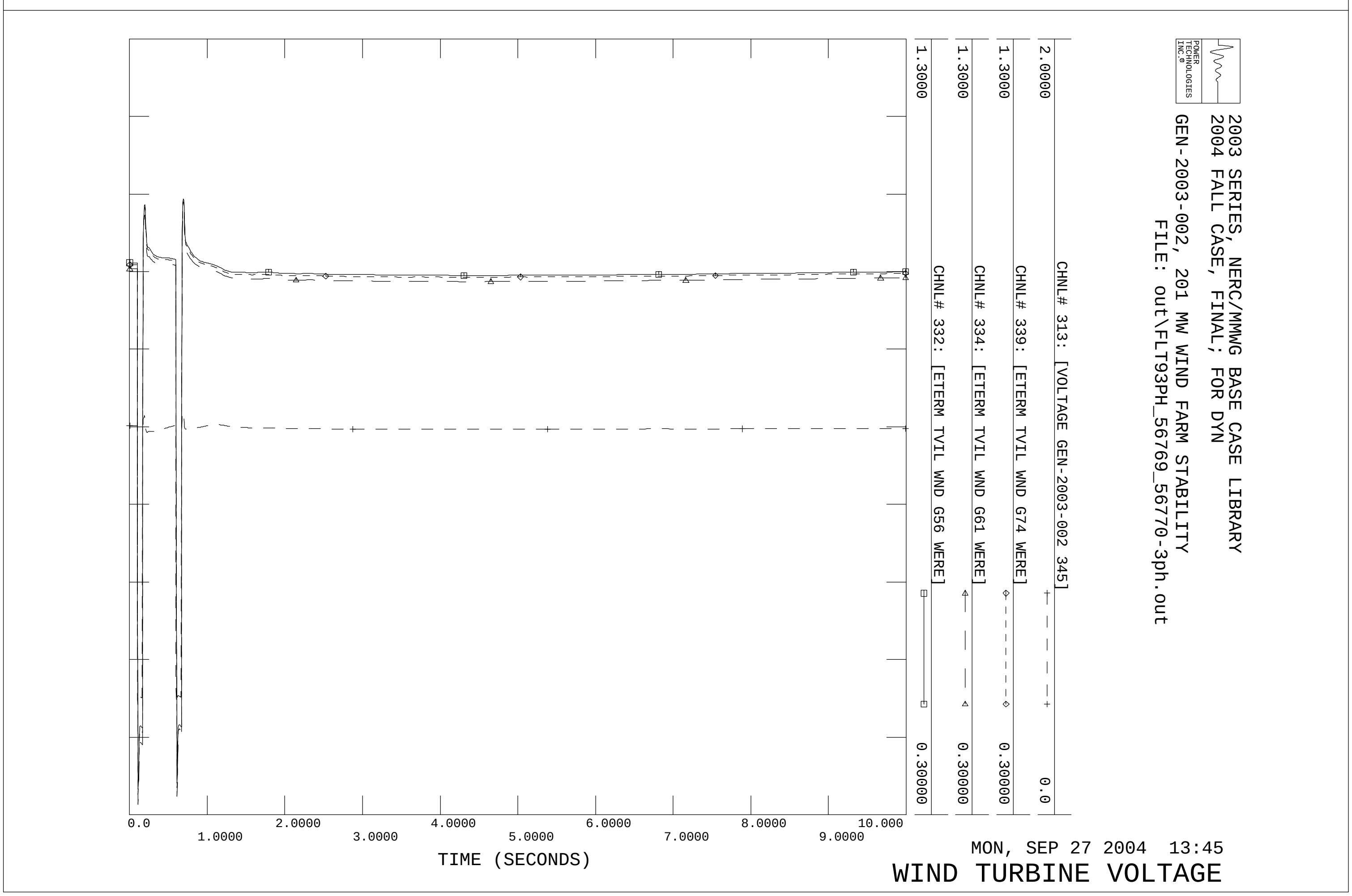
TIME (SECONDS)
MON, SEP 27 2004 13:45
SPEED


2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
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CHNL# 339: [ETERM TVIL WND G74 WERE]
CHNL# 334: [ETERM TVIL WND G61 WERE]
CHNL# 332: [ETERM TVIL WND G56 WERE]
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1.3000
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2.0000
3.0000
4.0000
5.0000
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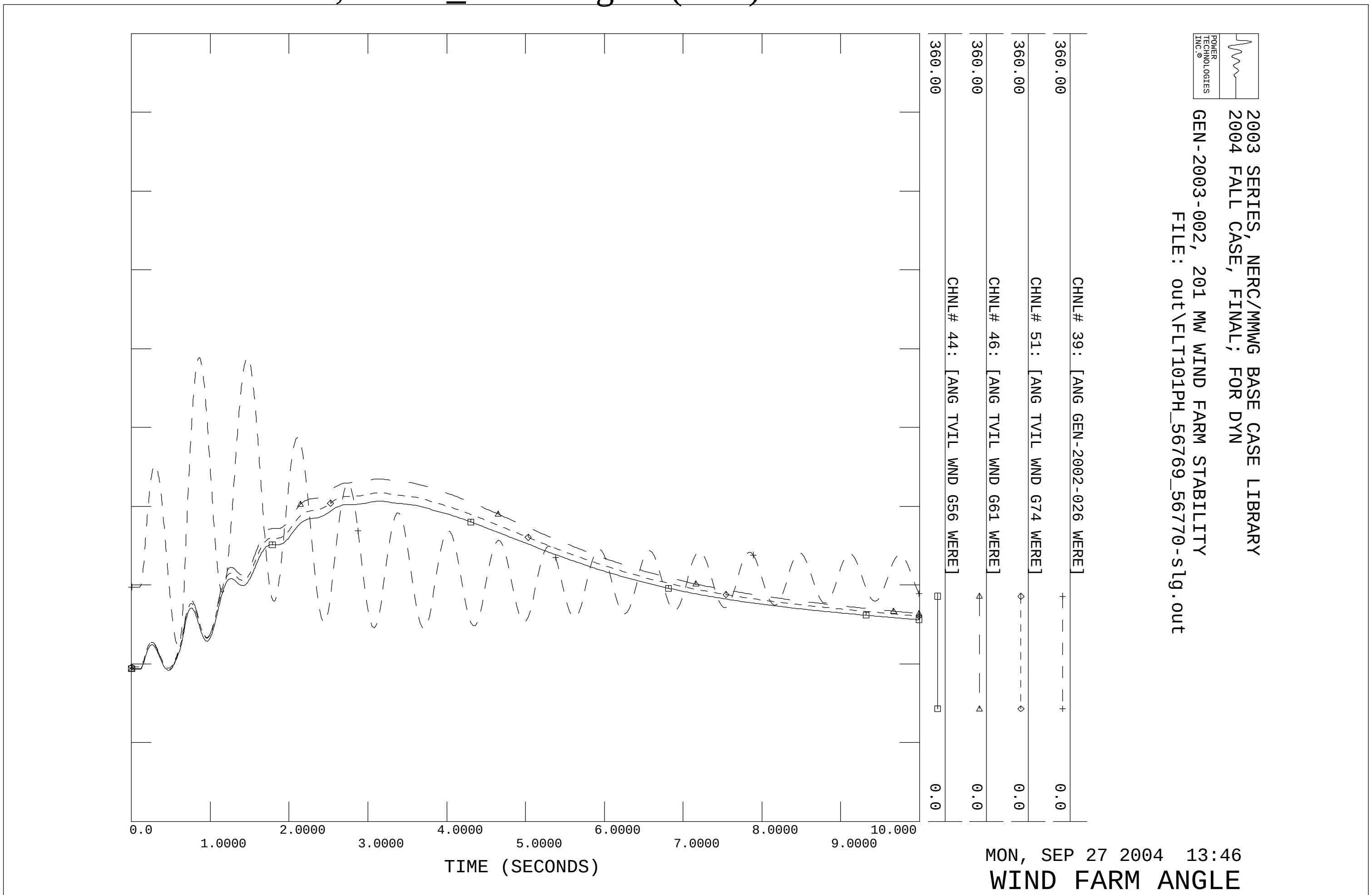
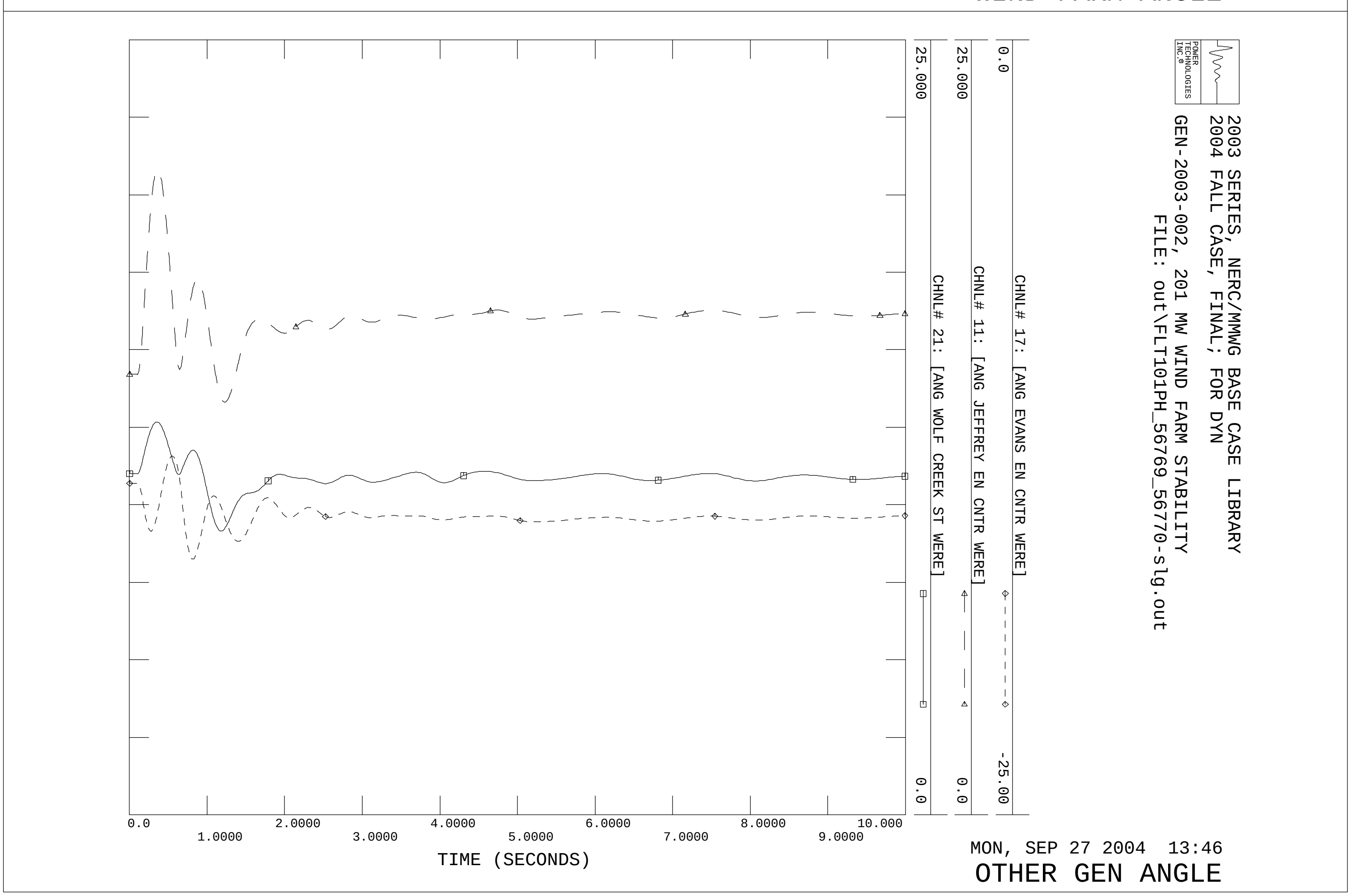
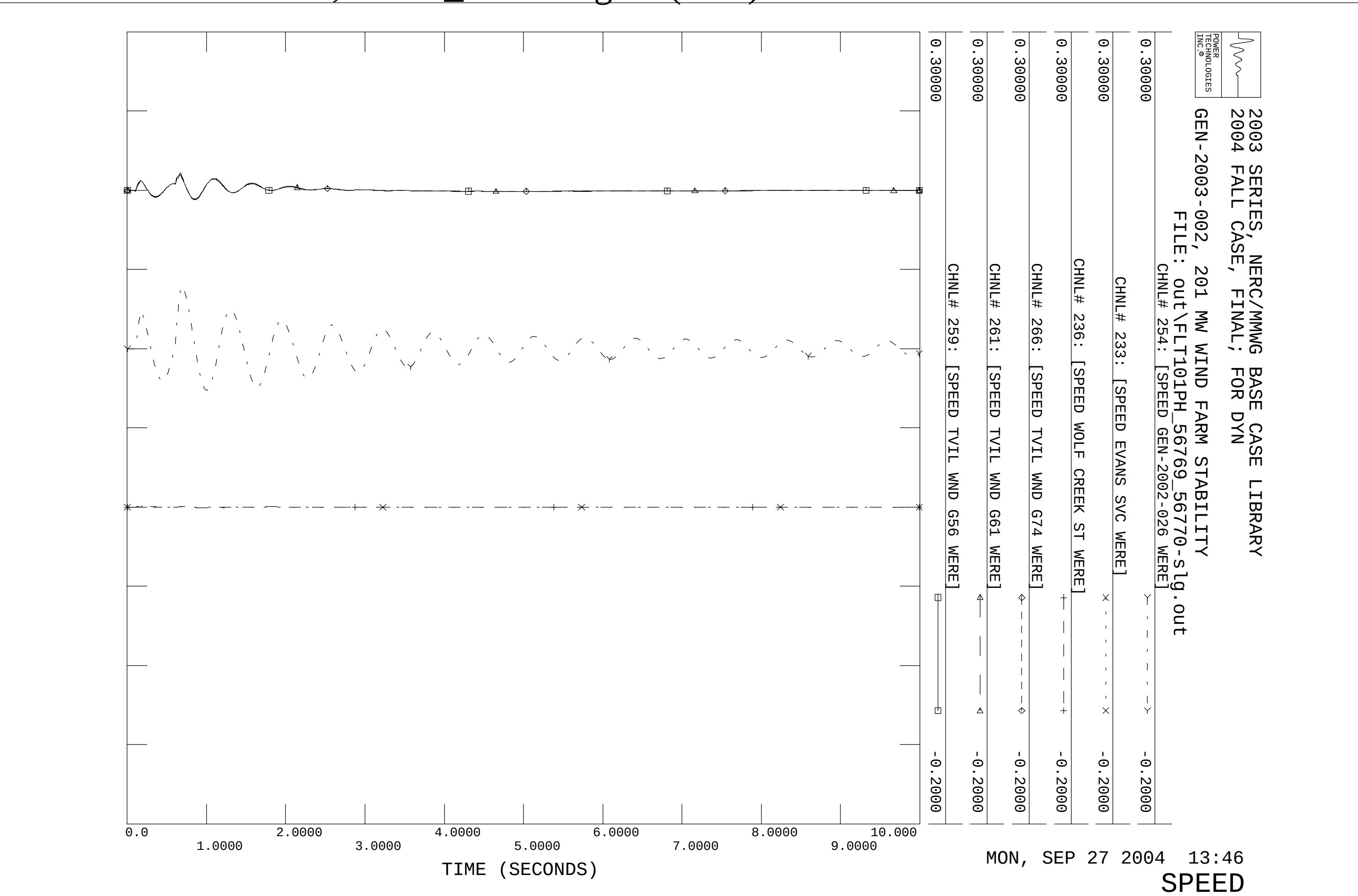
8.0000
9.0000
10.000
TIME (SECONDS)
MON, SEP 27 2004 13:45
WIND TURBINE VOLTAGE

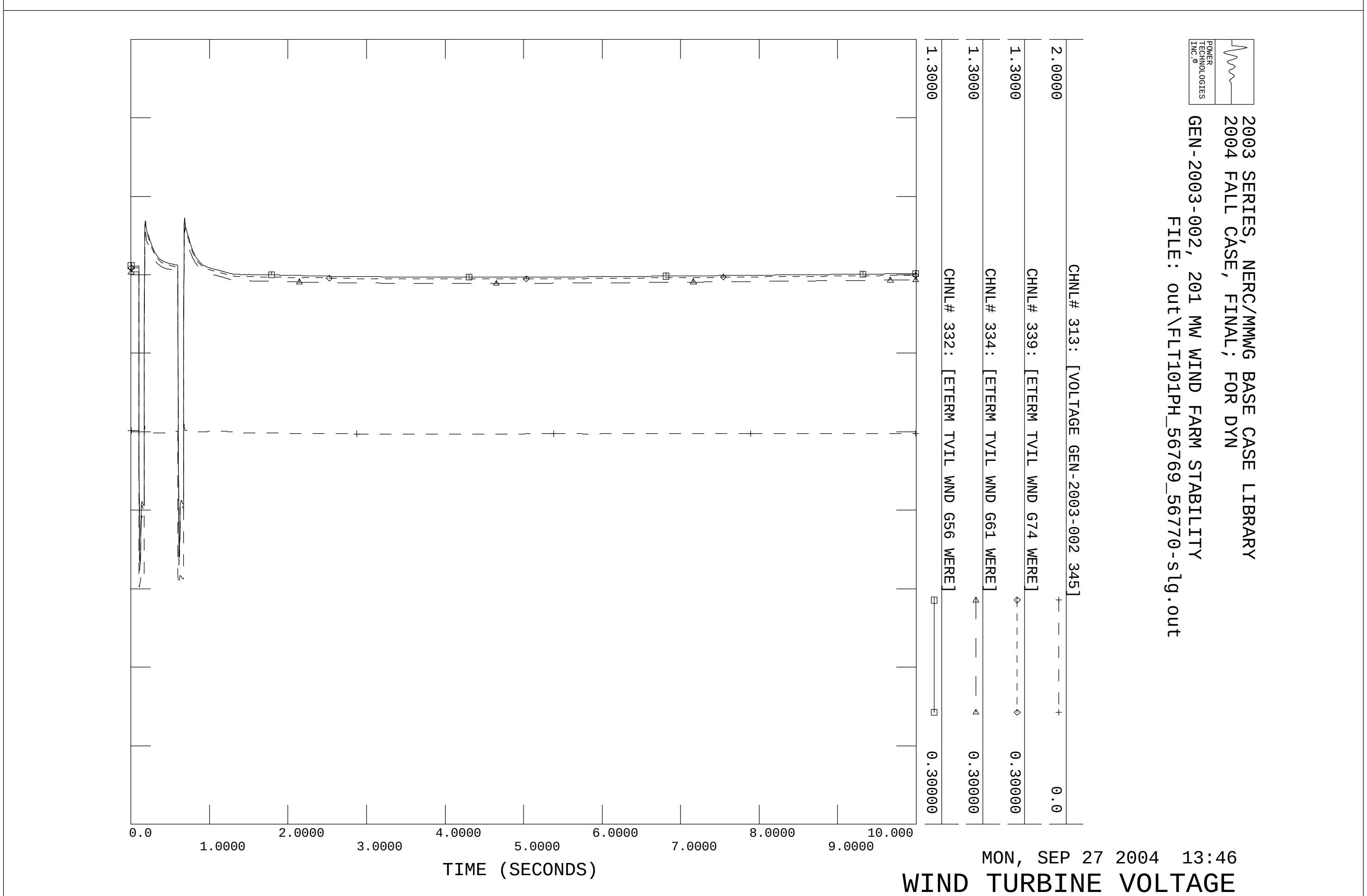
CASE ID: FLT101PH, 56769_56770-slg (1 / 2)



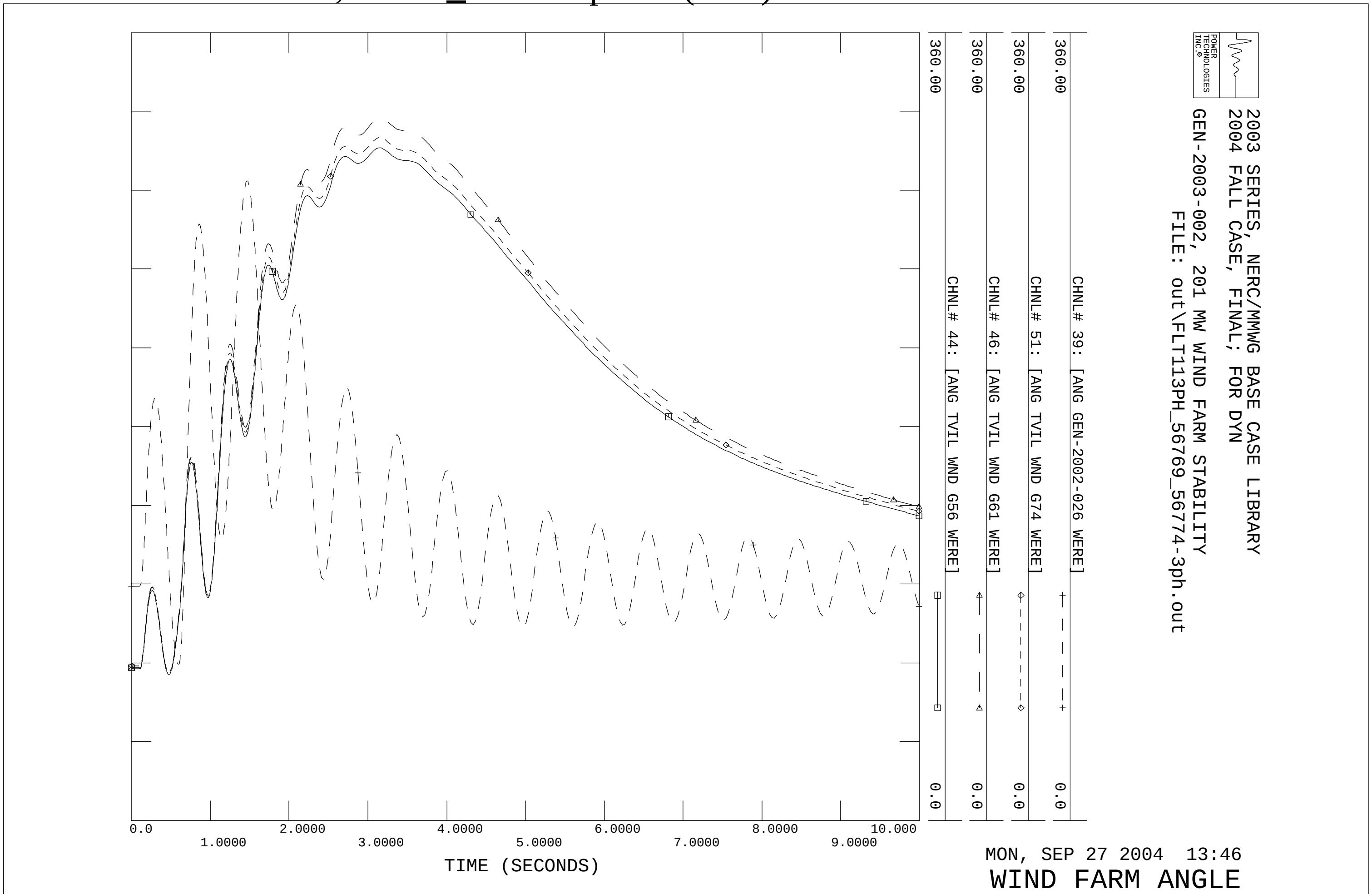


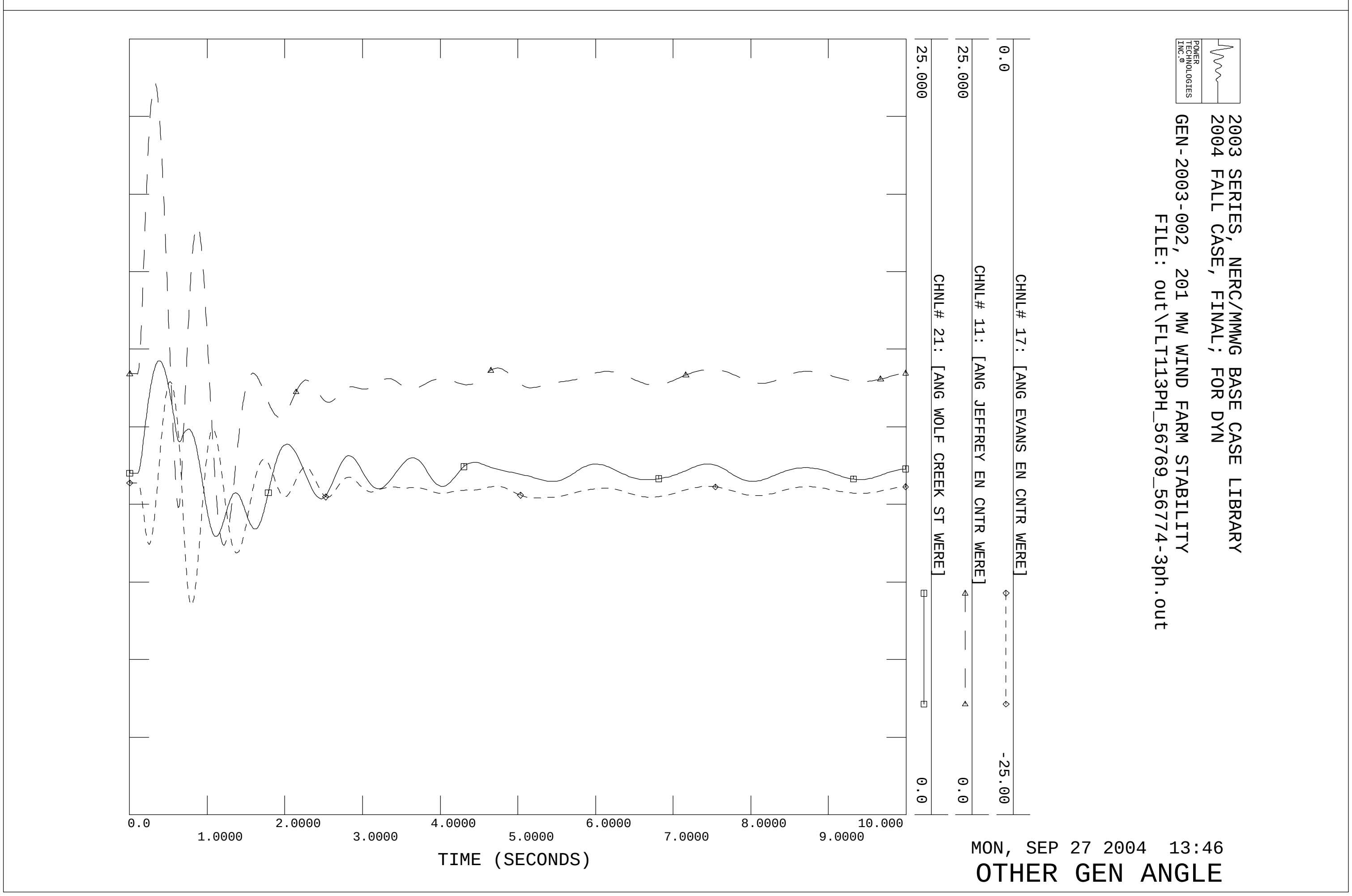
CASE ID: FLT101PH, 56769_56770-slg (2 / 2)



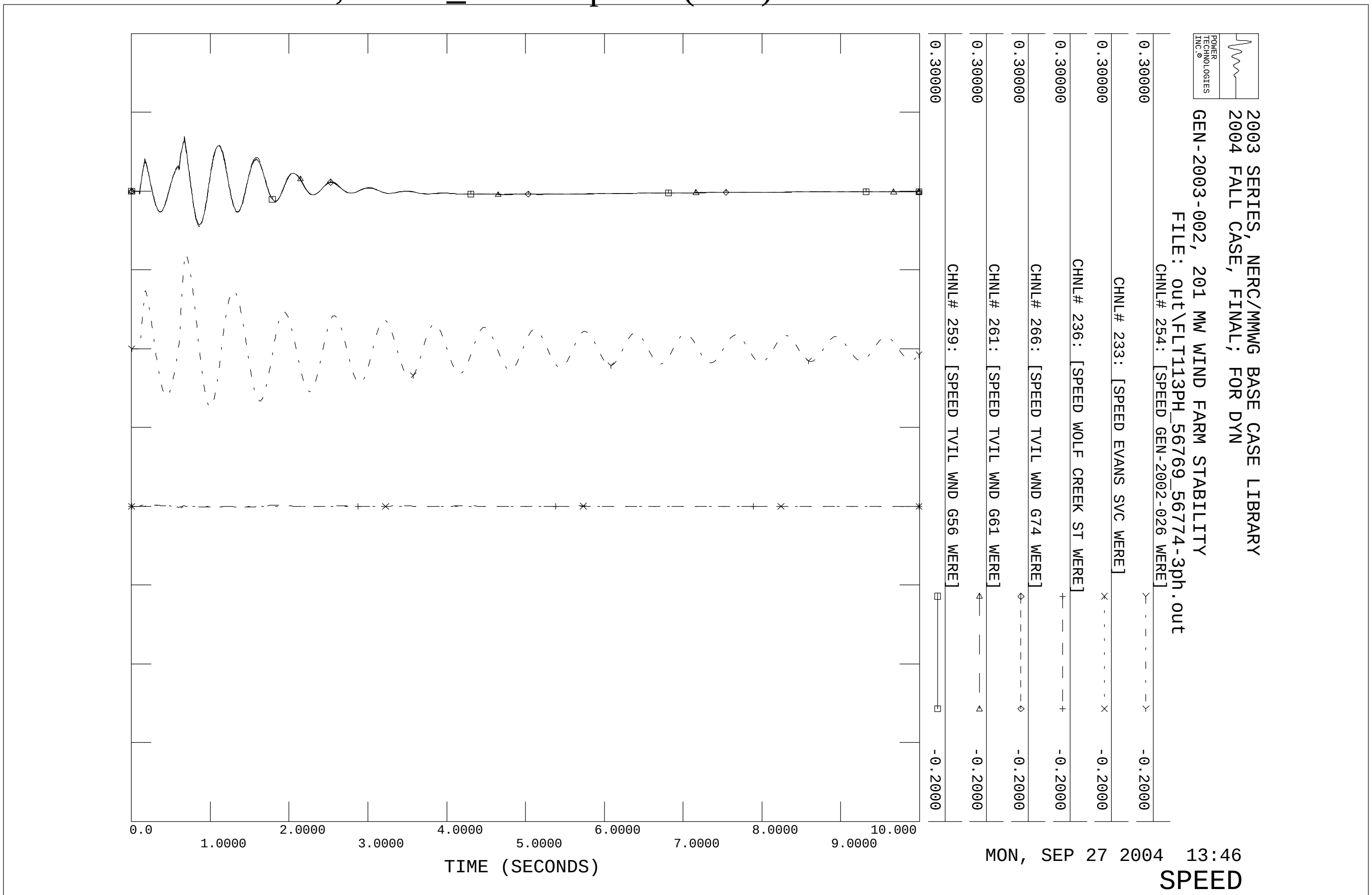


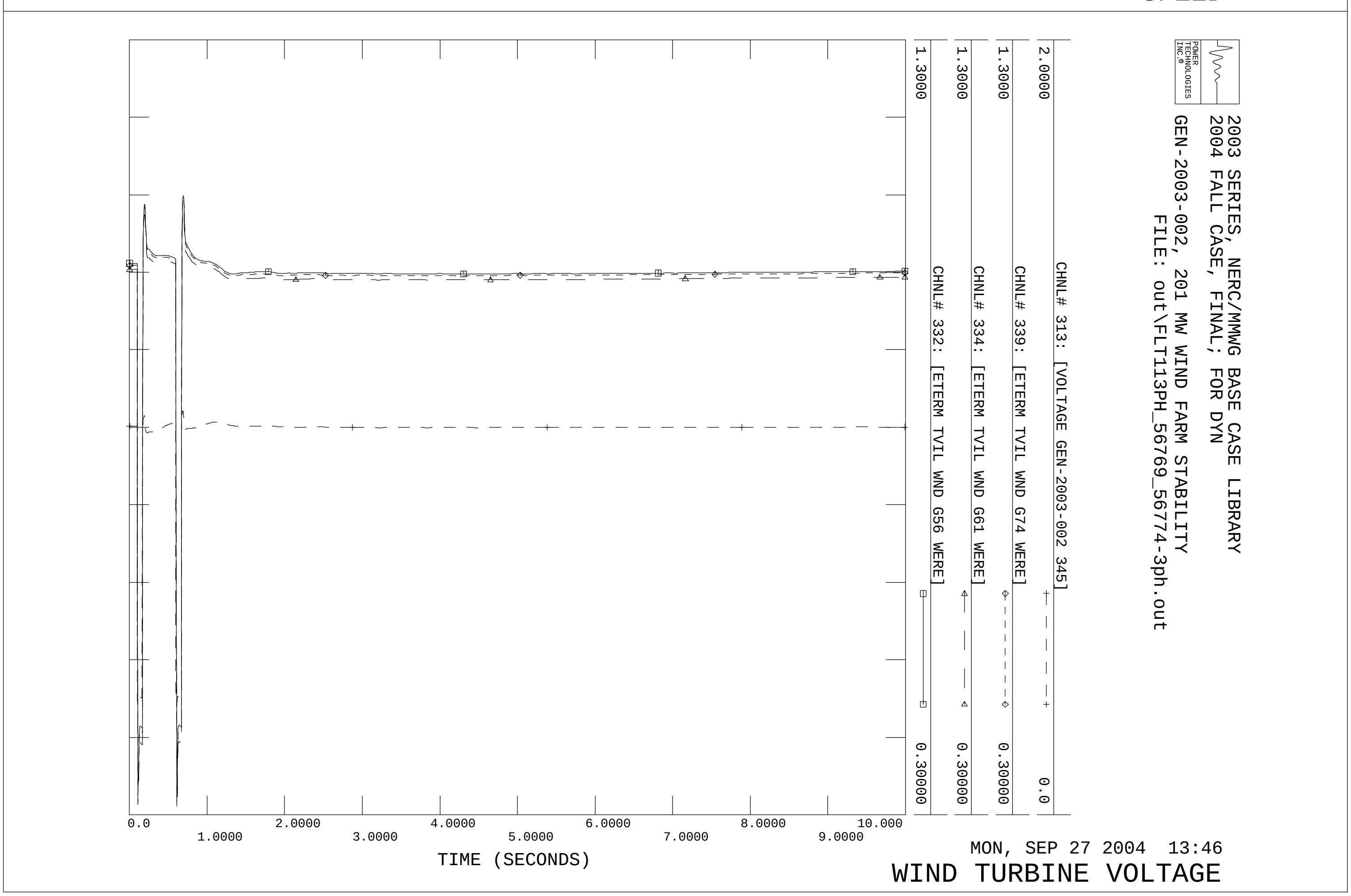
CASE ID: FLT113PH, 56769_56774-3ph (1 / 2)



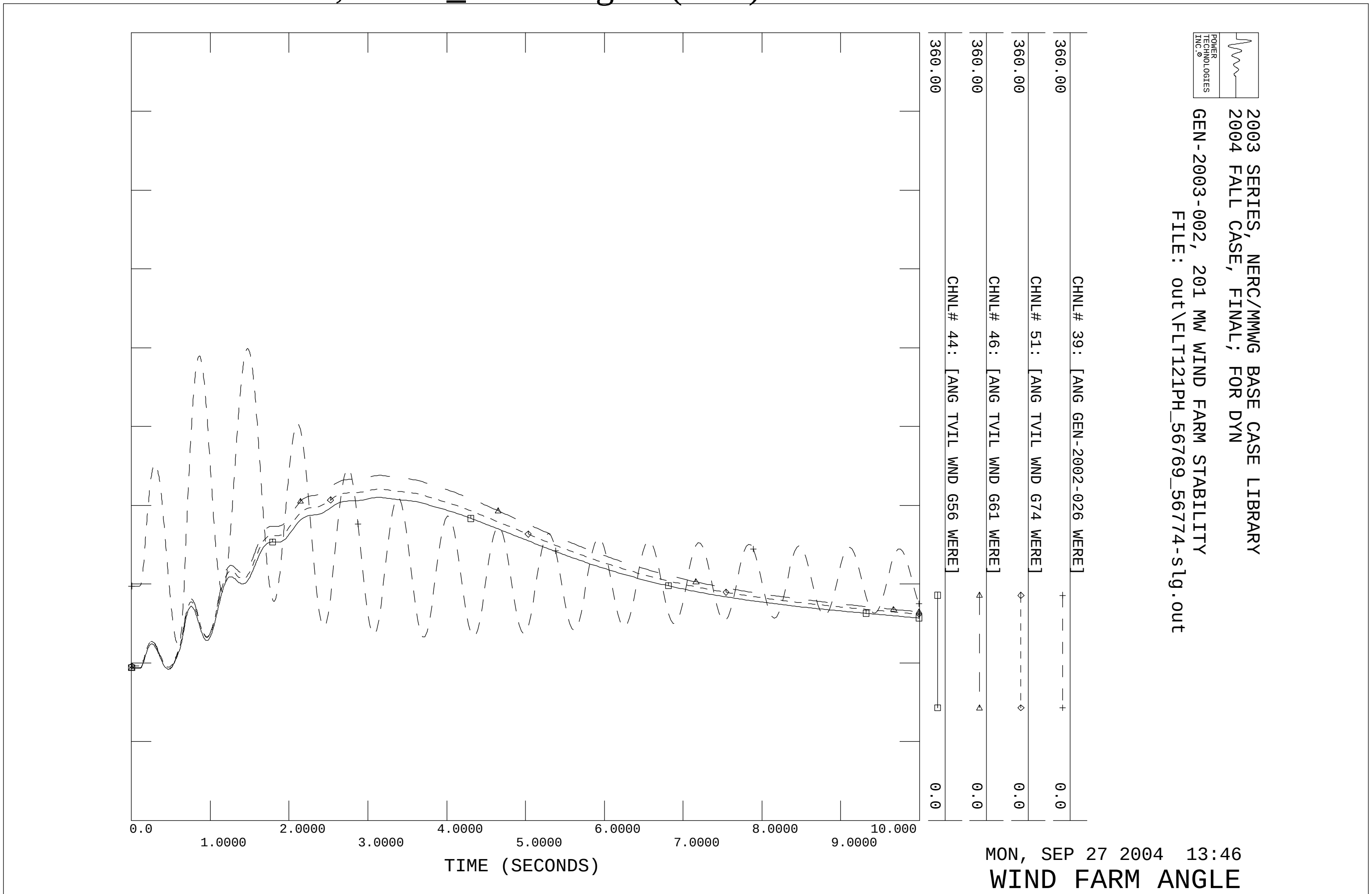


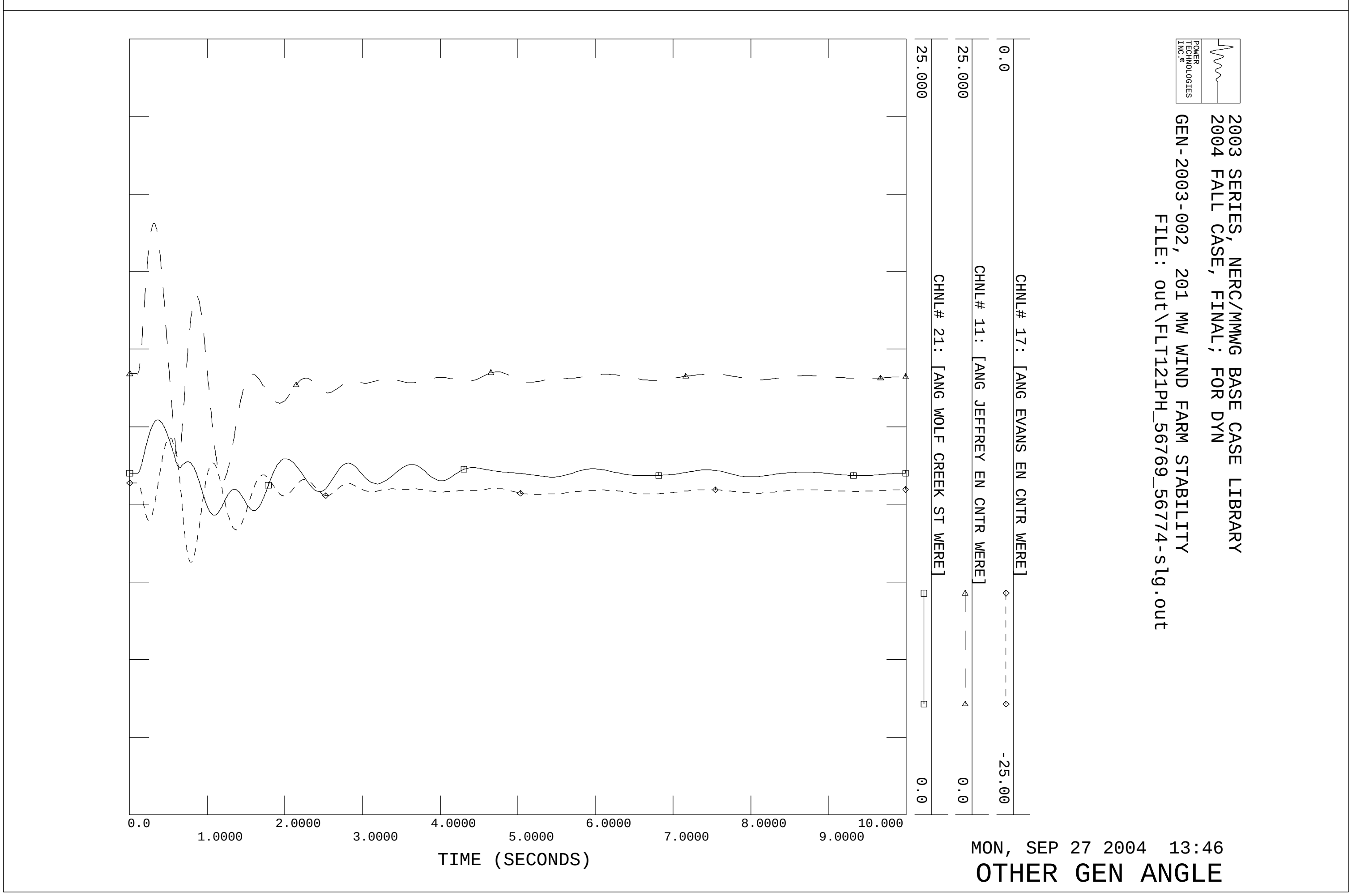
CASE ID: FLT113PH, 56769_56774-3ph (2 / 2)



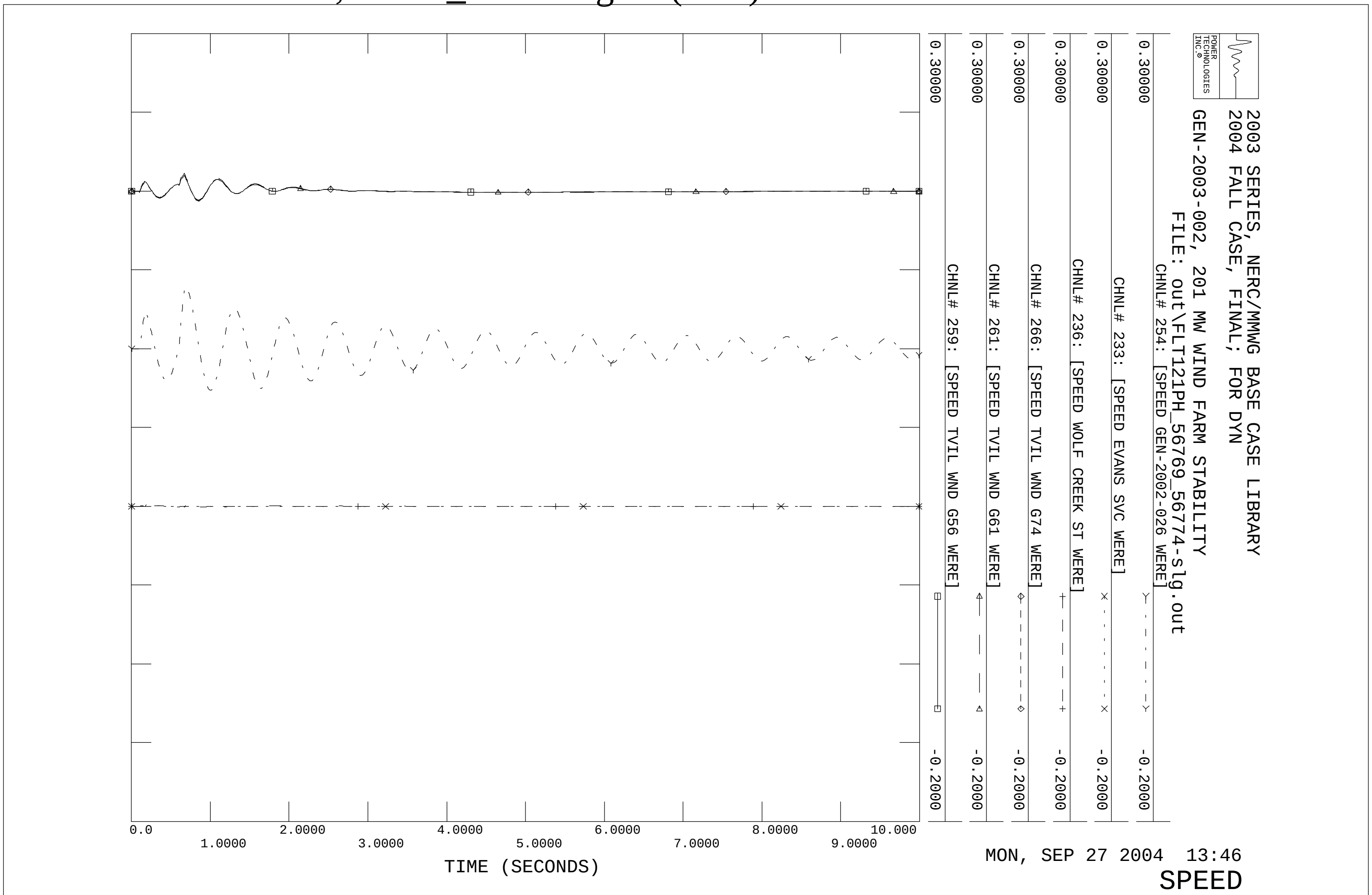


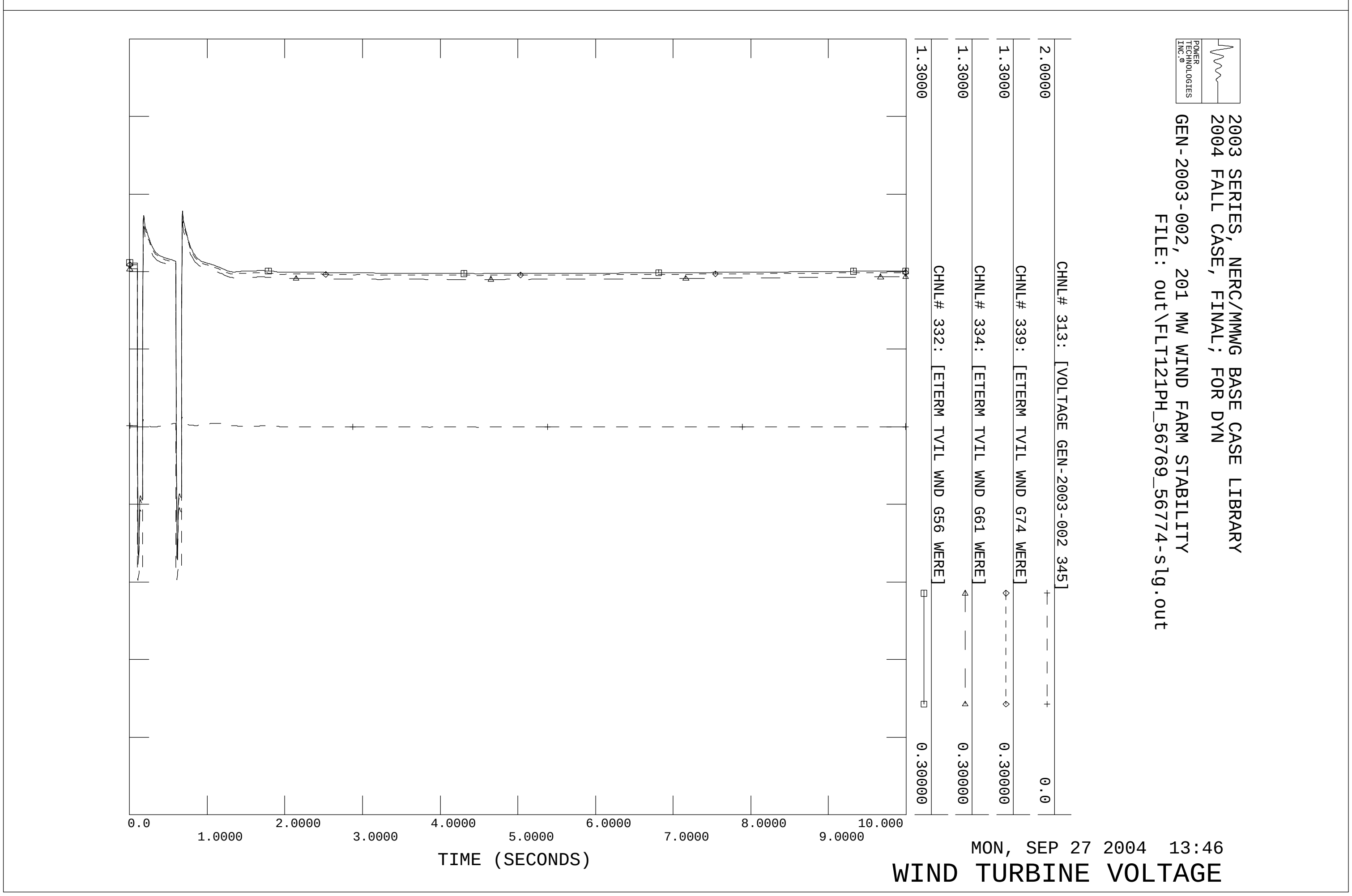
CASE ID: FLT121PH, 56769_56774-slg (1 / 2)



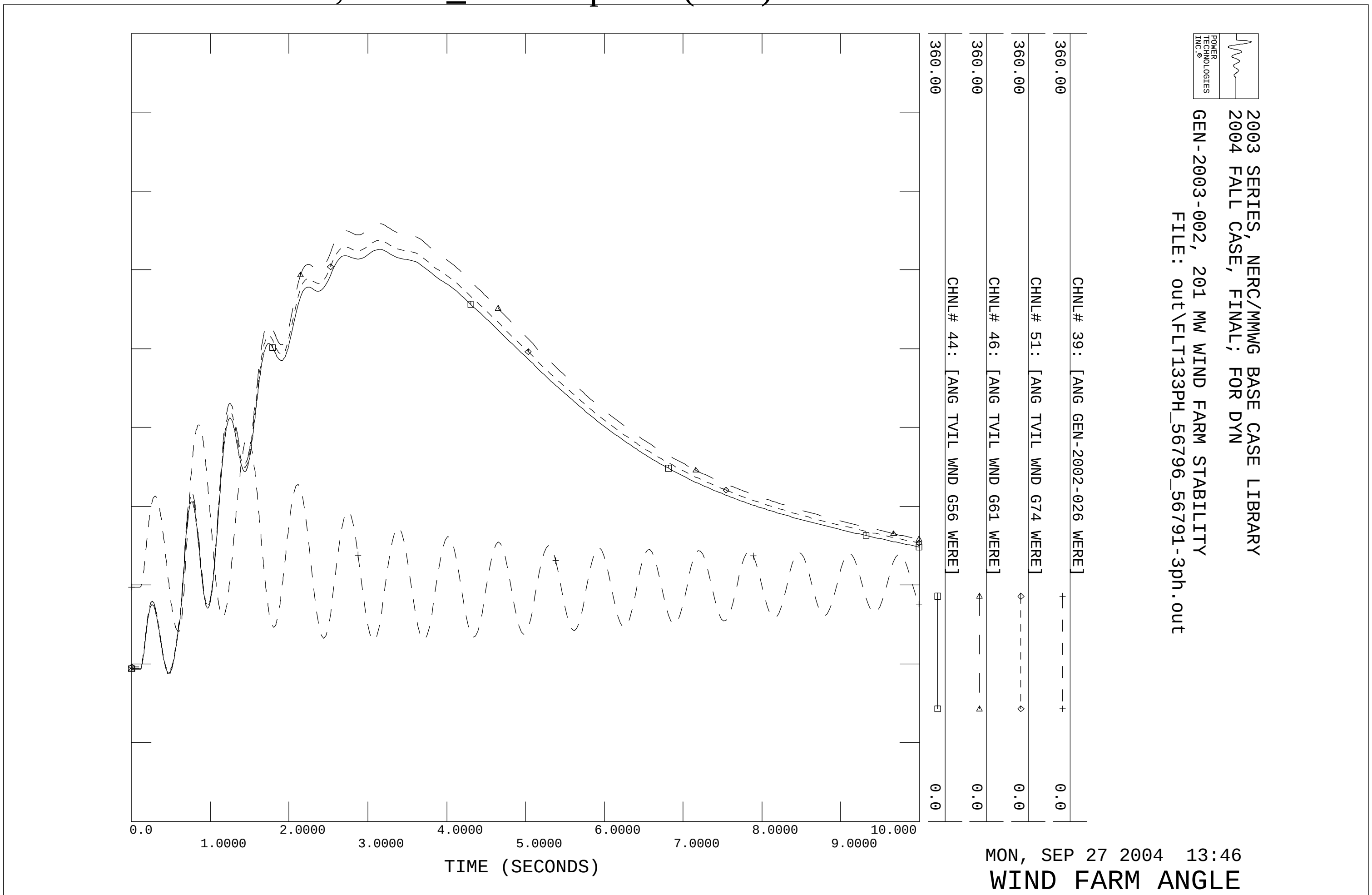


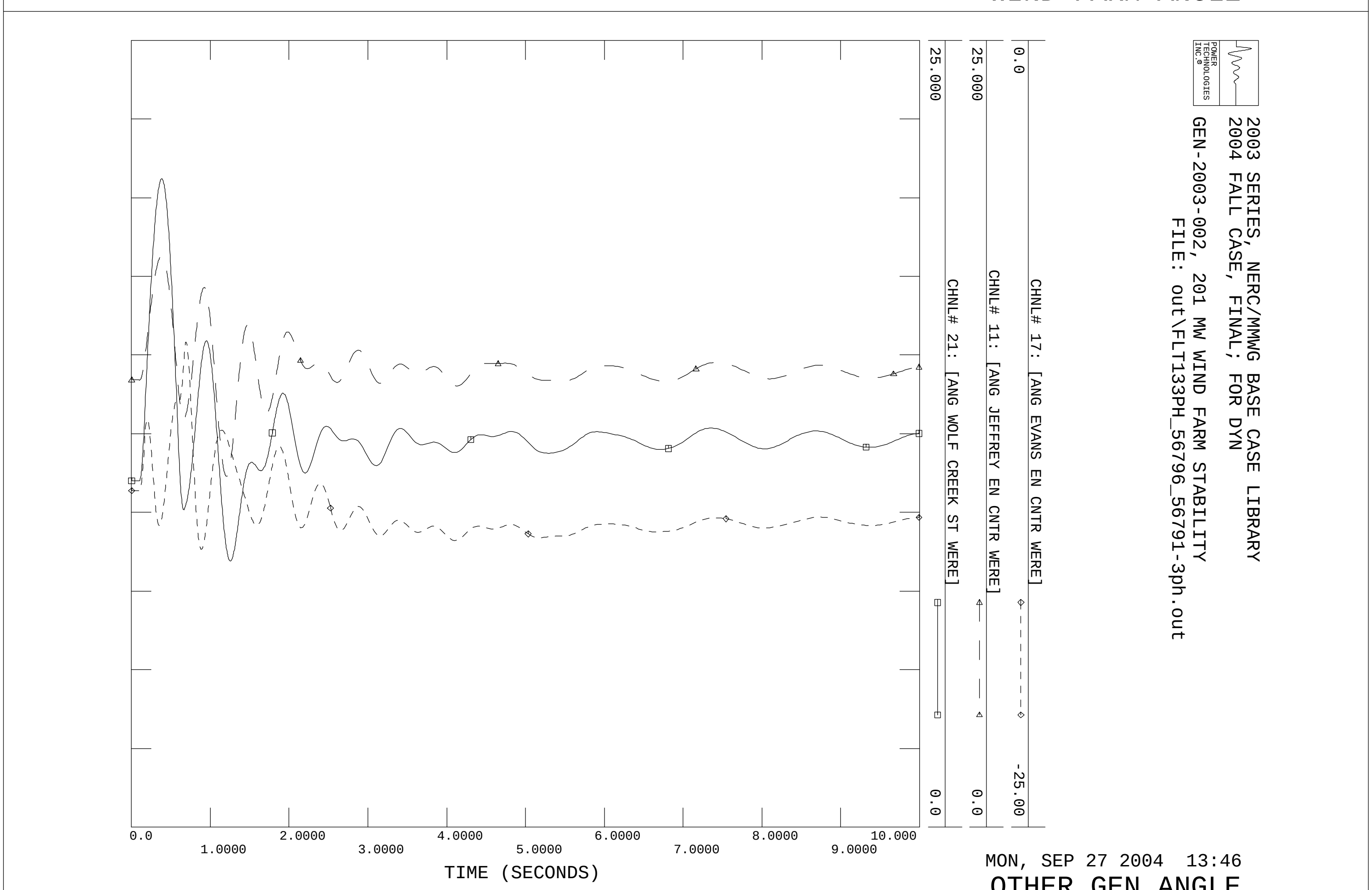
CASE ID: FLT121PH, 56769_56774-slg (2 / 2)



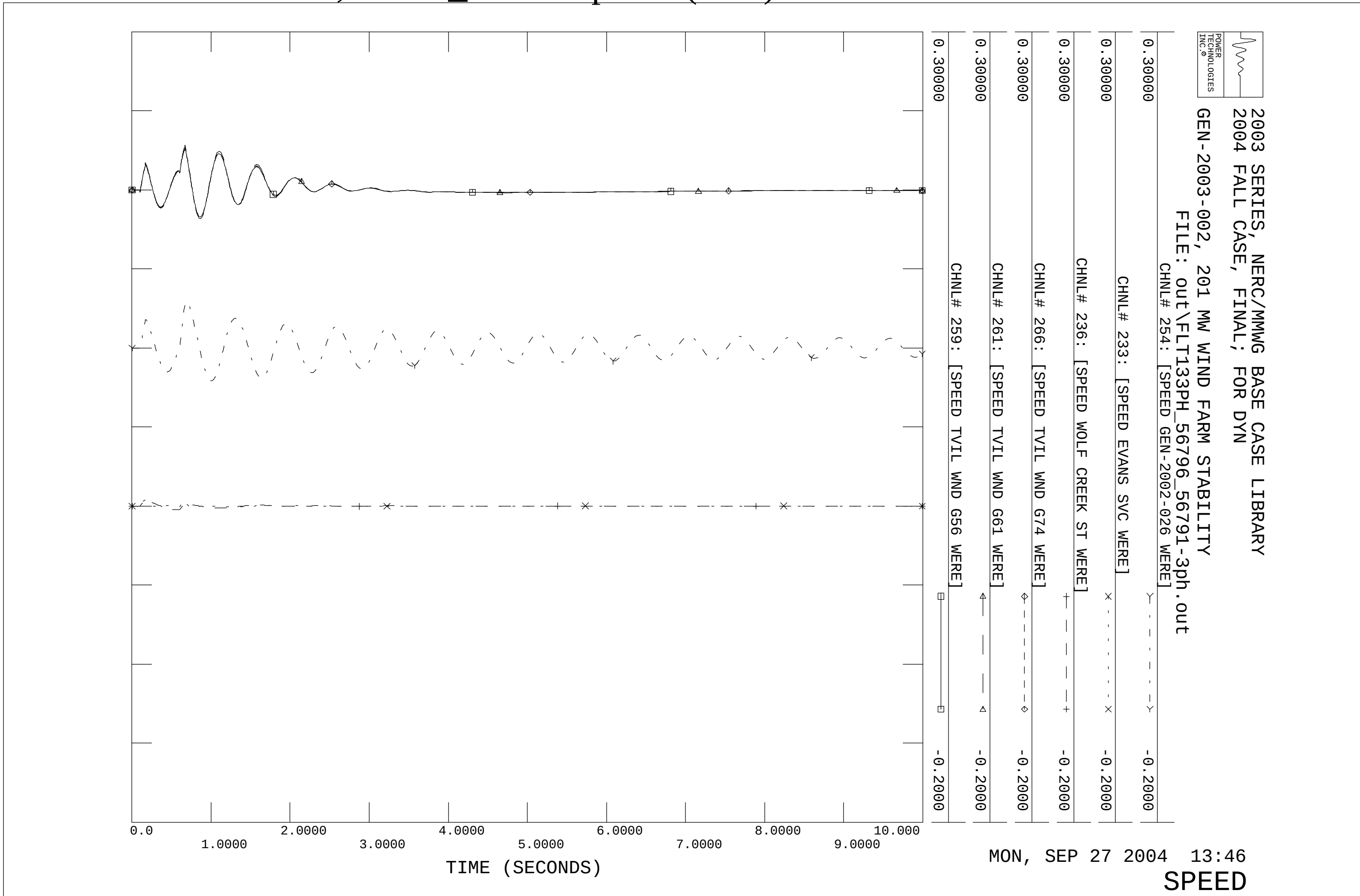


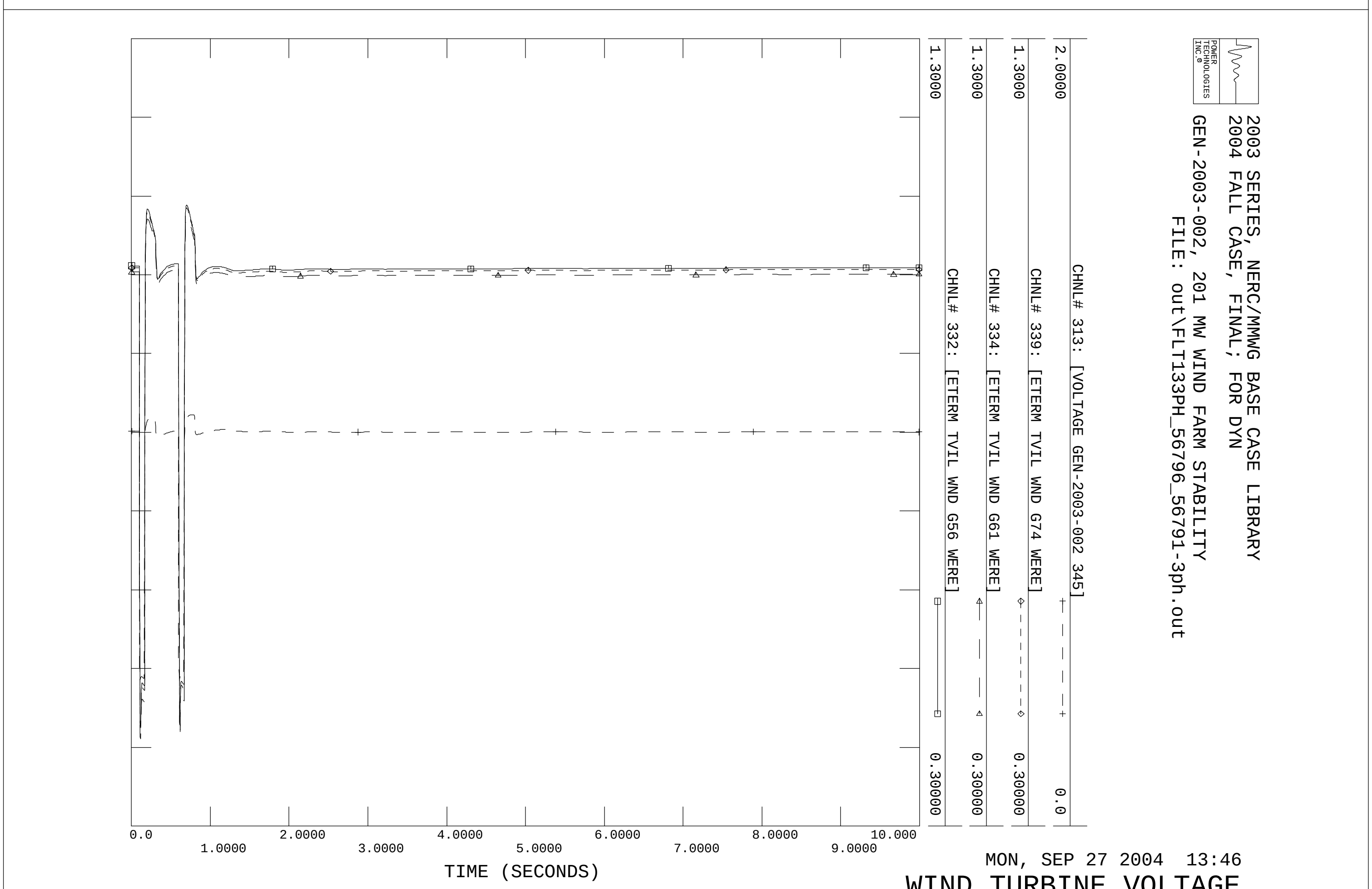
CASE ID: FLT133PH, 56796_56791-3ph (1 / 2)



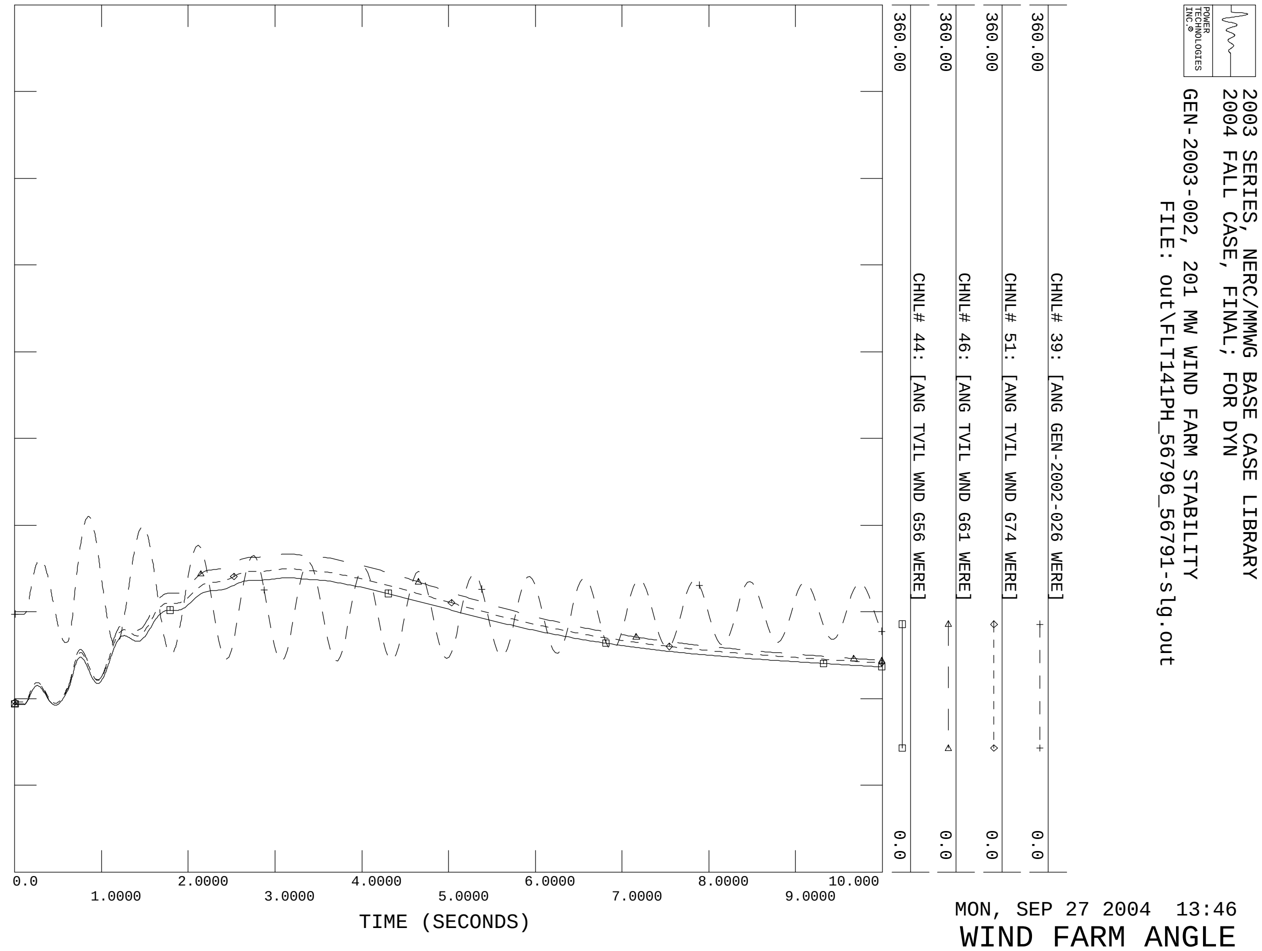


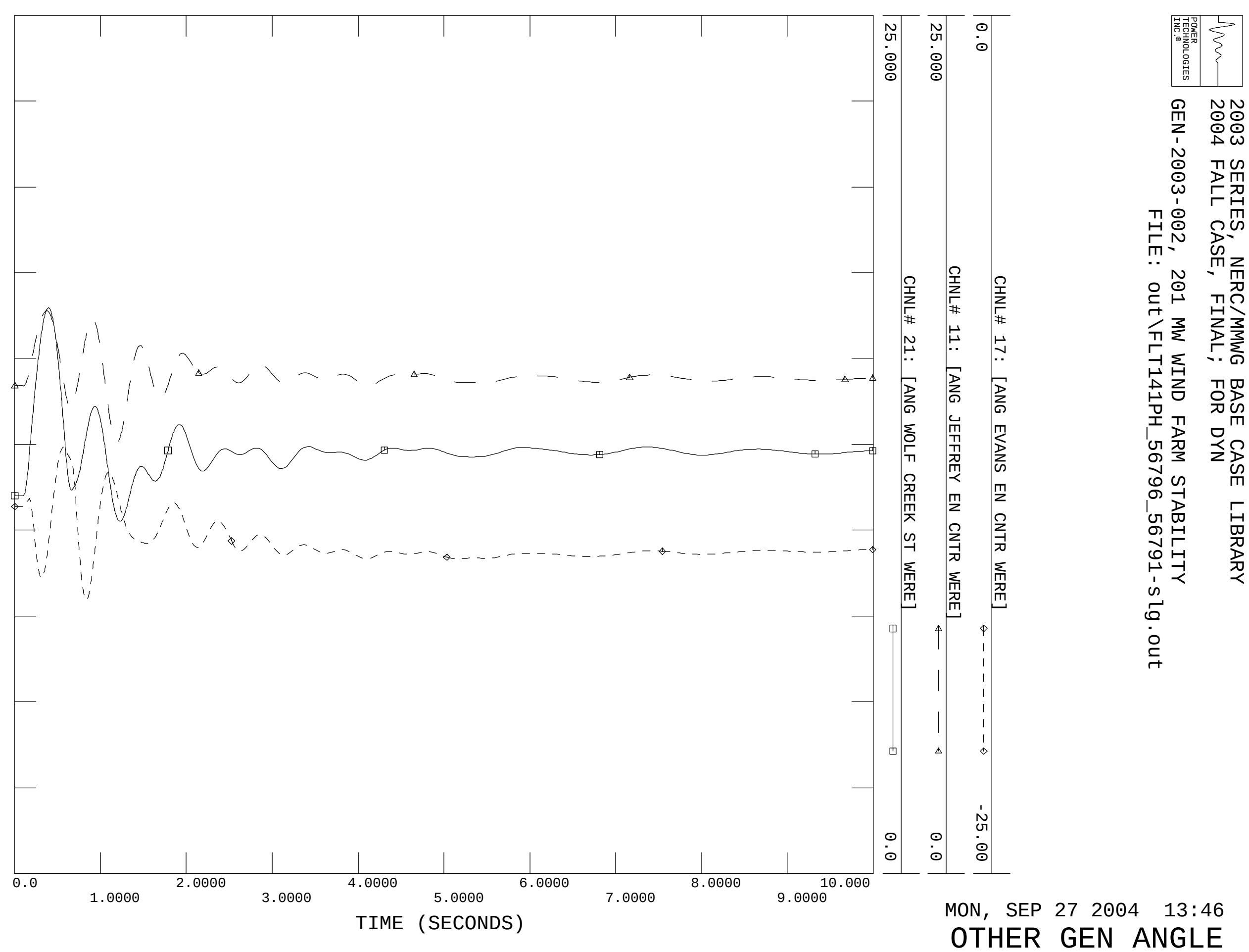
CASE ID: FLT133PH, 56796_56791-3ph (2 / 2)



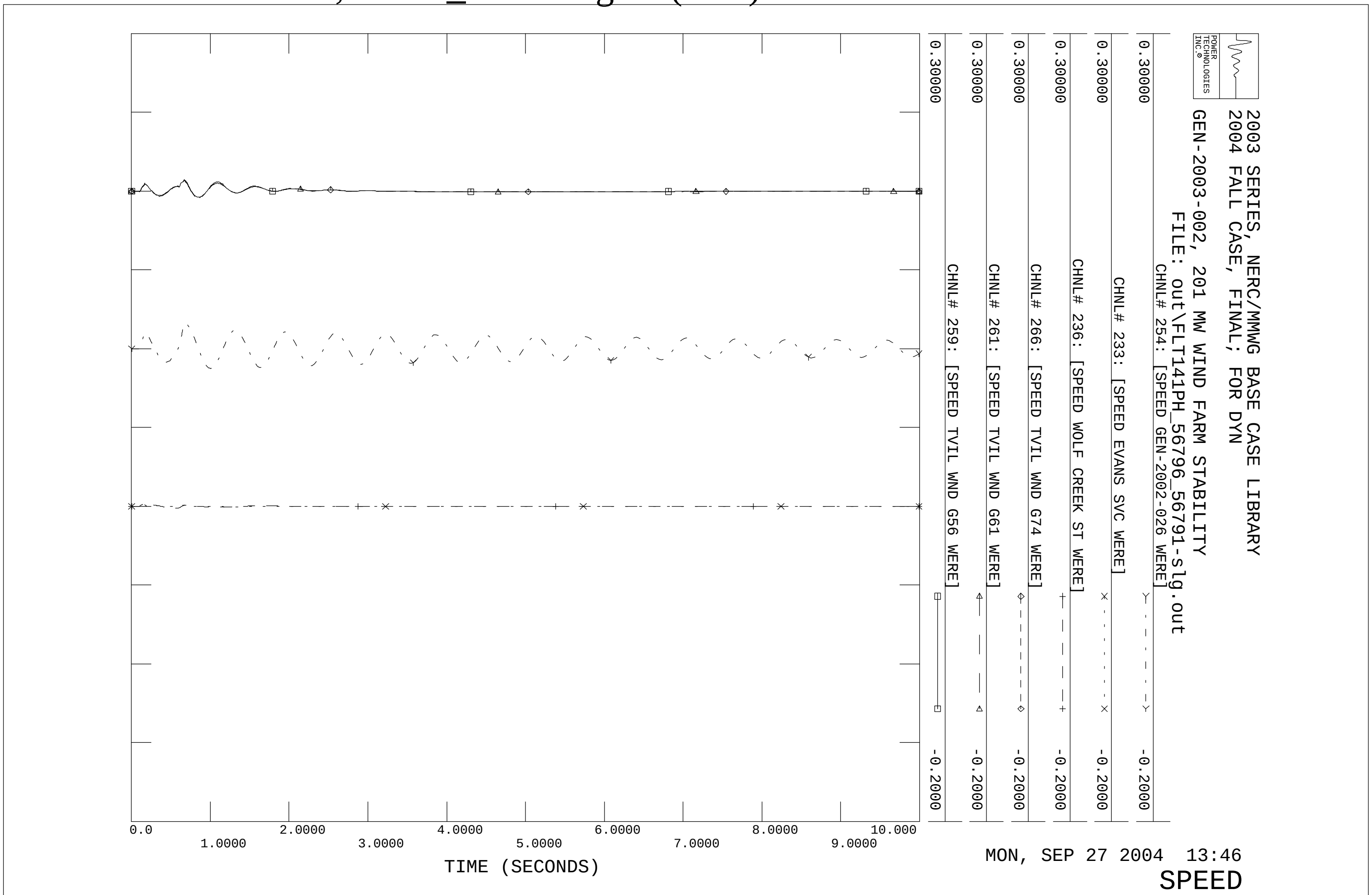


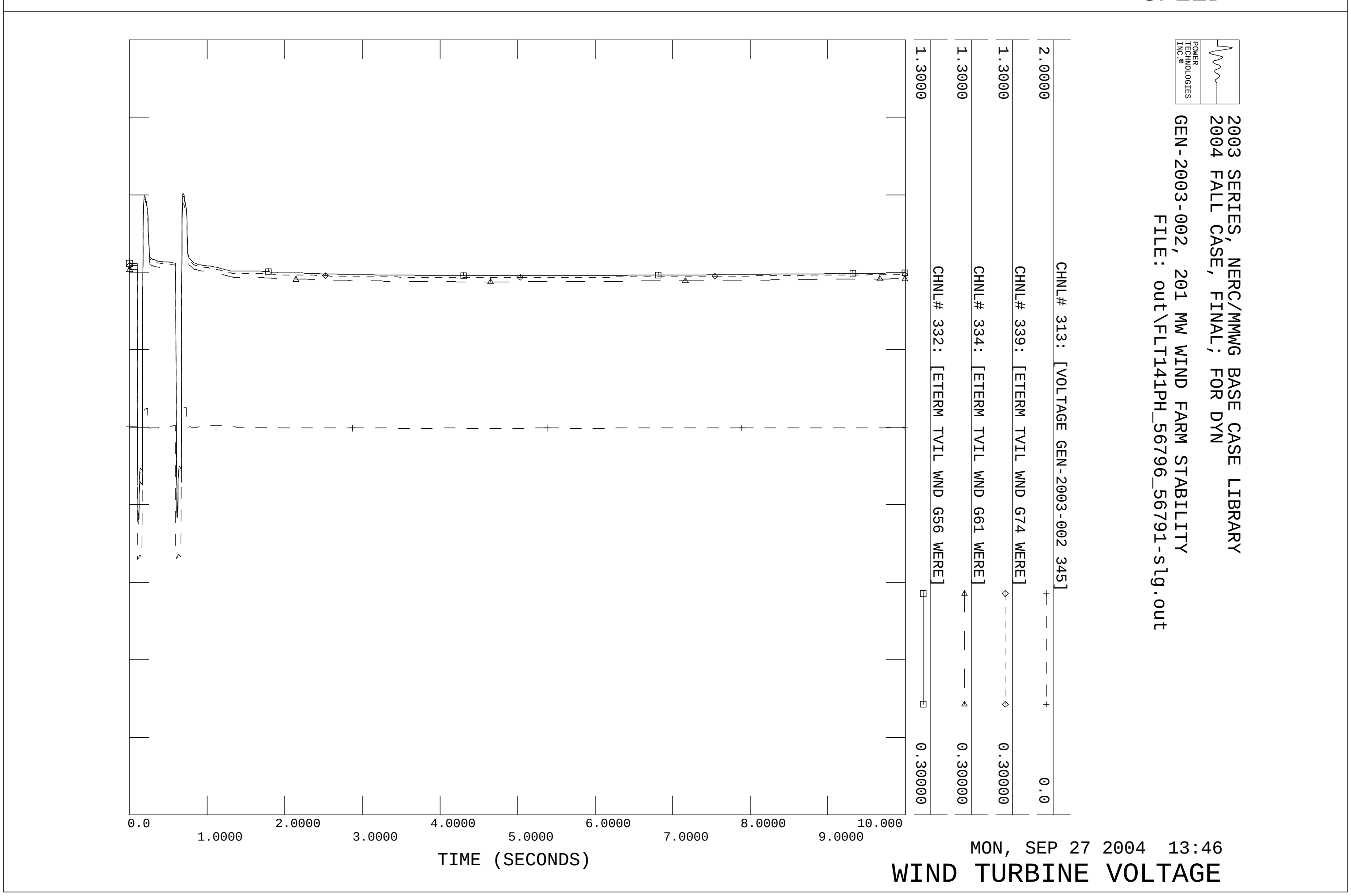
CASE ID: FLT141PH, 56796_56791-slg (1 / 2)

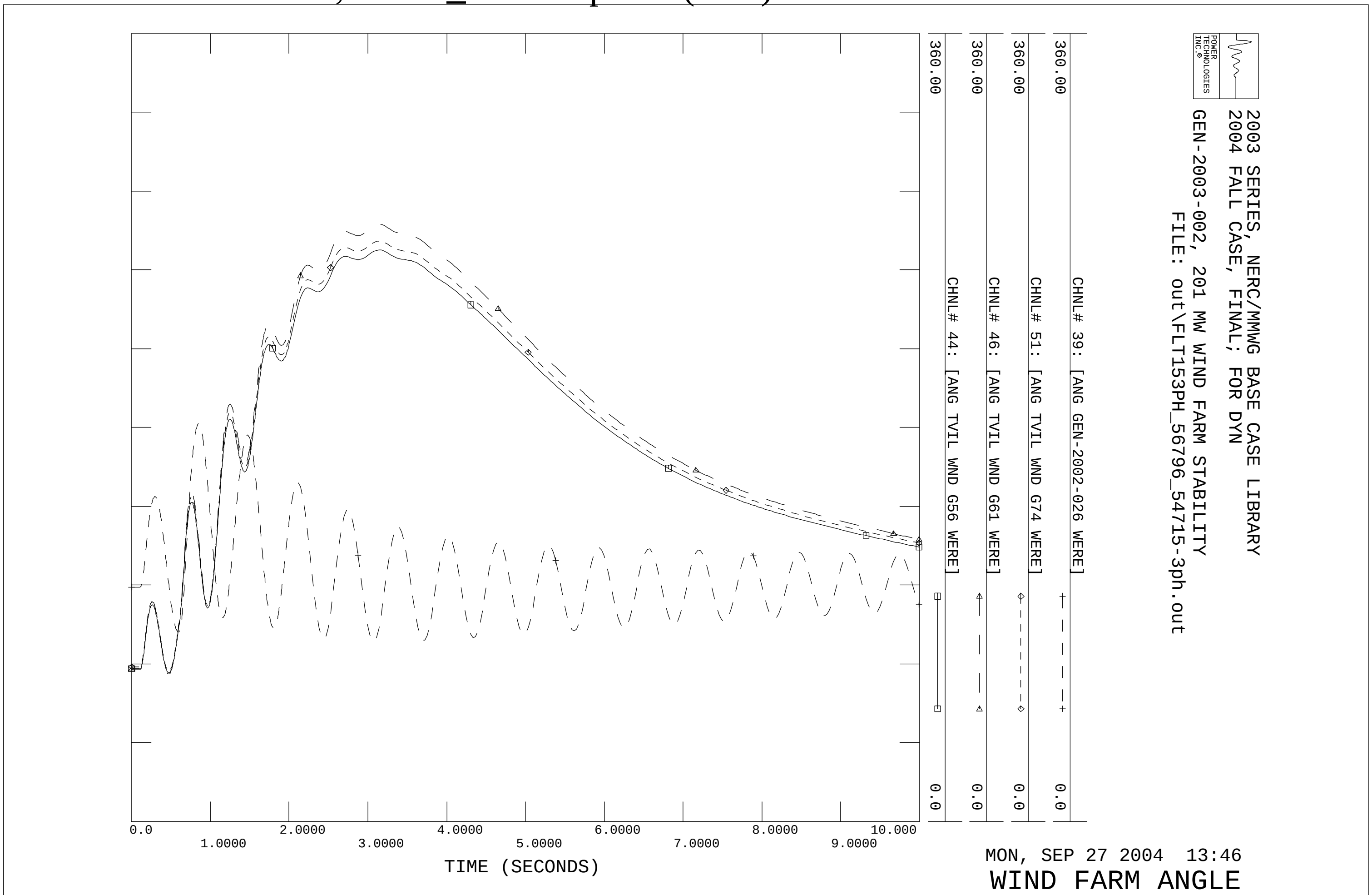


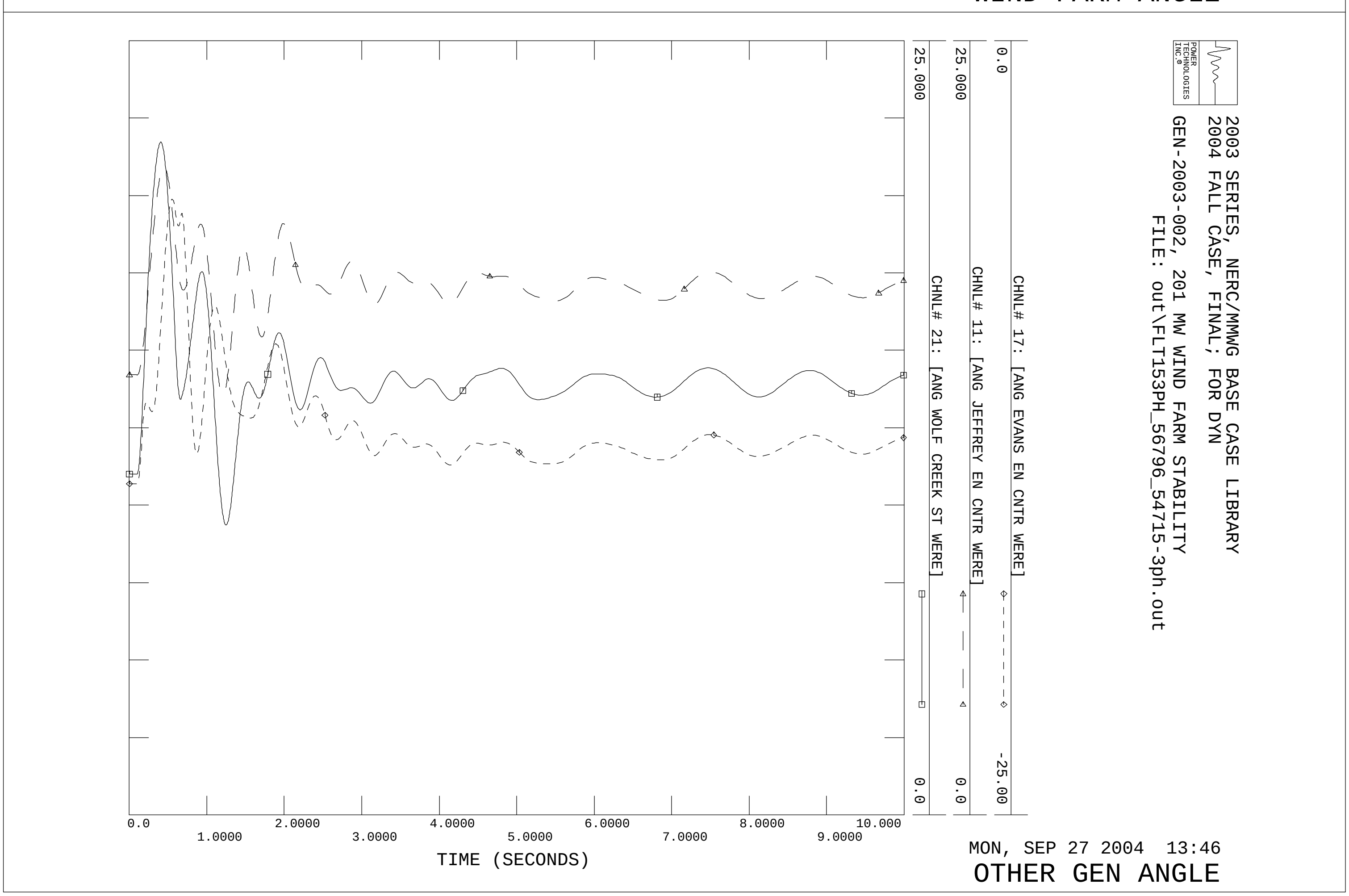


CASE ID: FLT141PH, 56796_56791-slg (2 / 2)

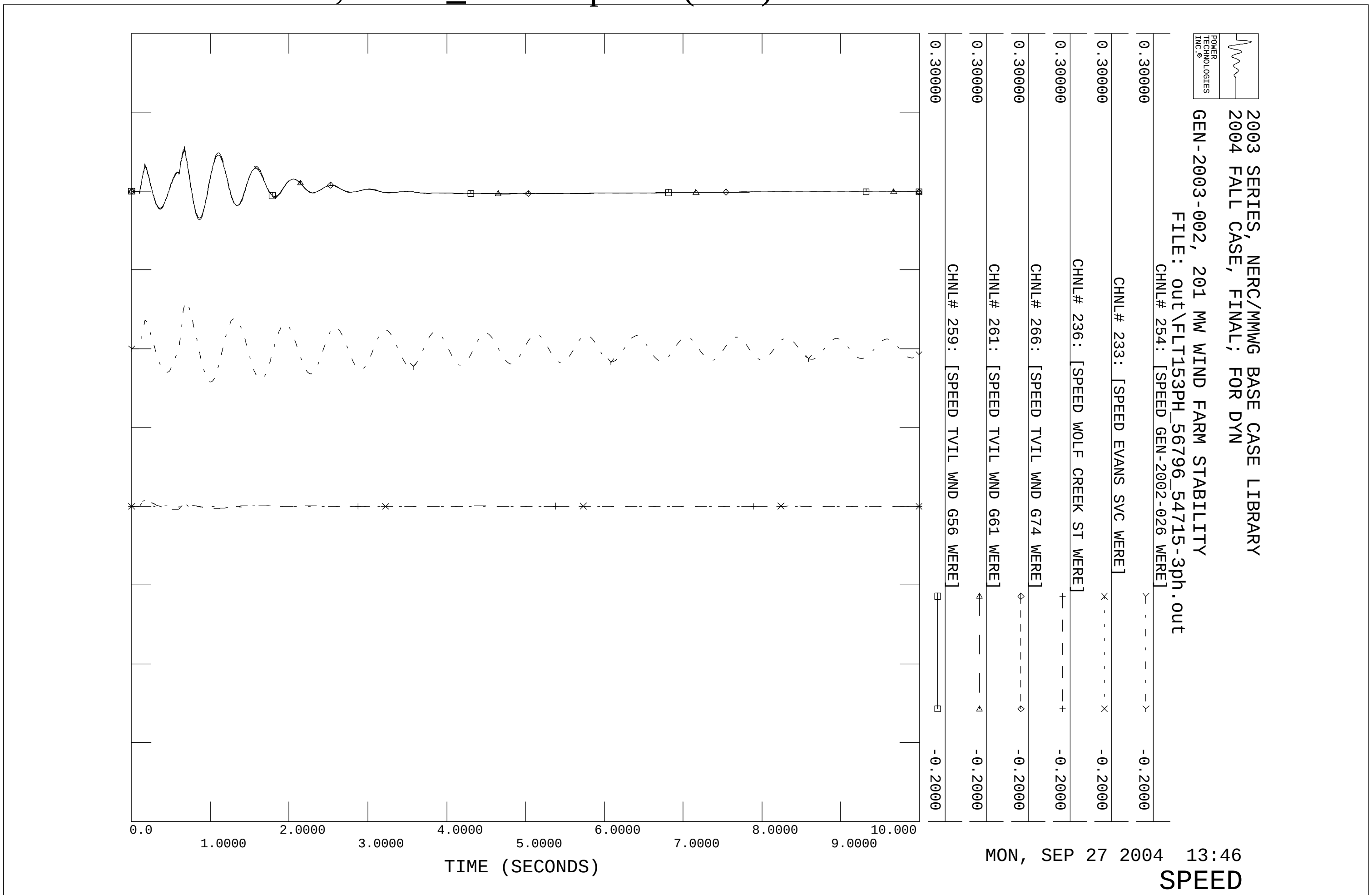


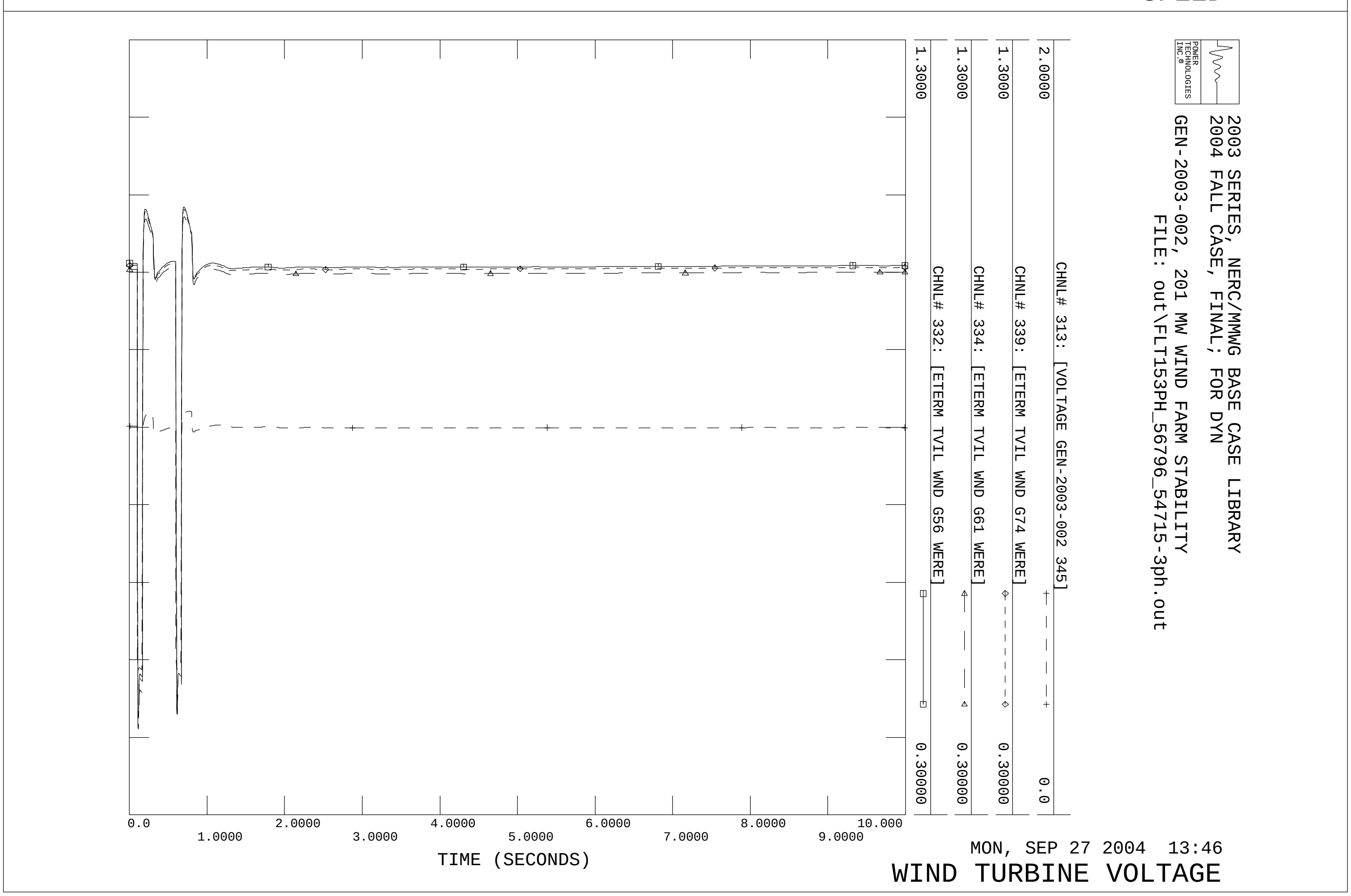



2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT153PH_56796_54715-3ph.out
CHNL# 39: [ANG GEN-2002-026 WERE]
360.00 0.0
CHNL# 51: [ANG TVIL WND G74 WERE]
360.00 0.0
CHNL# 46: [ANG TVIL WND G61 WERE]
360.00 0.0
CHNL# 44: [ANG TVIL WND G56 WERE]
360.00 0.0
0.0 1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000 10.000
TIME (SECONDS)
MON, SEP 27 2004 13:46
WIND FARM ANGLE

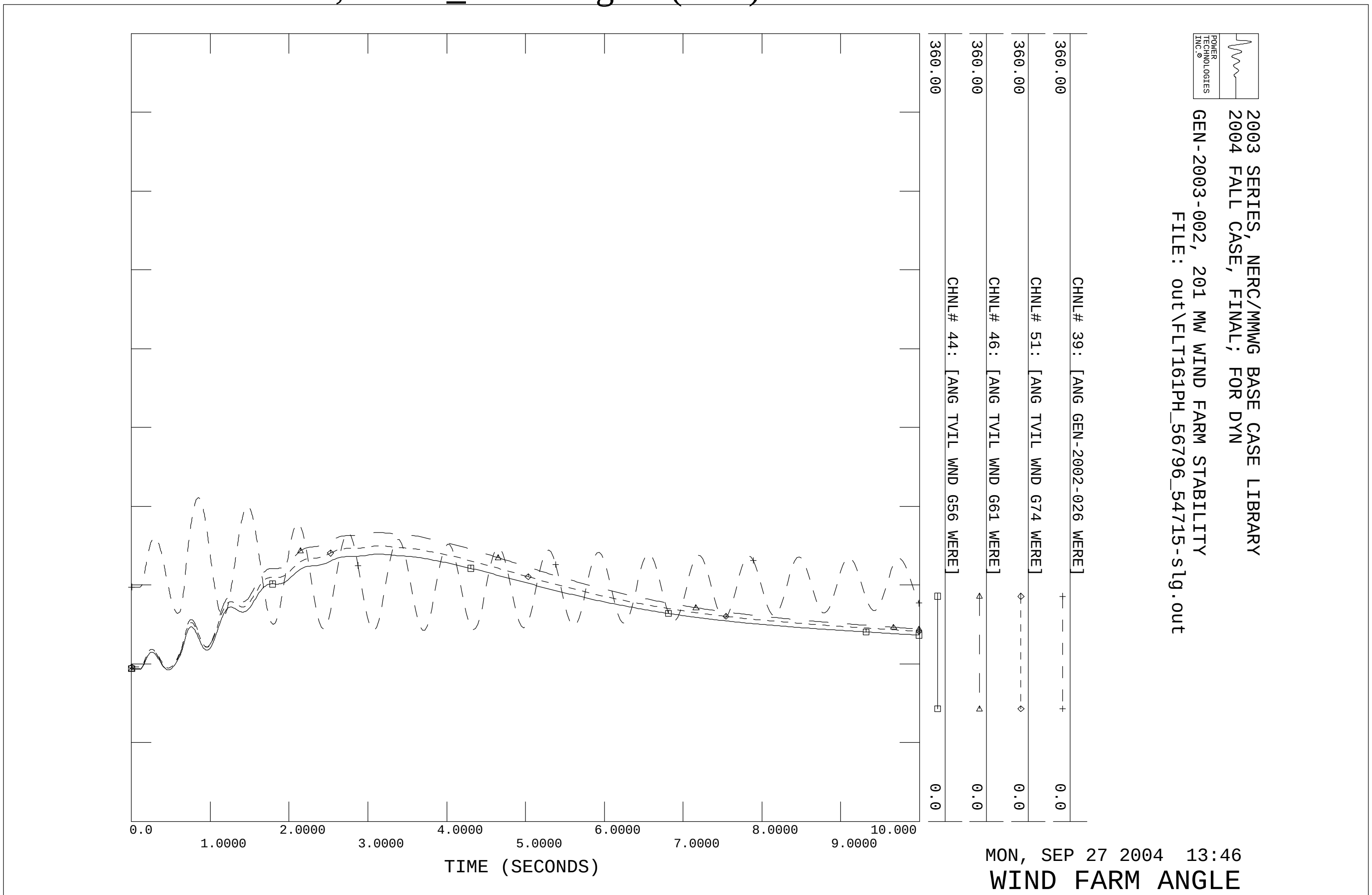

2003 SERIES, NERC/MMWG BASE CASE LIBRARY
2004 FALL CASE, FINAL; FOR DYN
GEN-2003-002, 201 MW WIND FARM STABILITY
FILE: out\FLT153PH_56796_54715-3ph.out
CHNL# 17: [ANG EVANS EN CNTR WERE]
0.0 -25.00
CHNL# 11: [ANG JEFFREY EN CNTR WERE]
25.000 0.0
CHNL# 21: [ANG WOLF CREEK ST WERE]
25.000 0.0
0.0 1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000 10.000
TIME (SECONDS)
MON, SEP 27 2004 13:46
OTHER GEN ANGLE

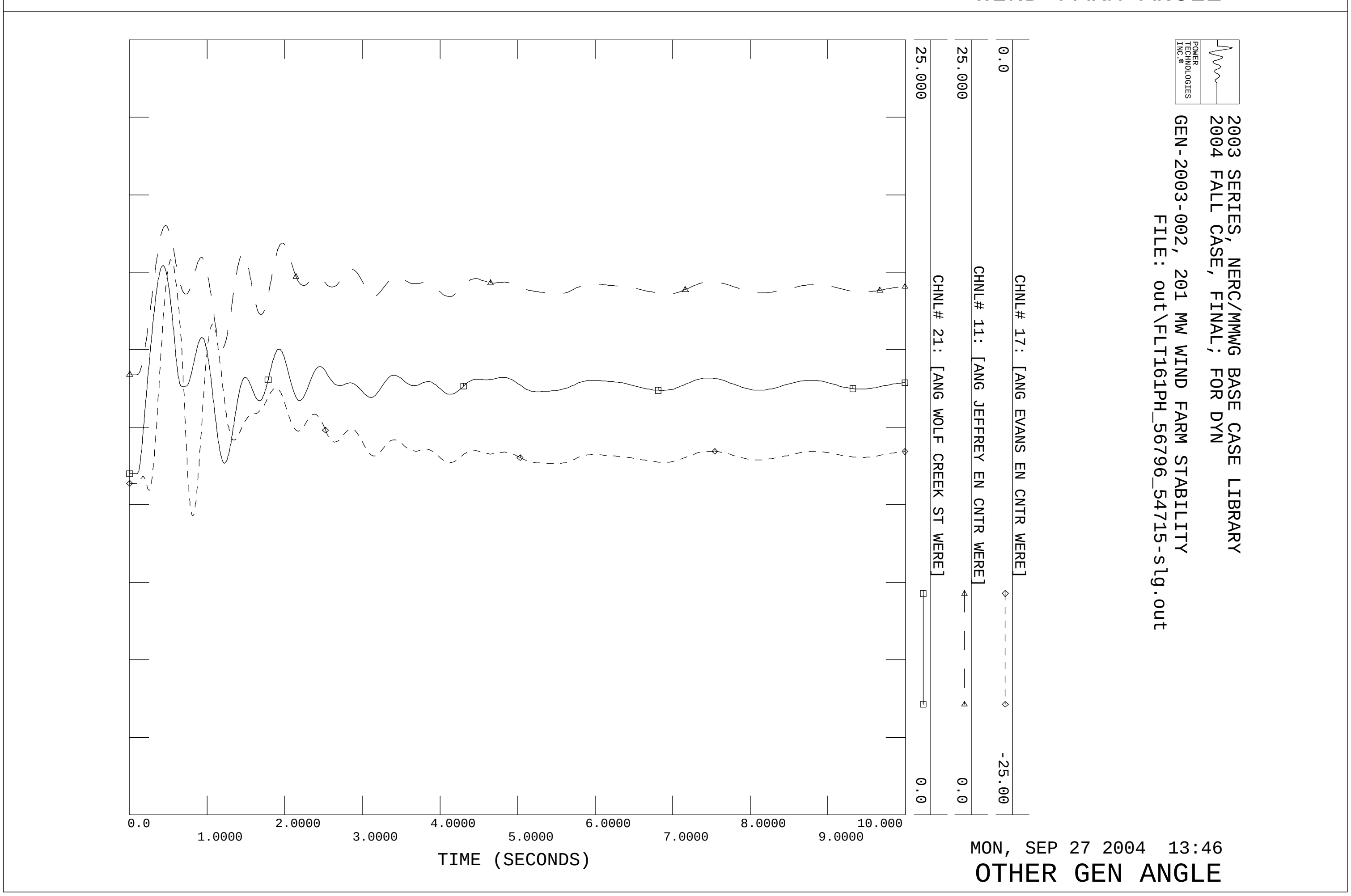
CASE ID: FLT153PH, 56796_54715-3ph (2 / 2)



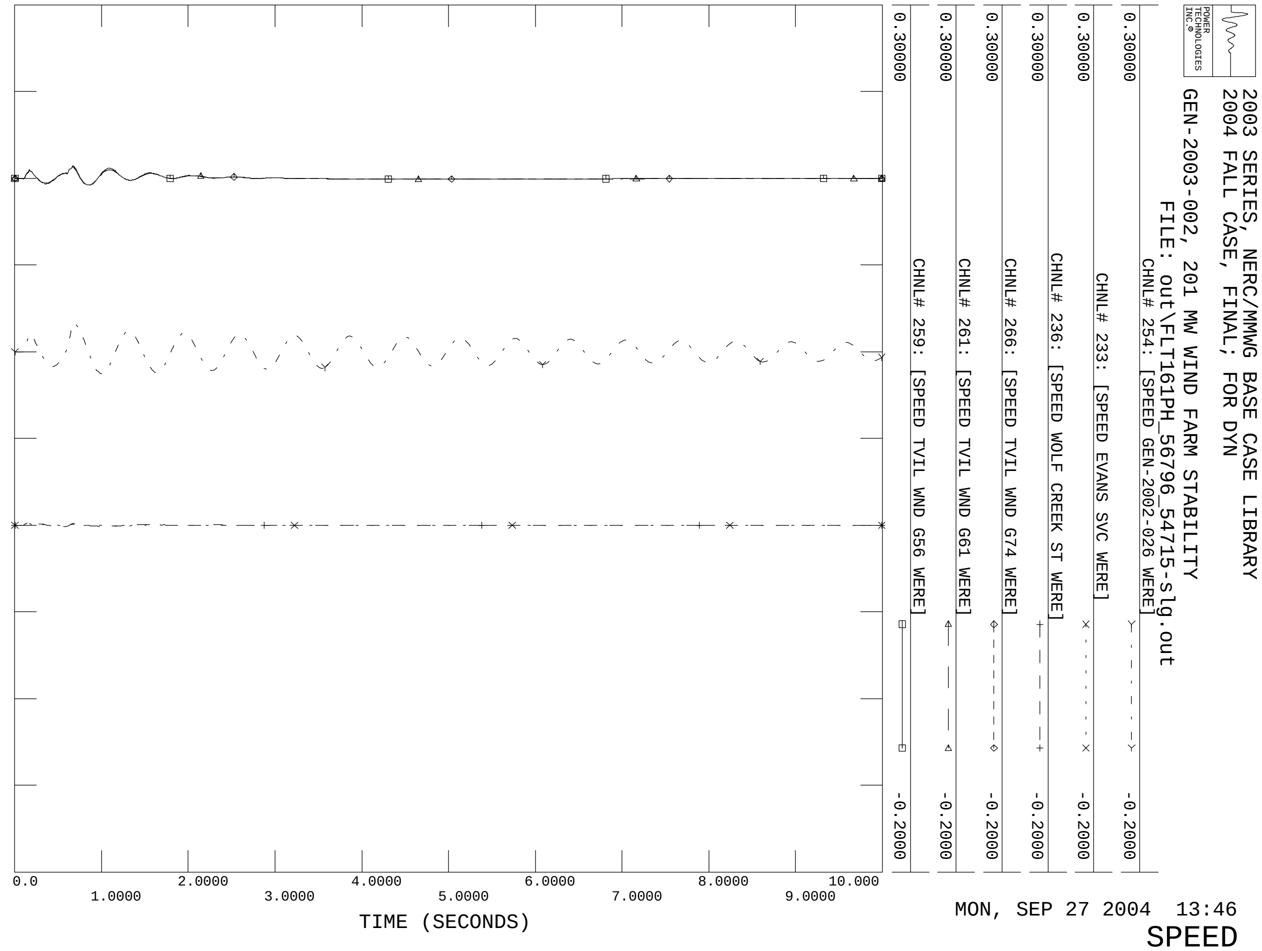


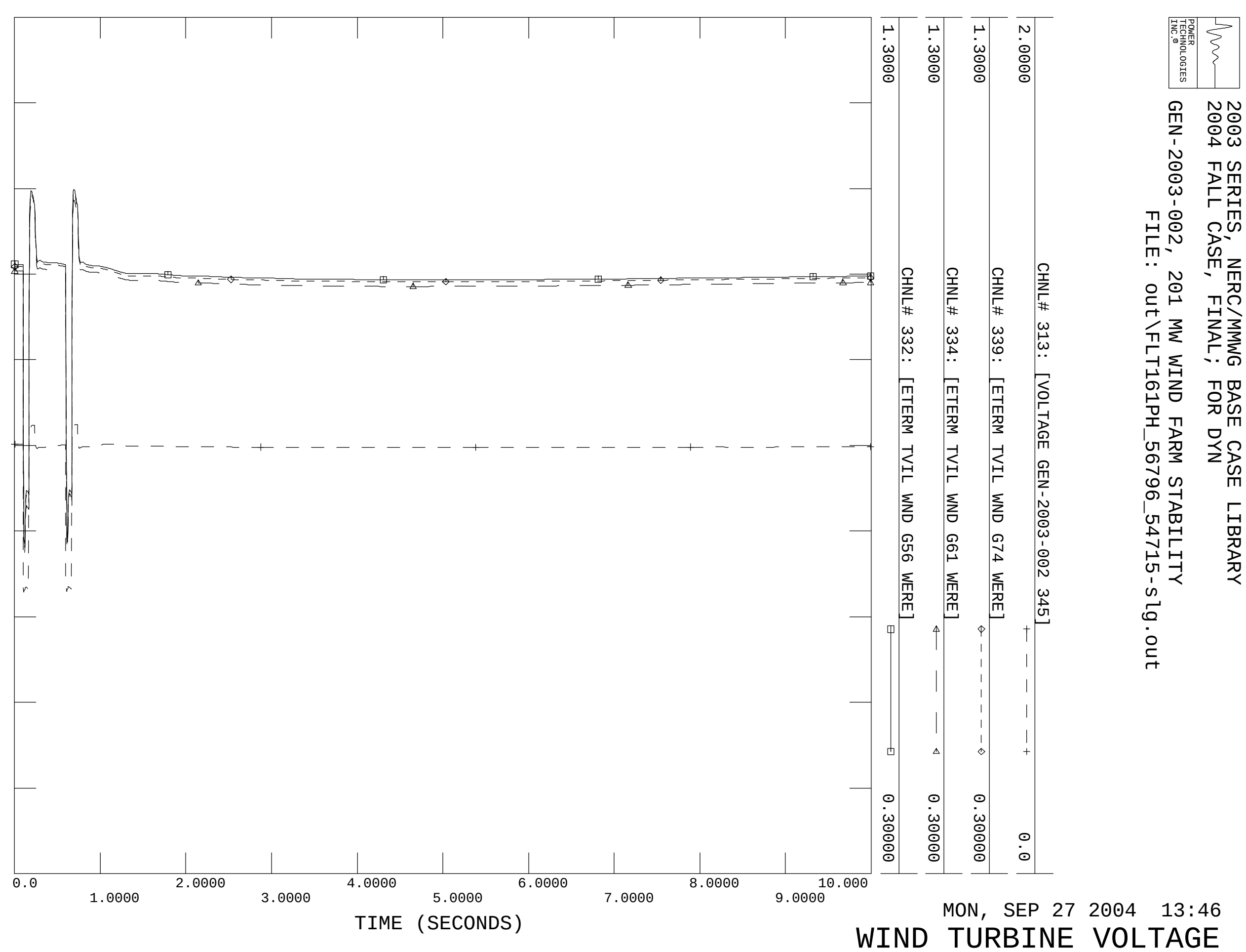
CASE ID: FLT161PH, 56796_54715-slg (1 / 2)

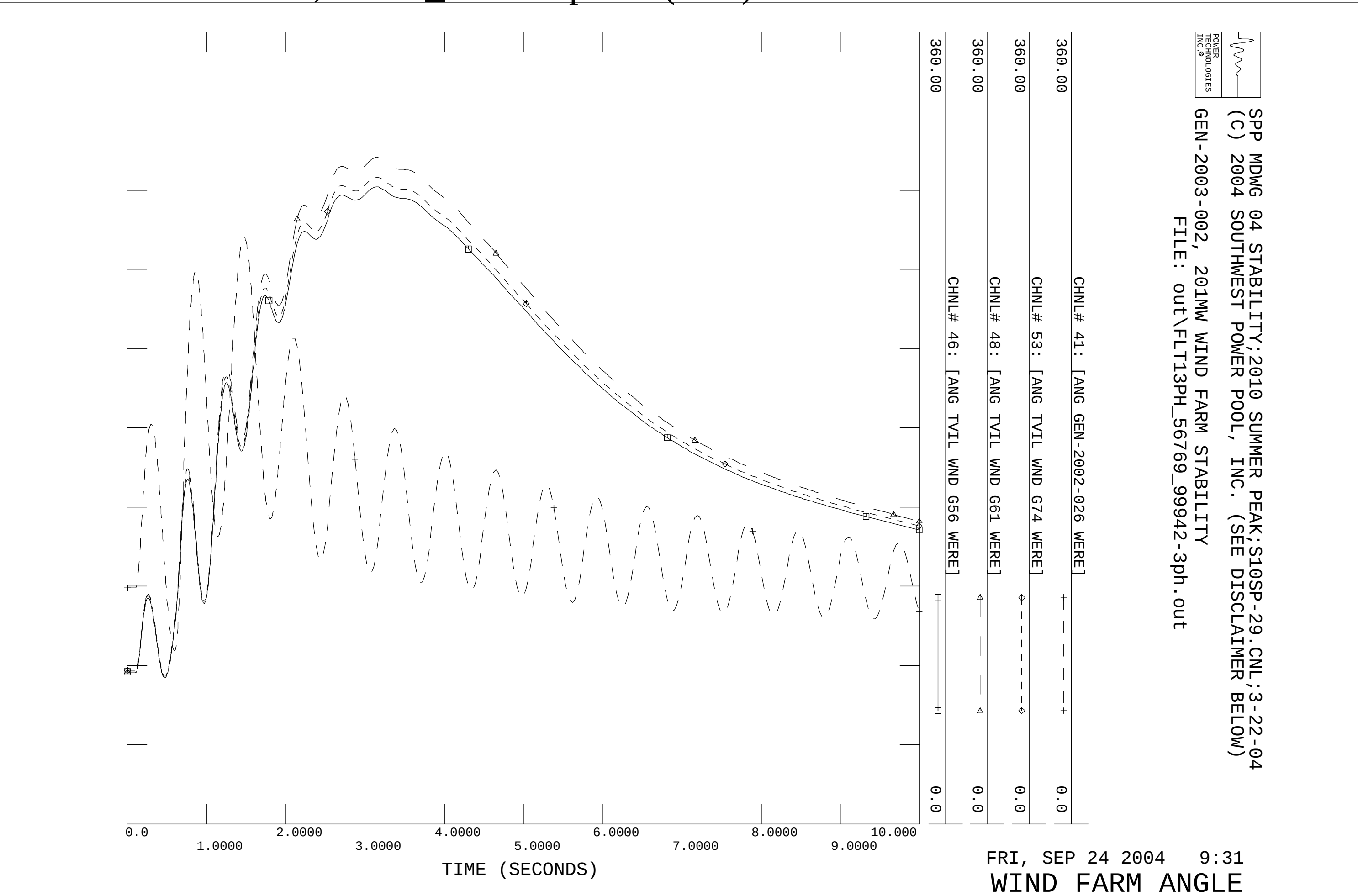


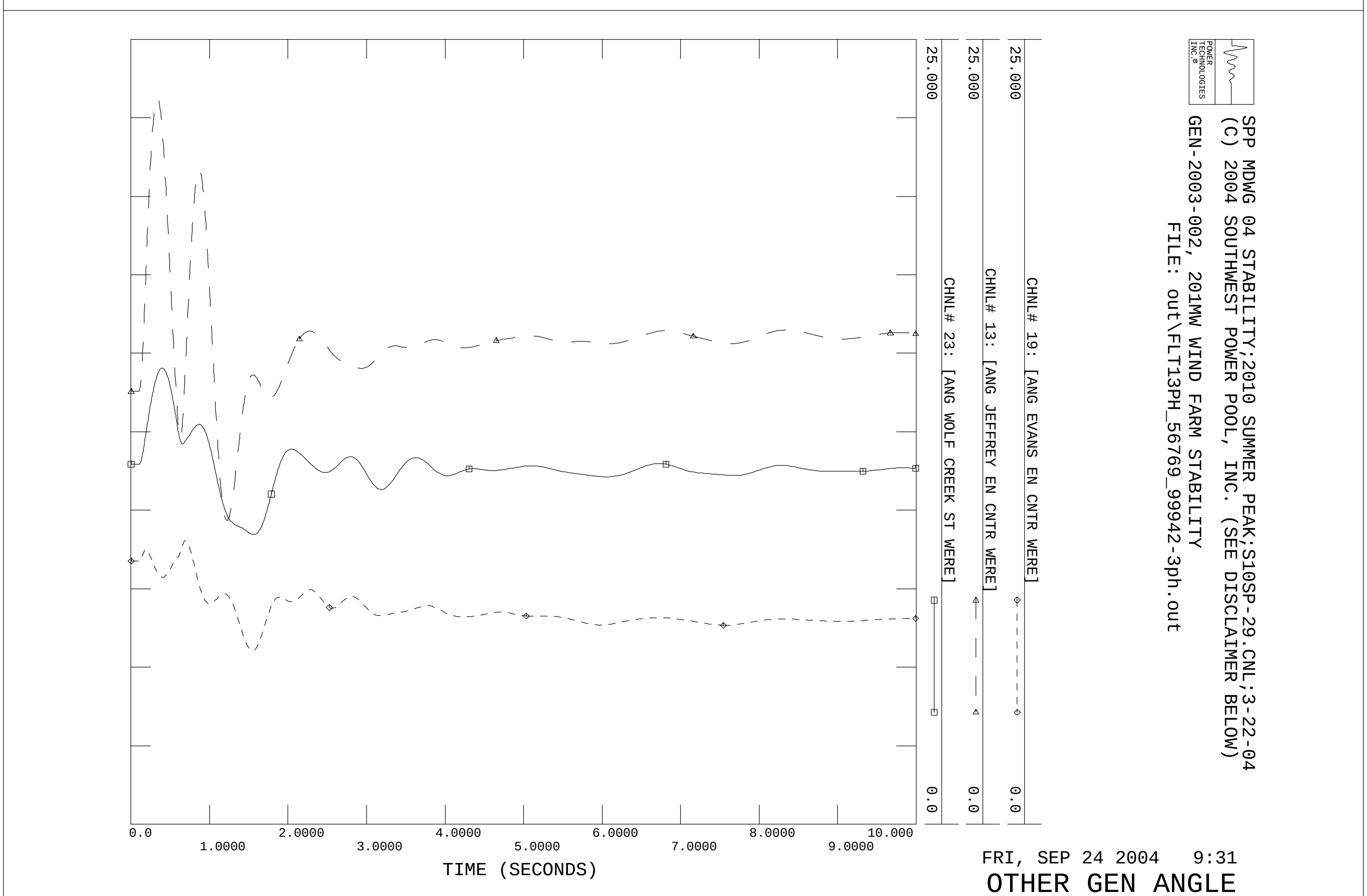


CASE ID: FLT161PH, 56796_54715-slg (2 / 2)

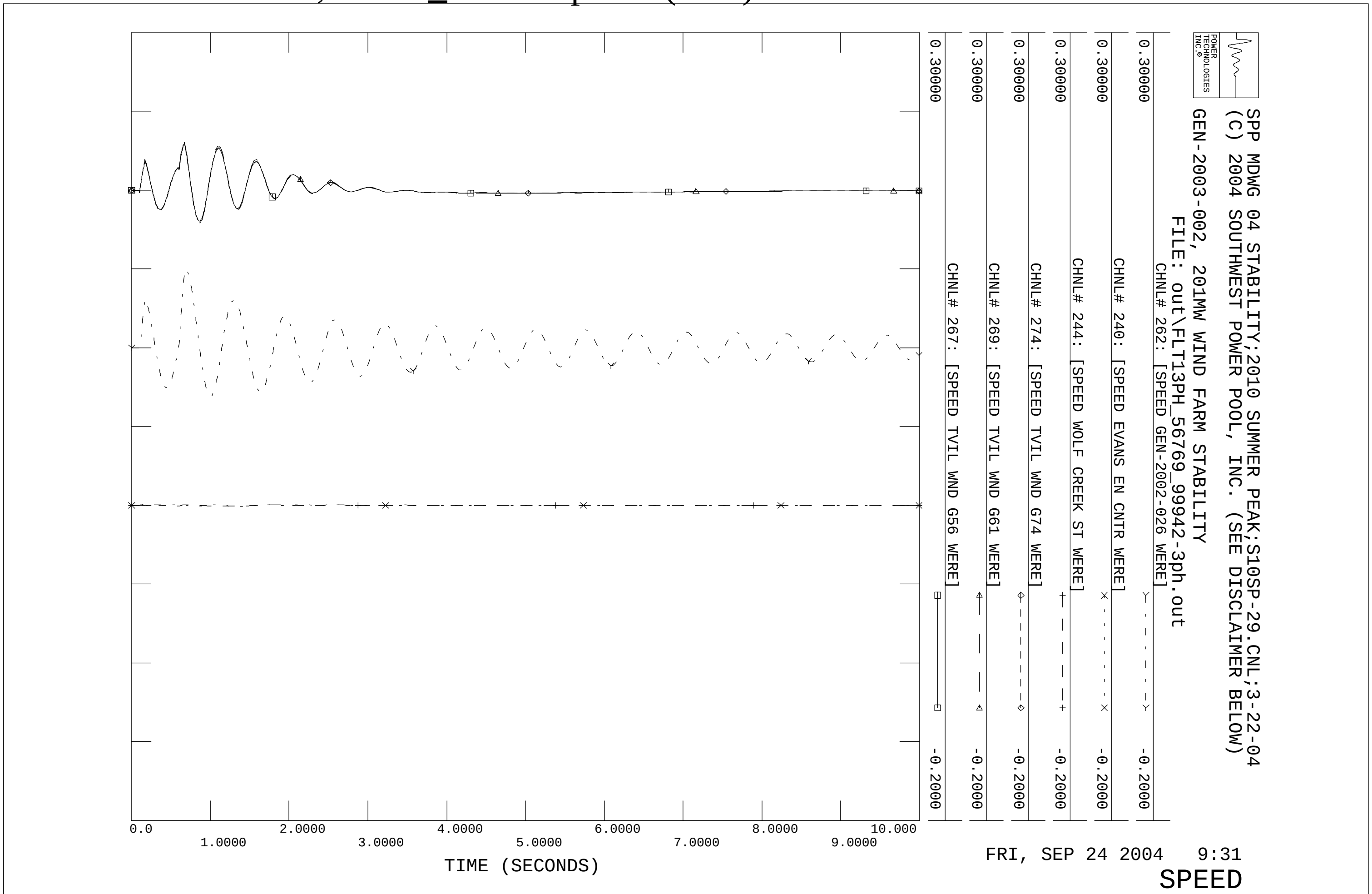


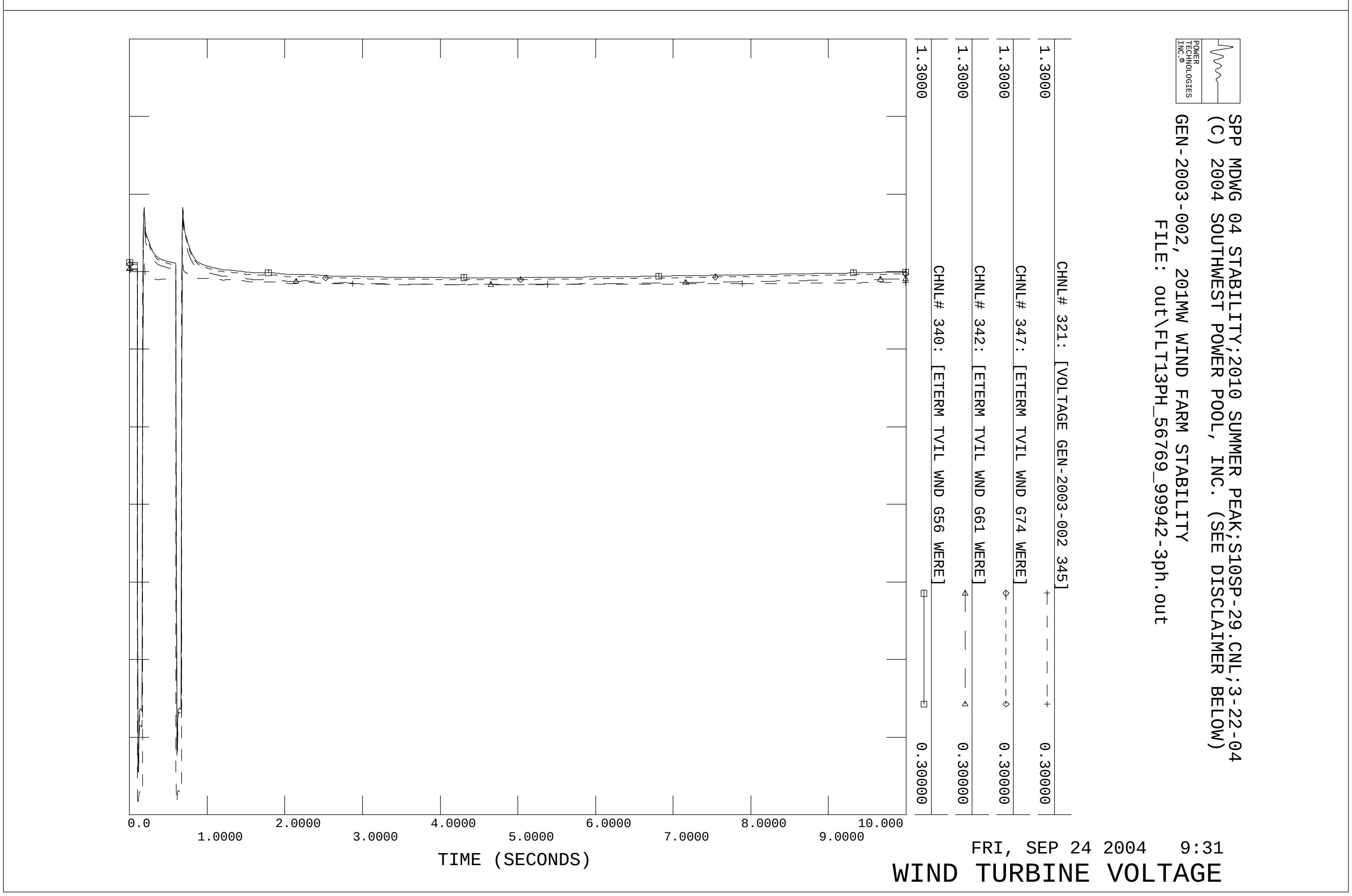



SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT13PH_56769_99942-3ph.out
CHNL# 41: [ANG GEN-2002-026 WERE]
CHNL# 53: [ANG TVIL WND G74 WERE]
CHNL# 48: [ANG TVIL WND G61 WERE]
CHNL# 46: [ANG TVIL WND G56 WERE]
360.00
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
WIND FARM ANGLE

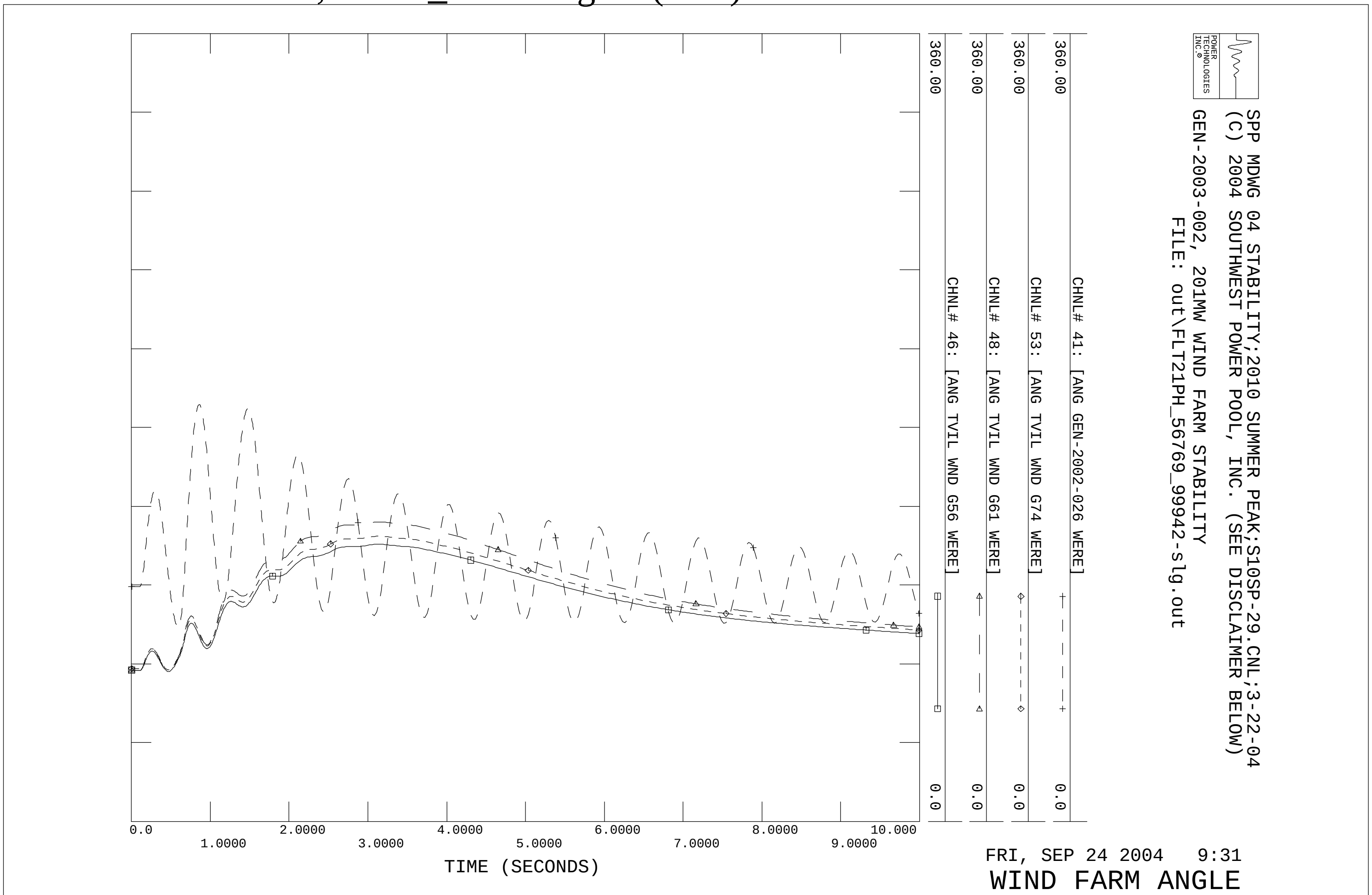

SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT13PH_56769_99942-3ph.out
CHNL# 19: [ANG EVANS EN CNTR WERE]
CHNL# 13: [ANG JEFFREY EN CNTR WERE]
CHNL# 23: [ANG WOLF CREEK ST WERE]
25.000
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
OTHER GEN ANGLE

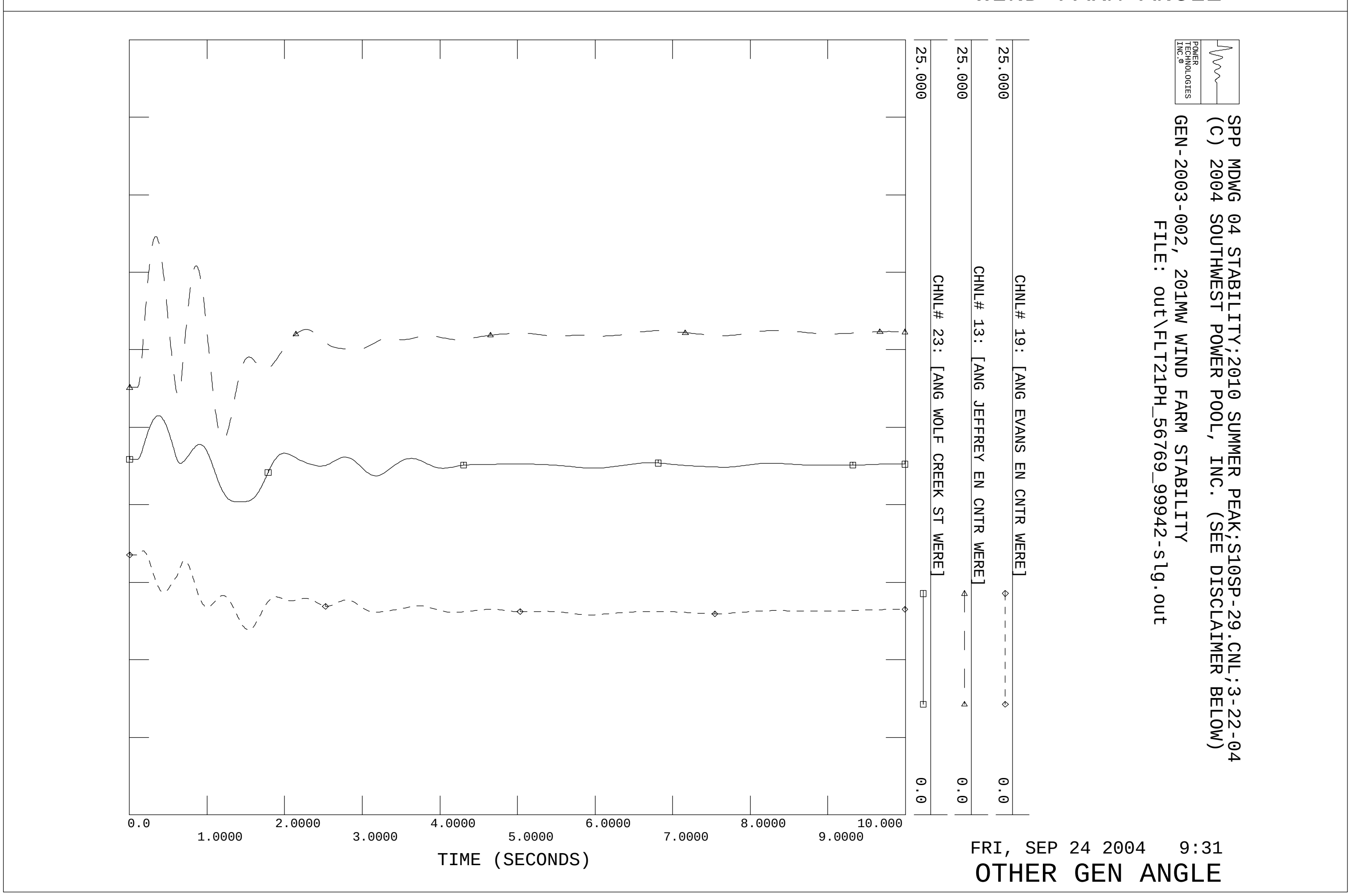
CASE ID: FLT13PH, 56769_99942-3ph (2 / 2)



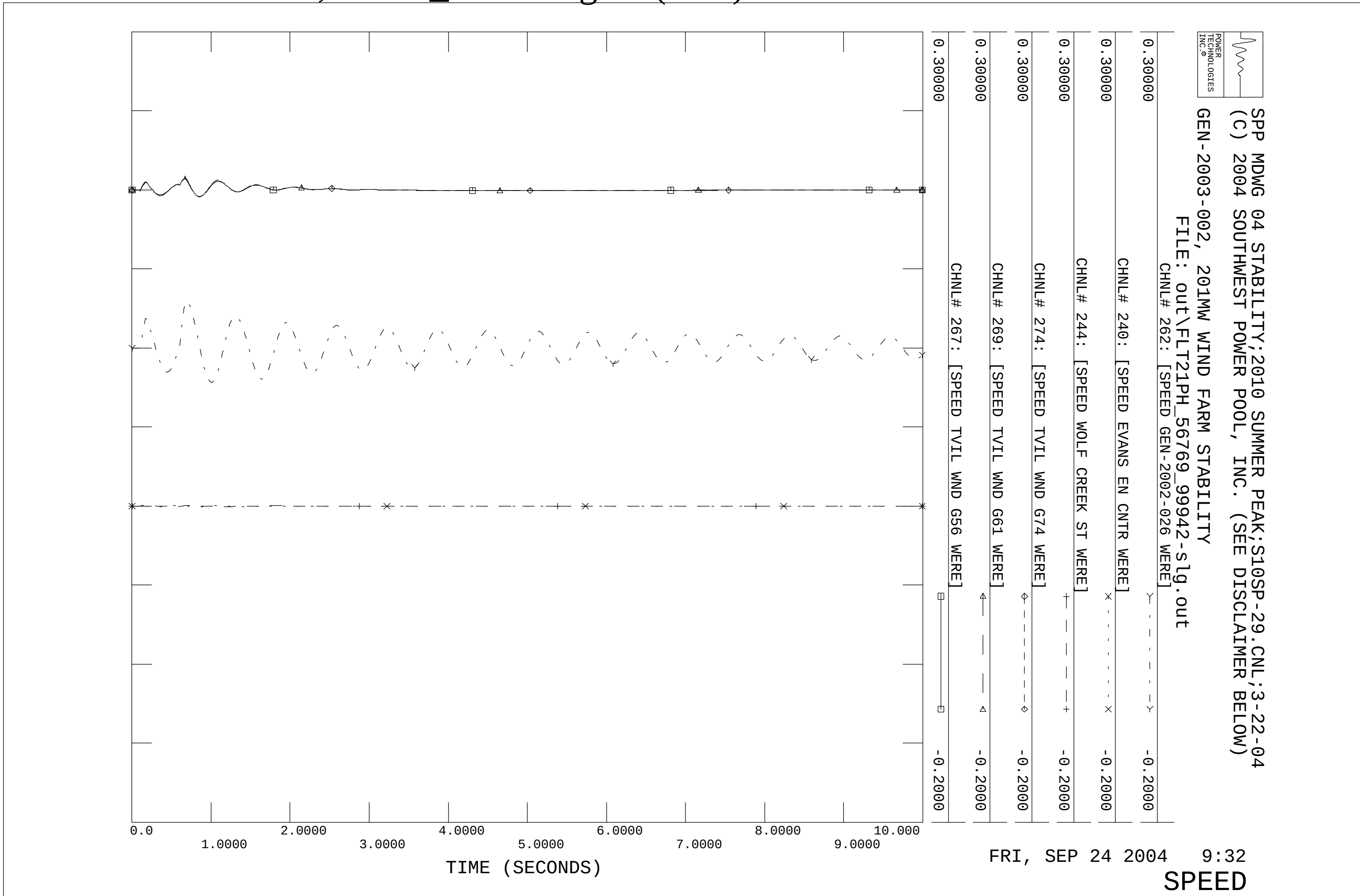


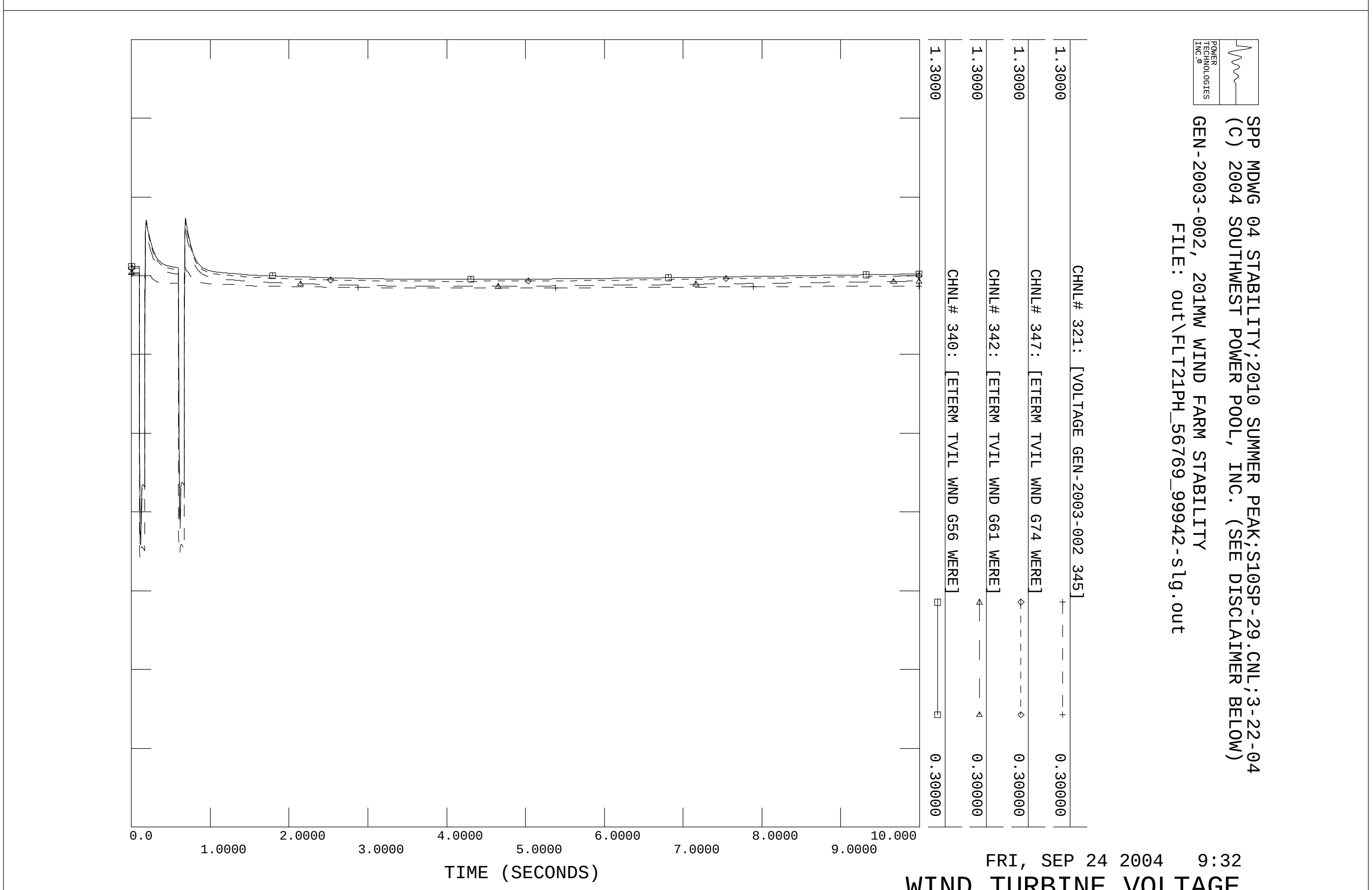
CASE ID: FLT21PH, 56769_99942-slg (1 / 2)



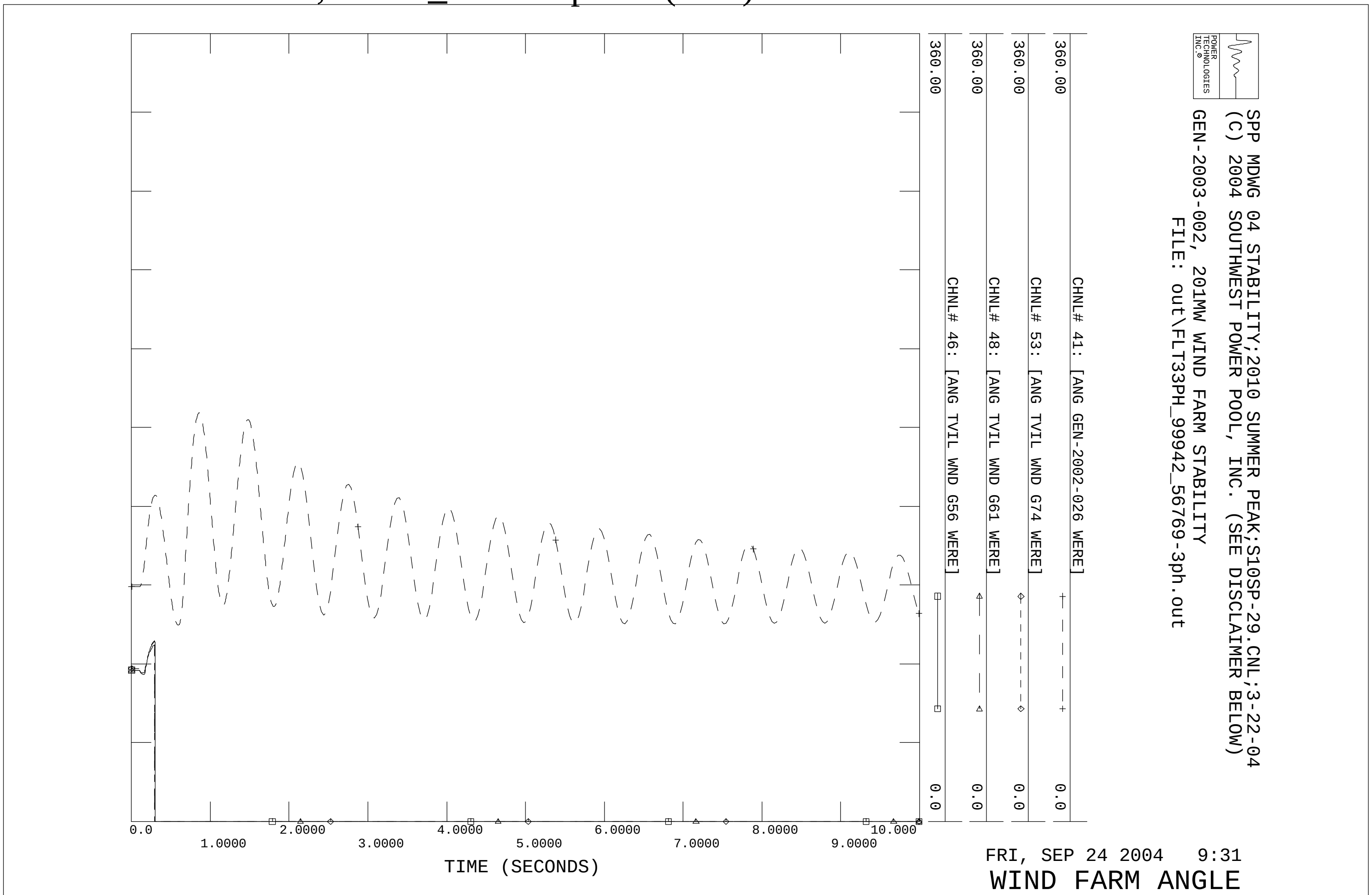


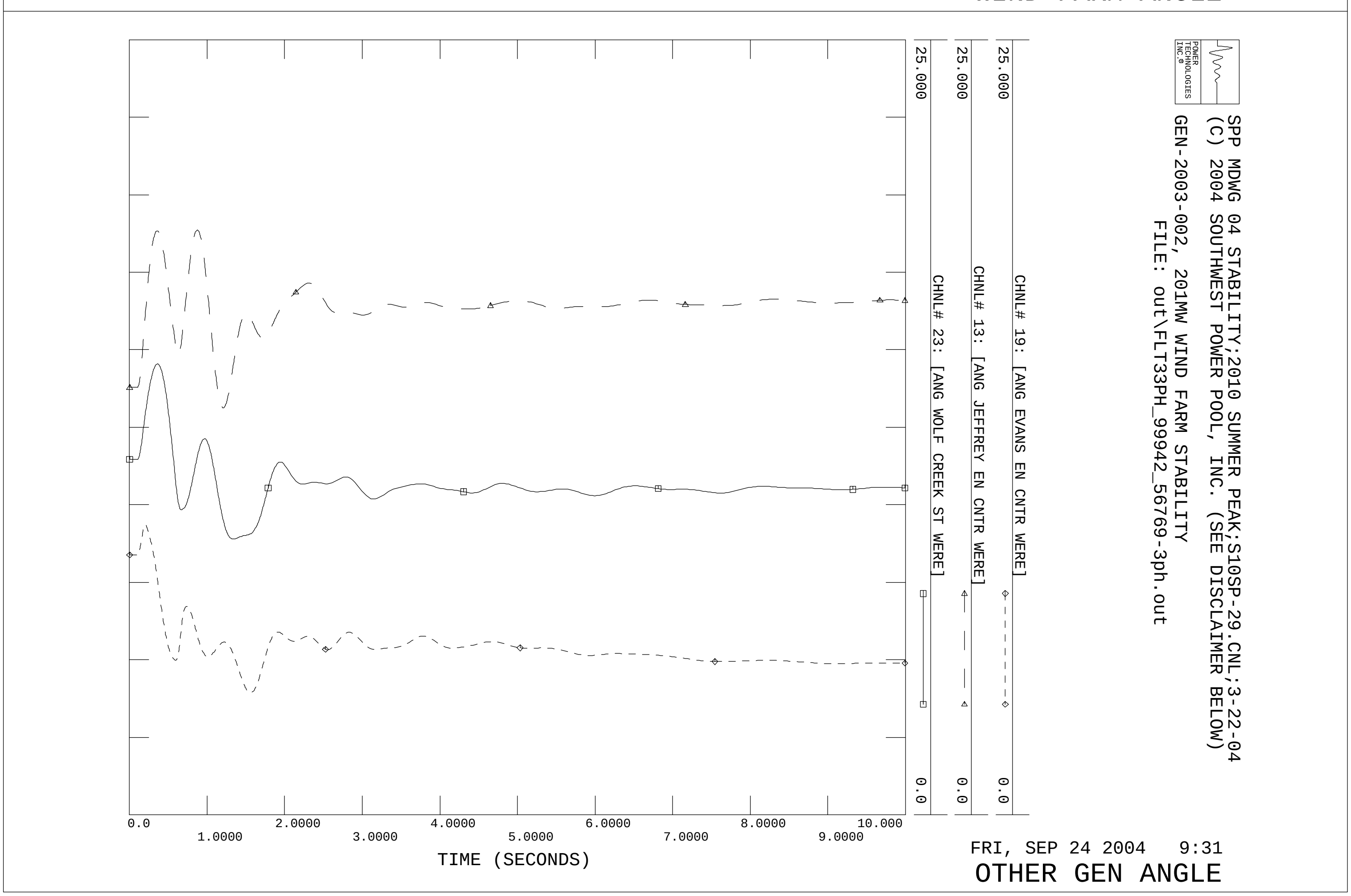
CASE ID: FLT21PH, 56769_99942-slg (2 / 2)



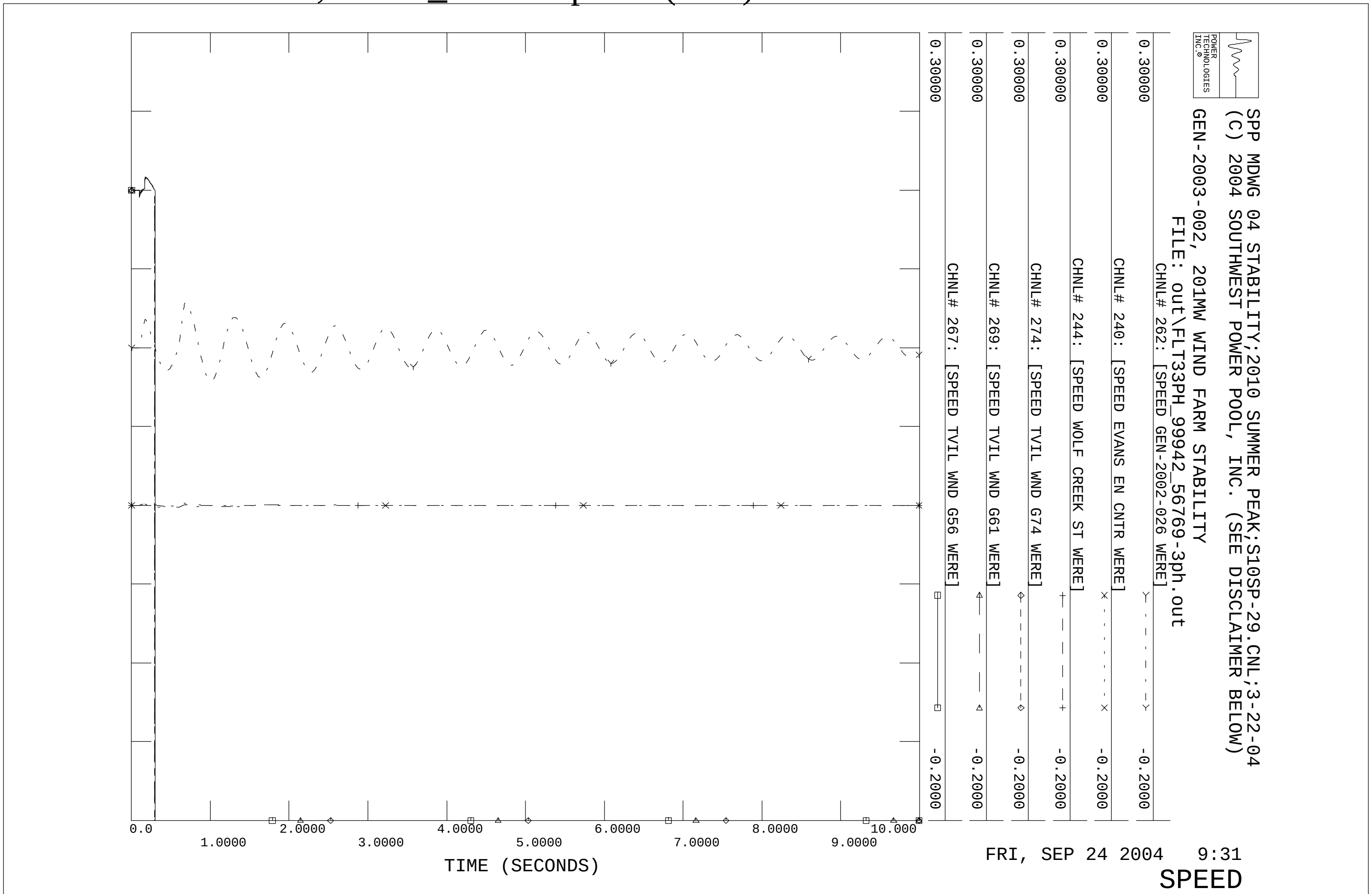


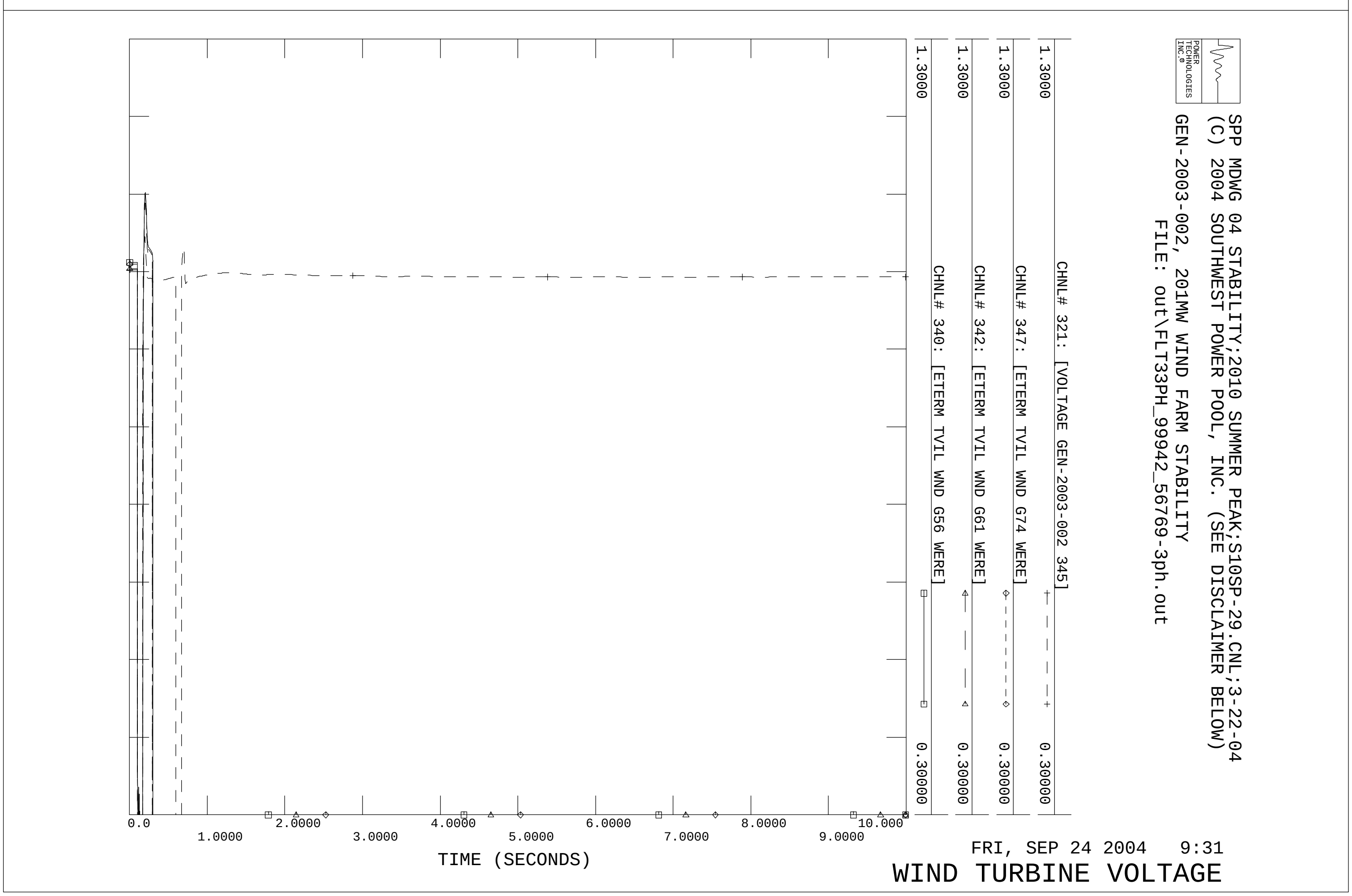
CASE ID: FLT33PH, 99942_56769-3ph   (1 / 2)

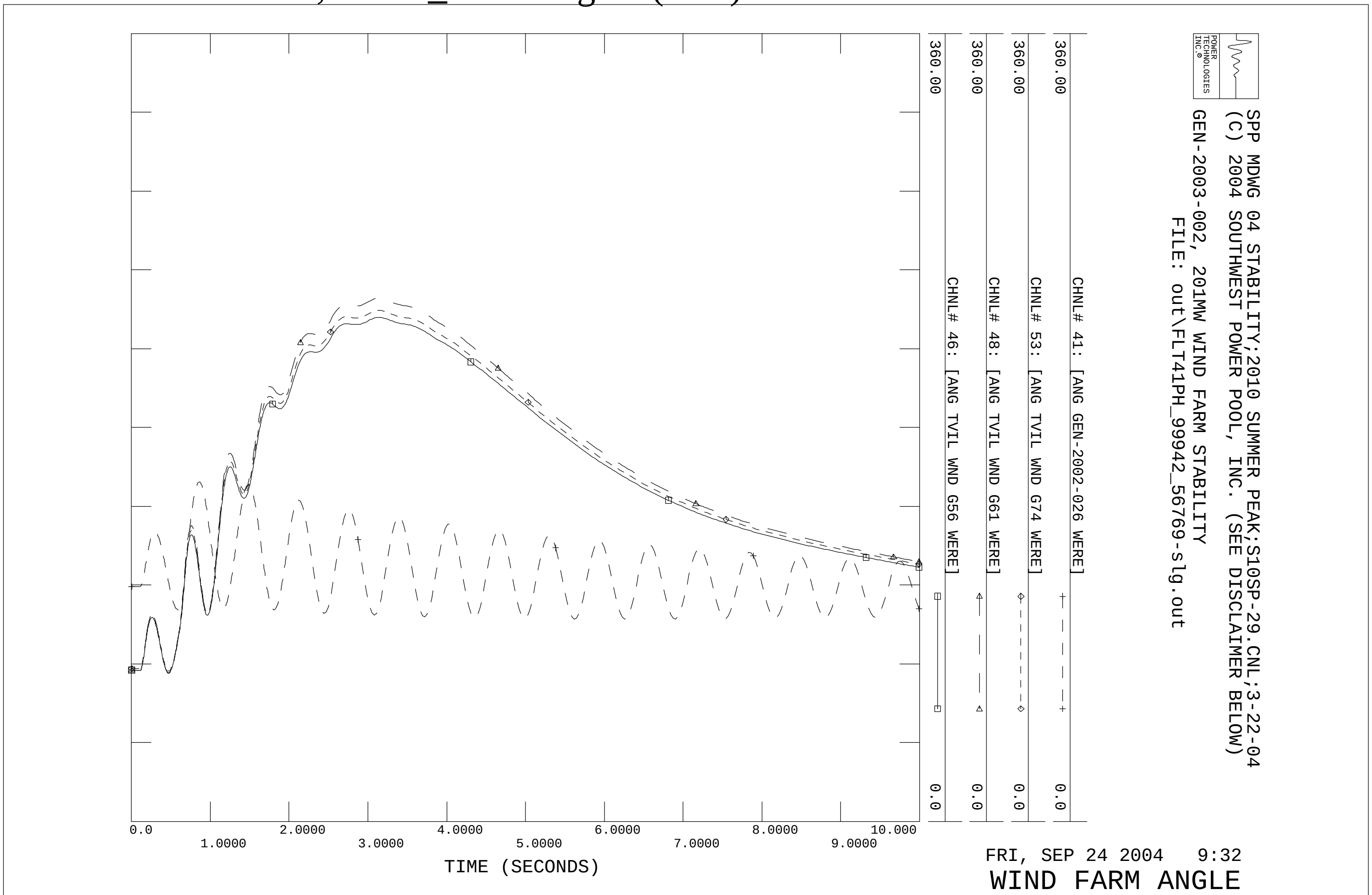


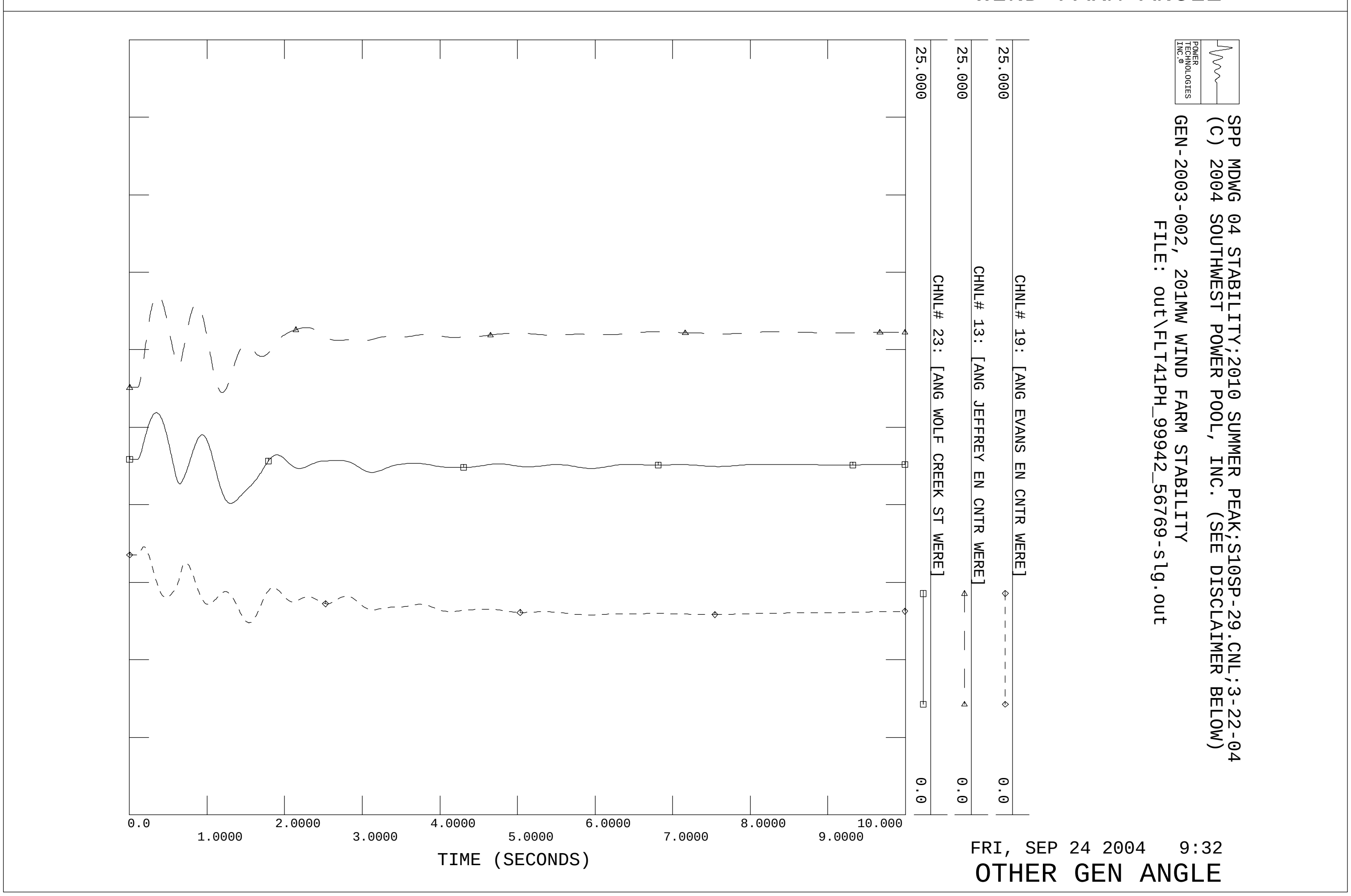


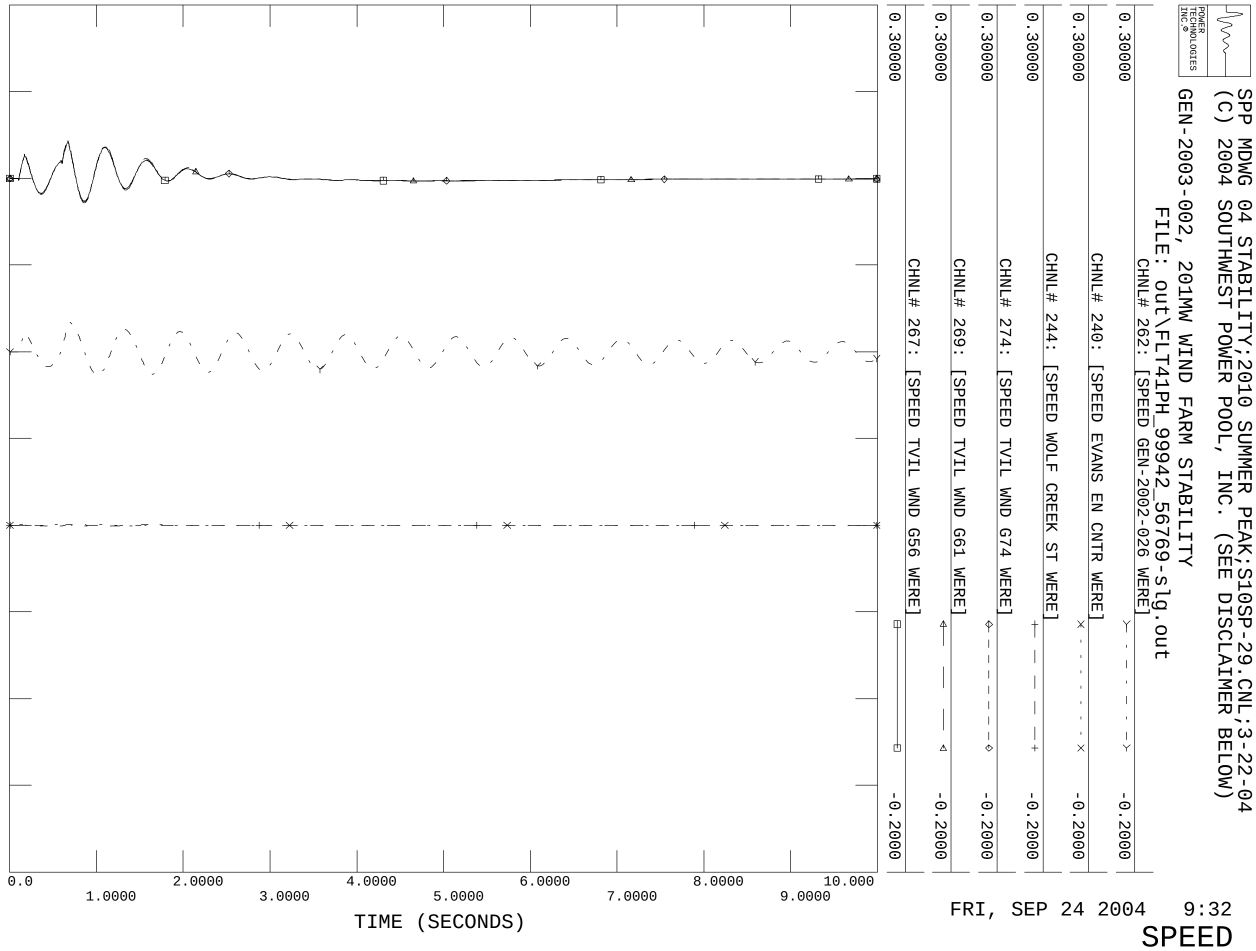
CASE ID: FLT33PH, 99942_56769-3ph (2 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT41PH_99942_56769-slg.out
CHNL# 41: [ANG GEN-2002-026 WERE]
CHNL# 53: [ANG TVIL WND G74 WERE]
CHNL# 48: [ANG TVIL WND G61 WERE]
CHNL# 46: [ANG TVIL WND G56 WERE]
360.00
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
WIND FARM ANGLE


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT41PH_99942_56769-slg.out
CHNL# 19: [ANG EVANS EN CNTR WERE]
CHNL# 13: [ANG JEFFREY EN CNTR WERE]
CHNL# 23: [ANG WOLF CREEK ST WERE]
25.000
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
OTHER GEN ANGLE


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT41PH_99942_56769-slg.out
CHNL# 262: [SPEED GEN-2002-026 WERE]
CHNL# 240: [SPEED EVANS EN CNTR WERE]
CHNL# 244: [SPEED WOLF CREEK ST WERE]
CHNL# 274: [SPEED TVIL WND G74 WERE]
CHNL# 269: [SPEED TVIL WND G61 WERE]
CHNL# 267: [SPEED TVIL WND G56 WERE]
0.30000
-0.2000
0.0
1.0000
2.0000
3.0000
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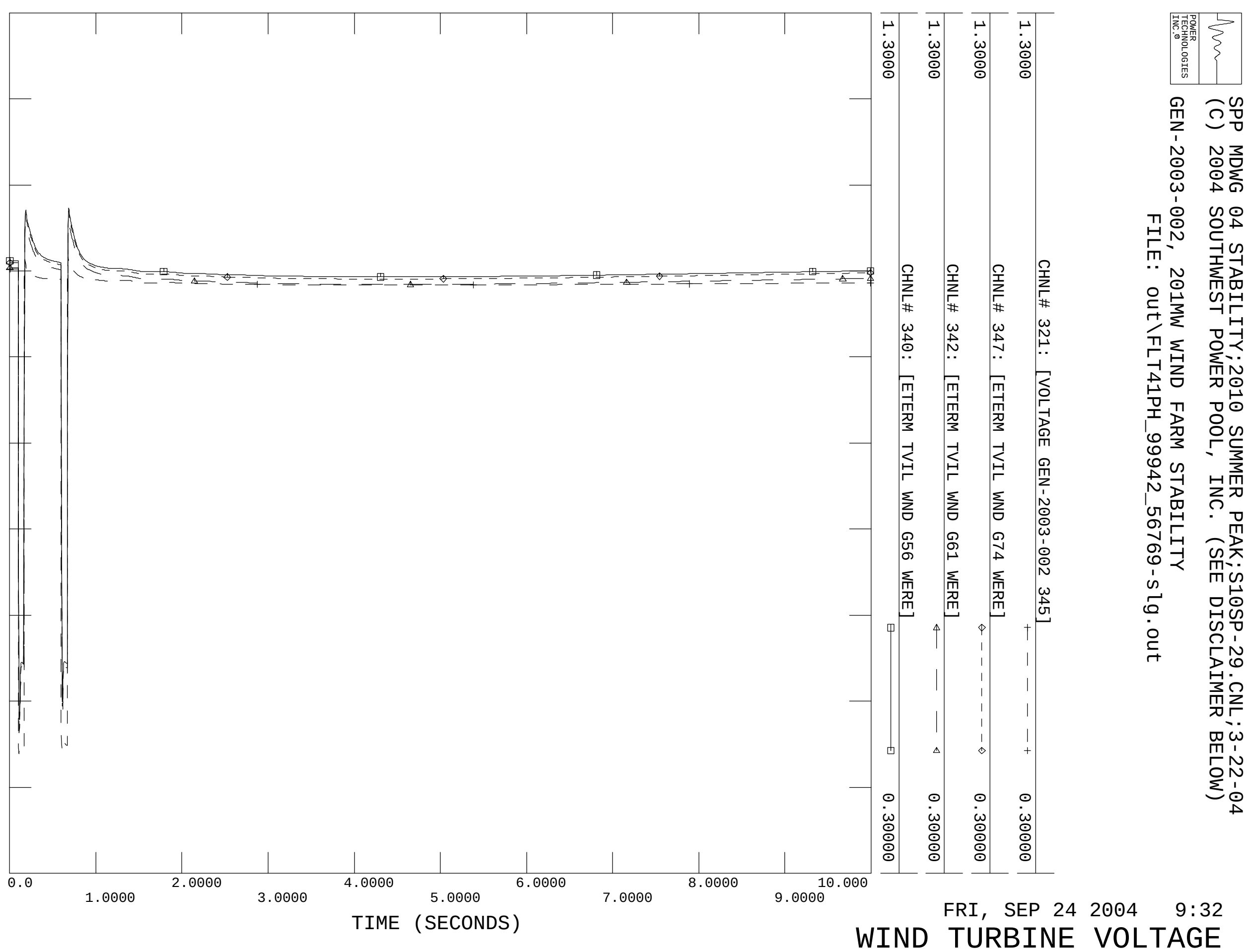
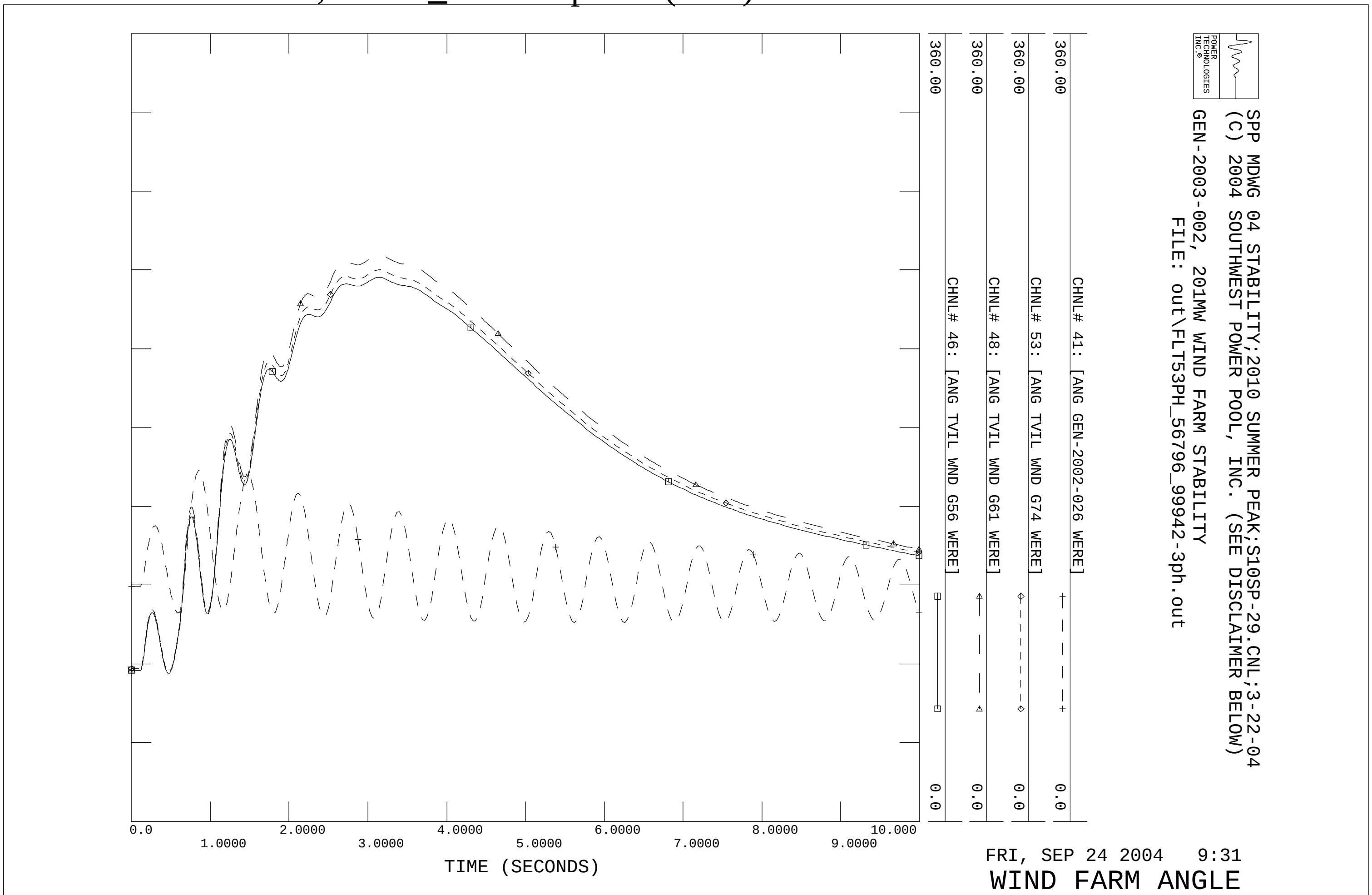
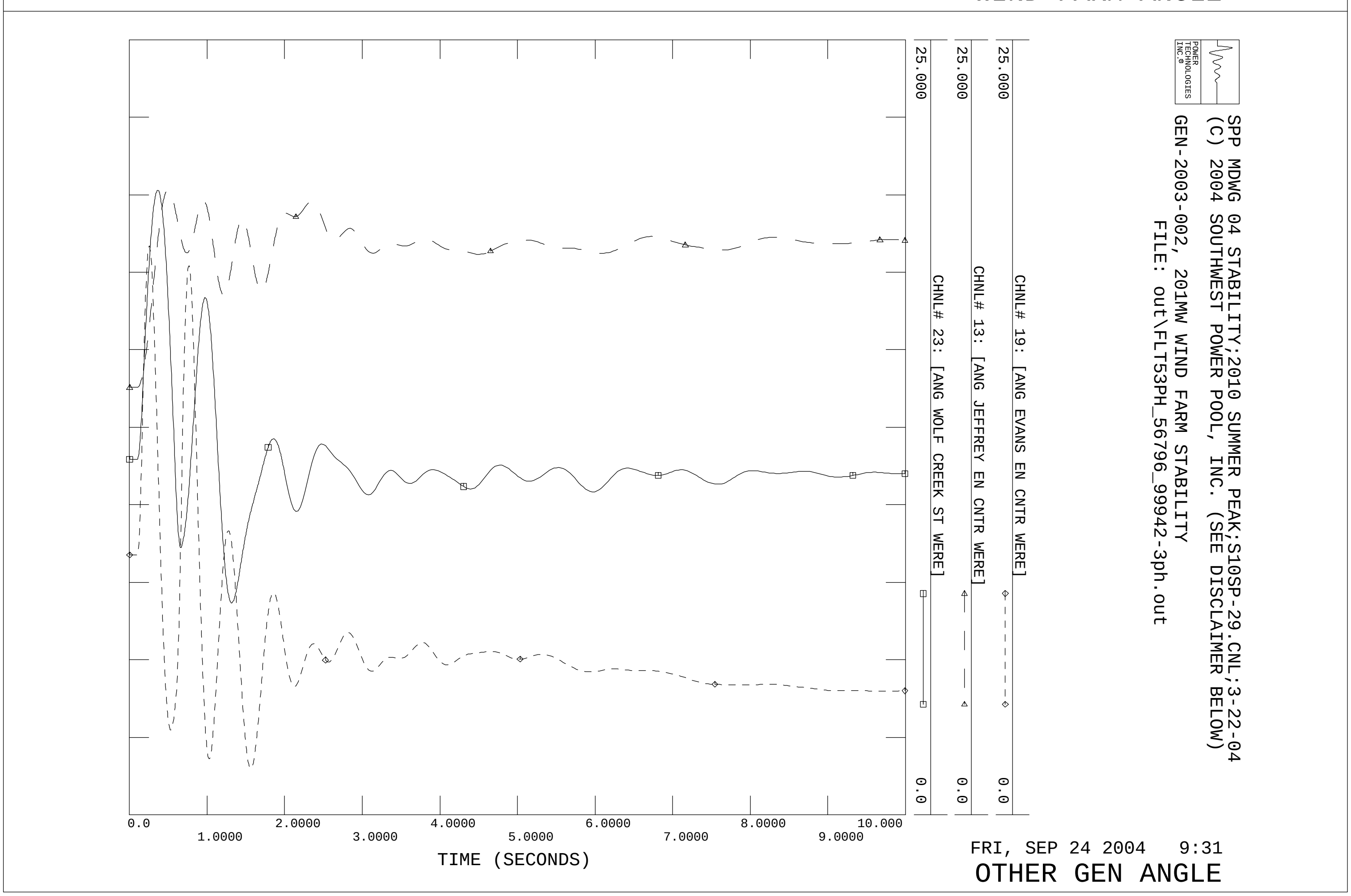
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
SPEED

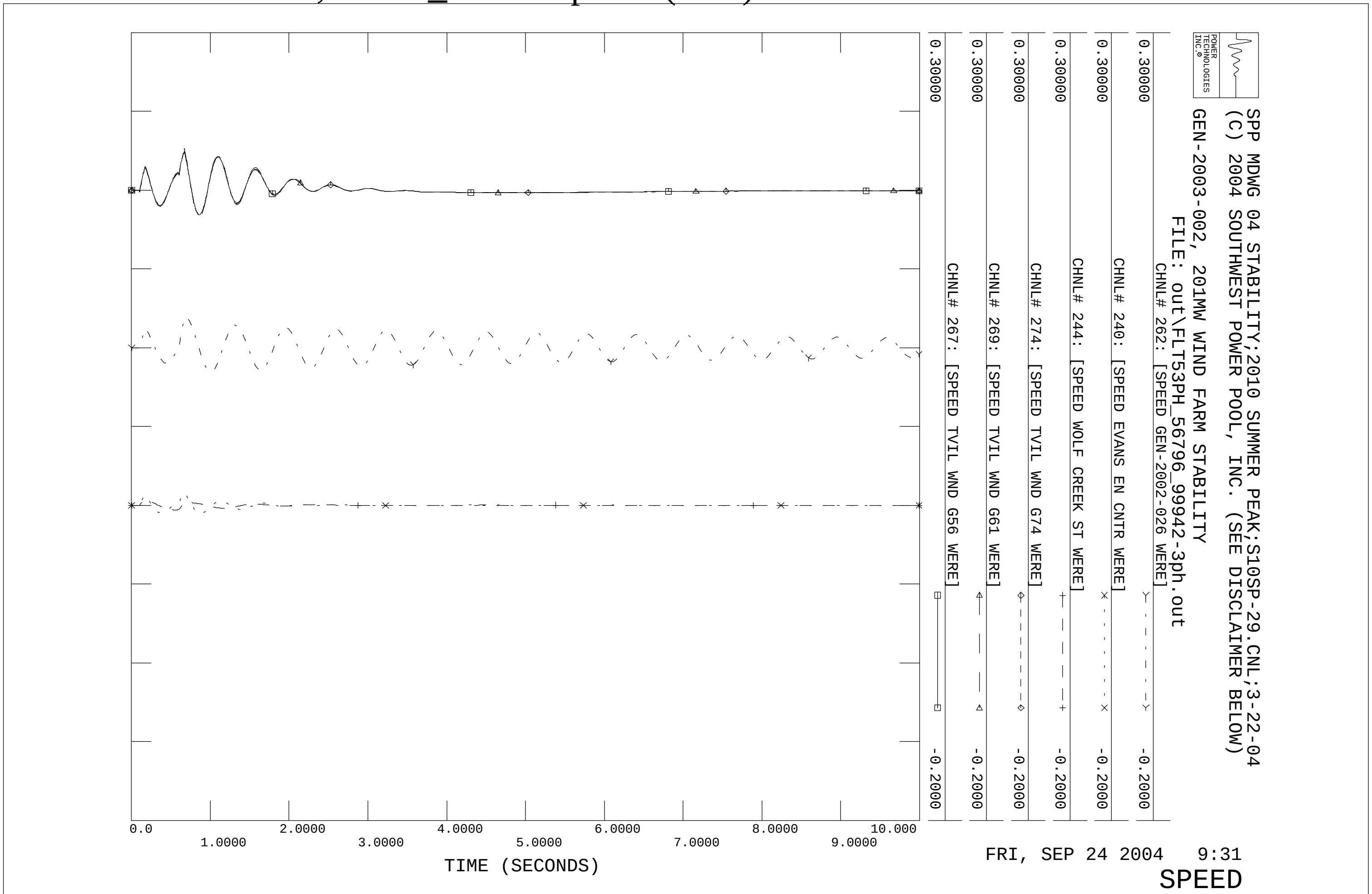

SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT41PH_99942_56769-slg.out
CHNL# 321: [VOLTAGE GEN-2003-002 345]
CHNL# 347: [ETERM TVIL WND G74 WERE]
CHNL# 342: [ETERM TVIL WND G61 WERE]
CHNL# 340: [ETERM TVIL WND G56 WERE]
1.3000
0.30000
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
WIND TURBINE VOLTAGE

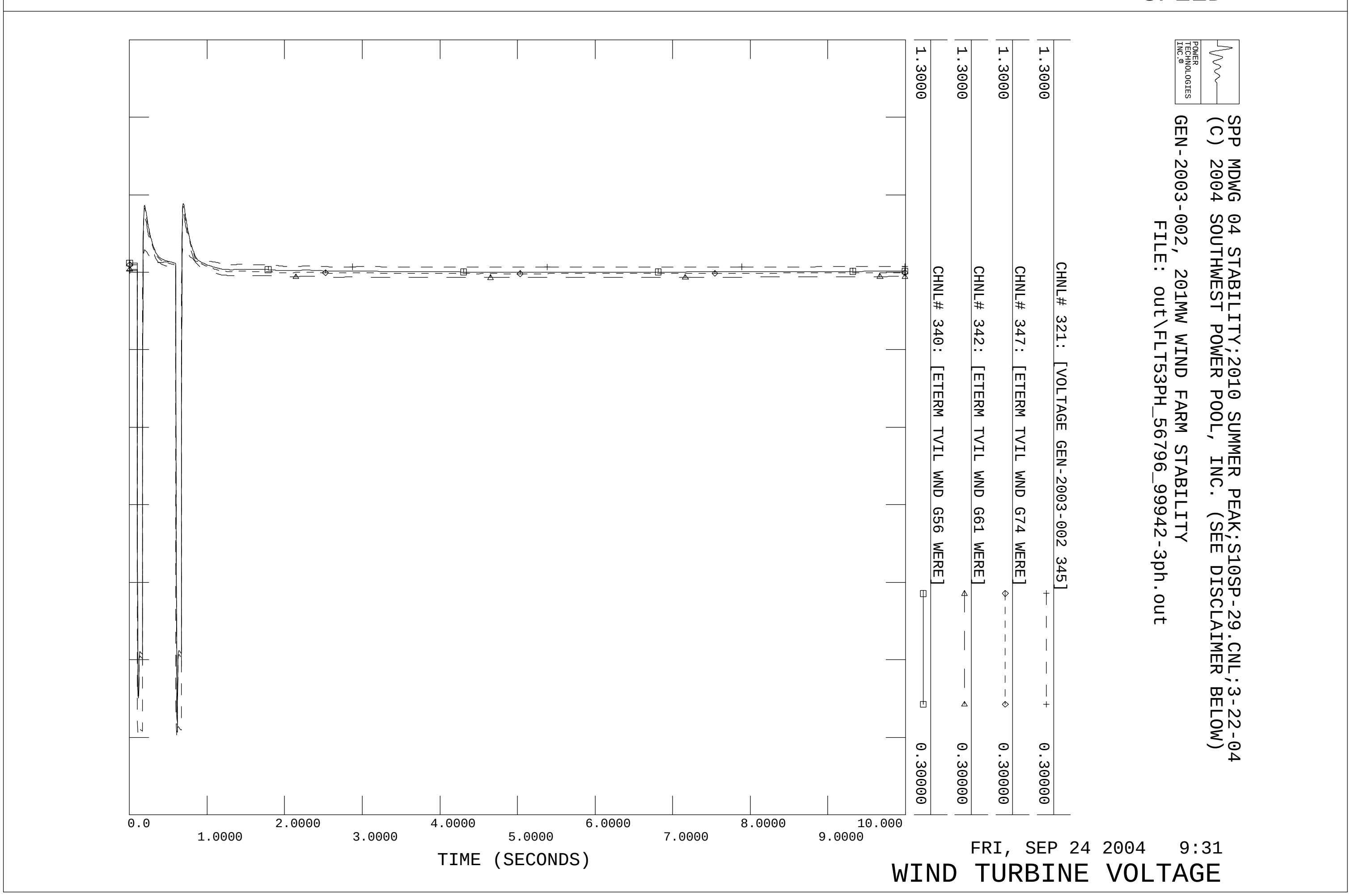
CASE ID: FLT53PH, 56796_99942-3ph (1 / 2)



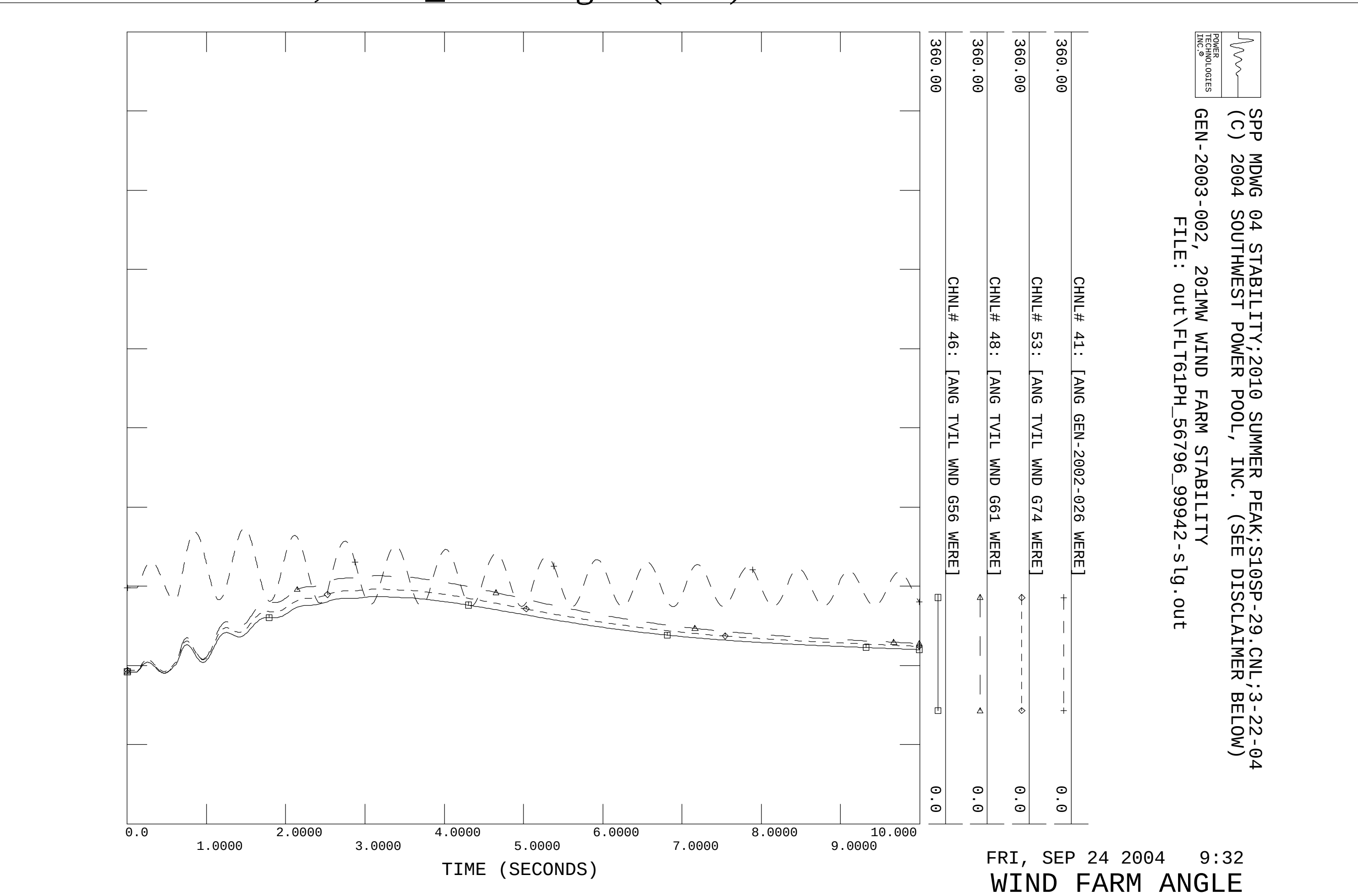


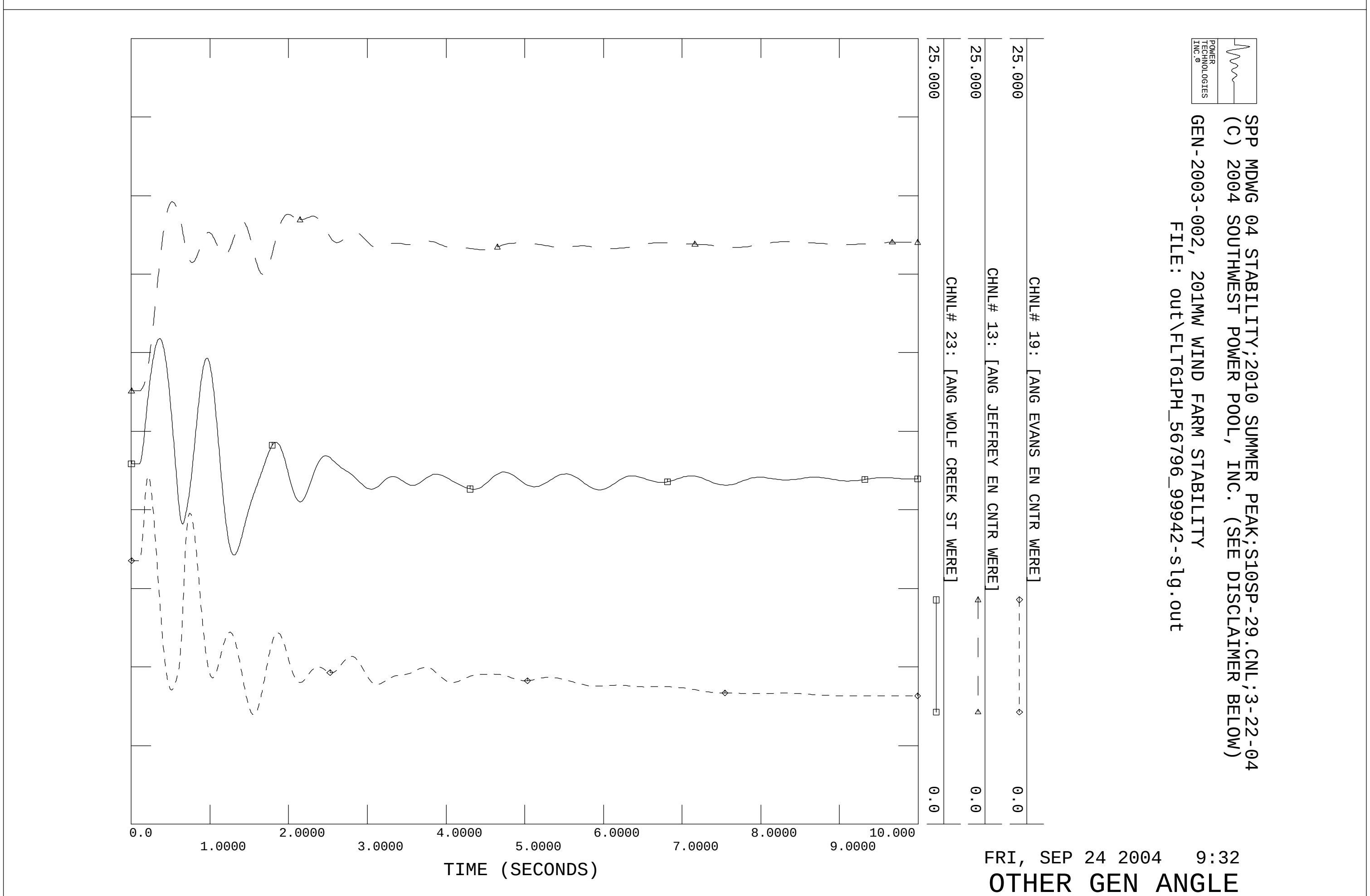
CASE ID: FLT53PH, 56796_99942-3ph (2 / 2)



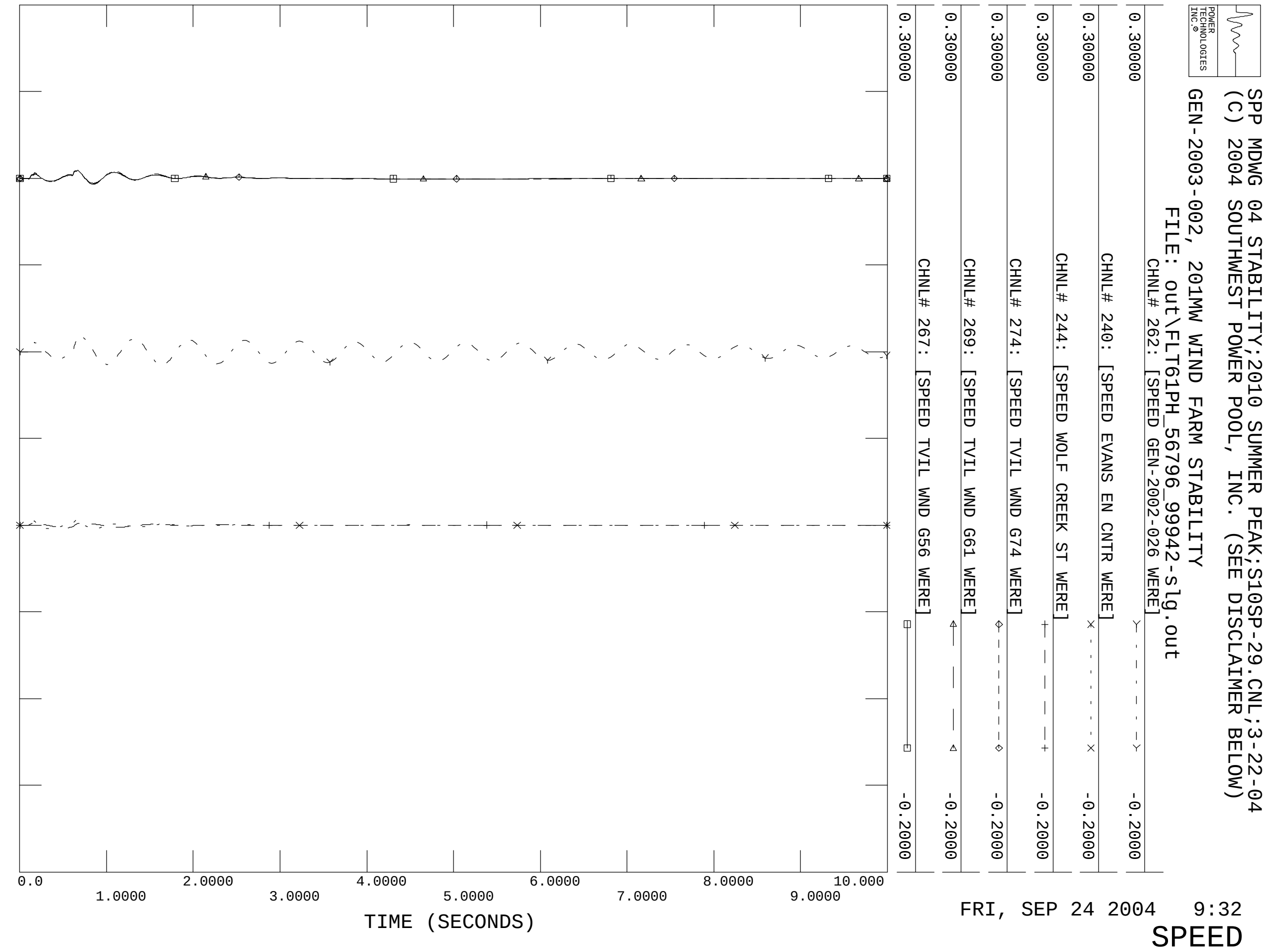


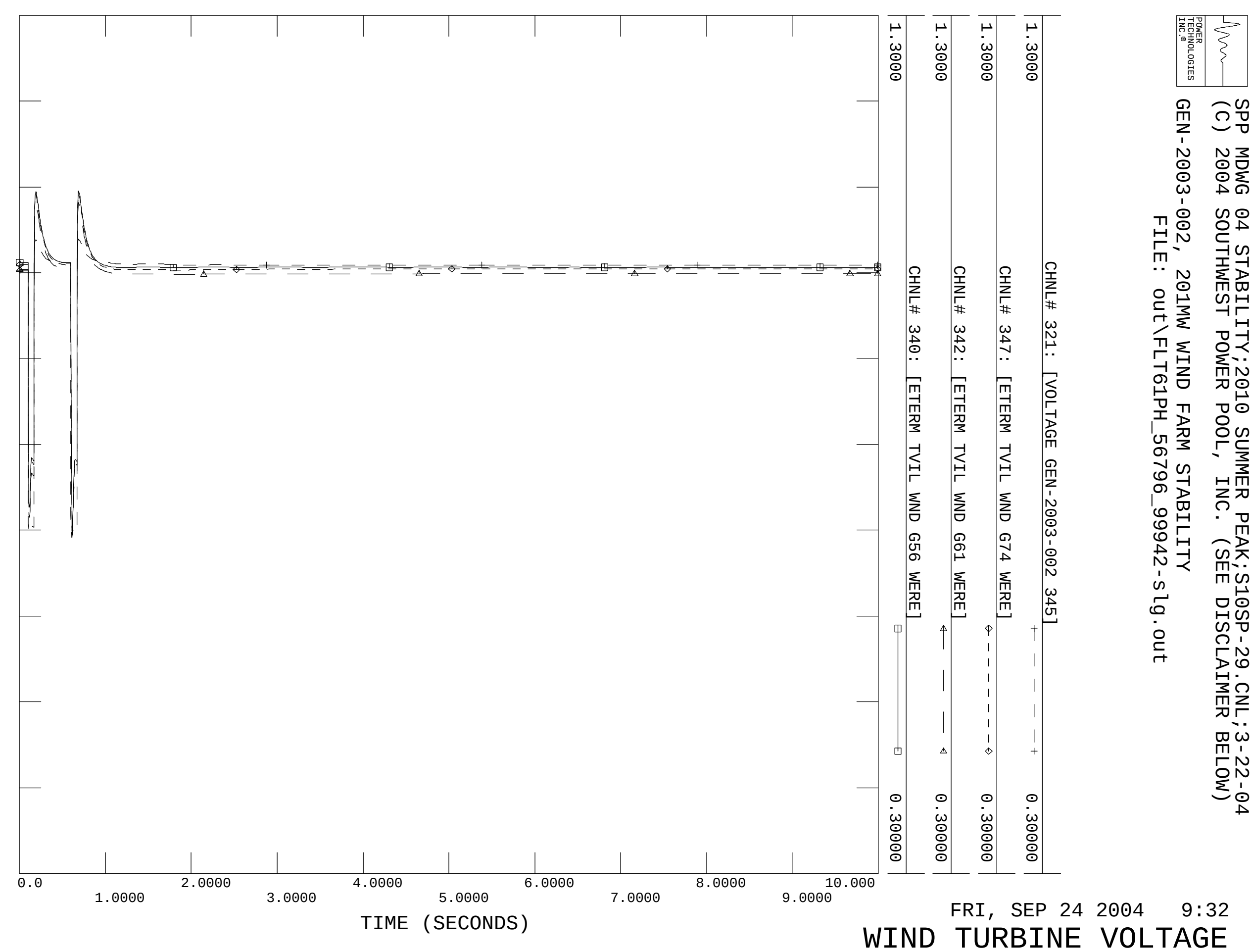
CASE ID: FLT61PH, 56796_99942-slg (1 / 2)



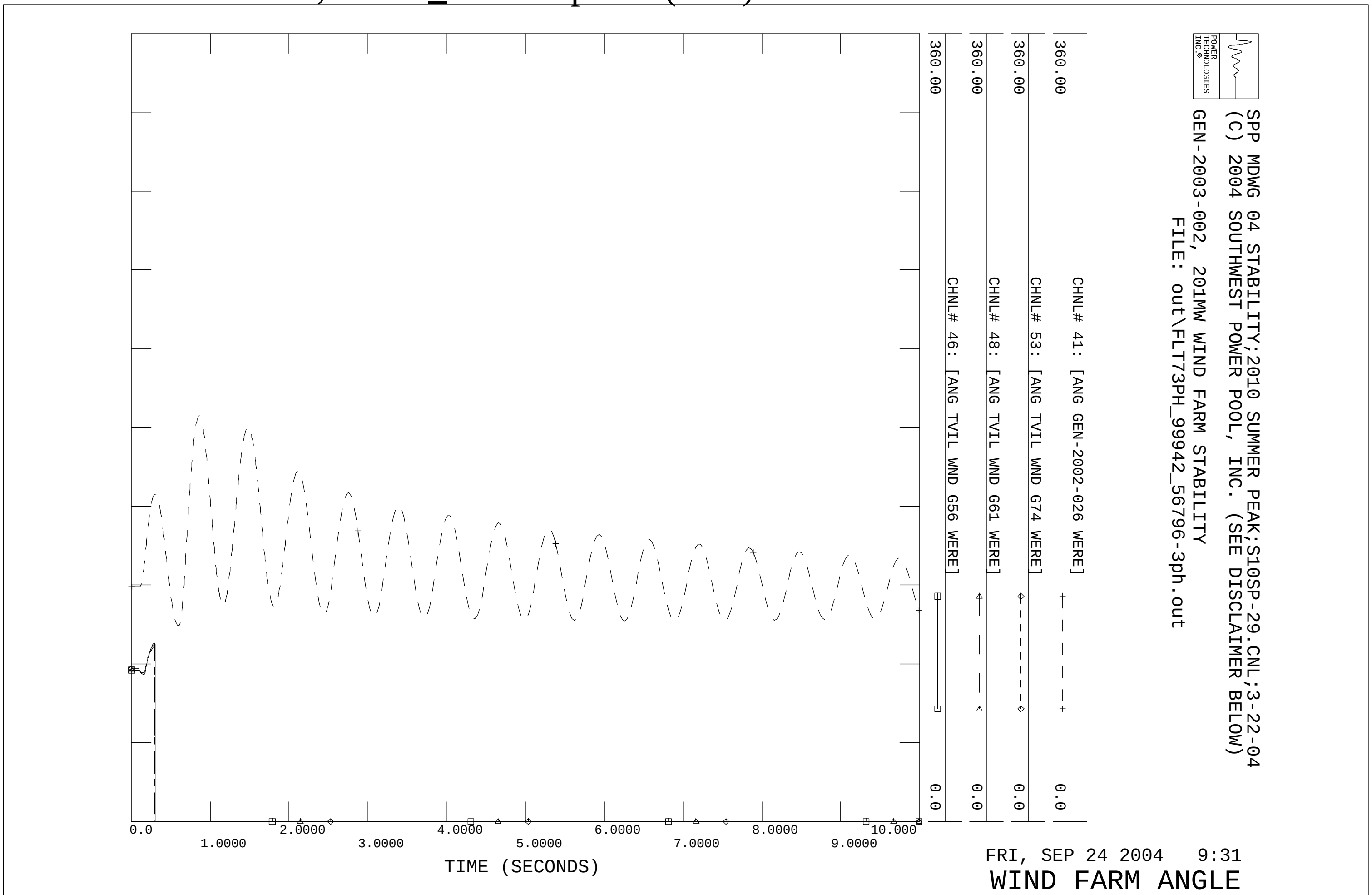


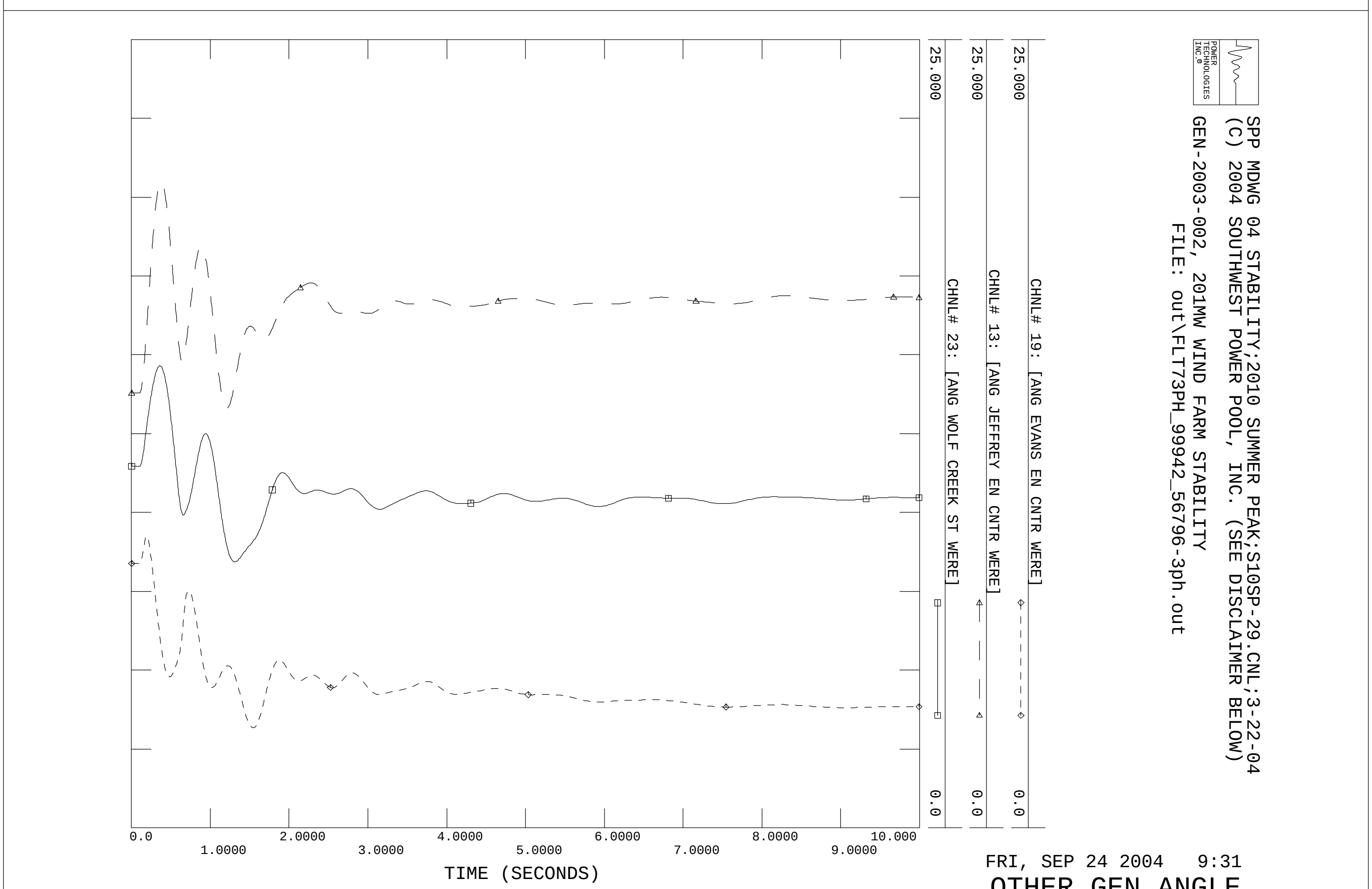
CASE ID: FLT61PH, 56796_99942-slg (2 / 2)

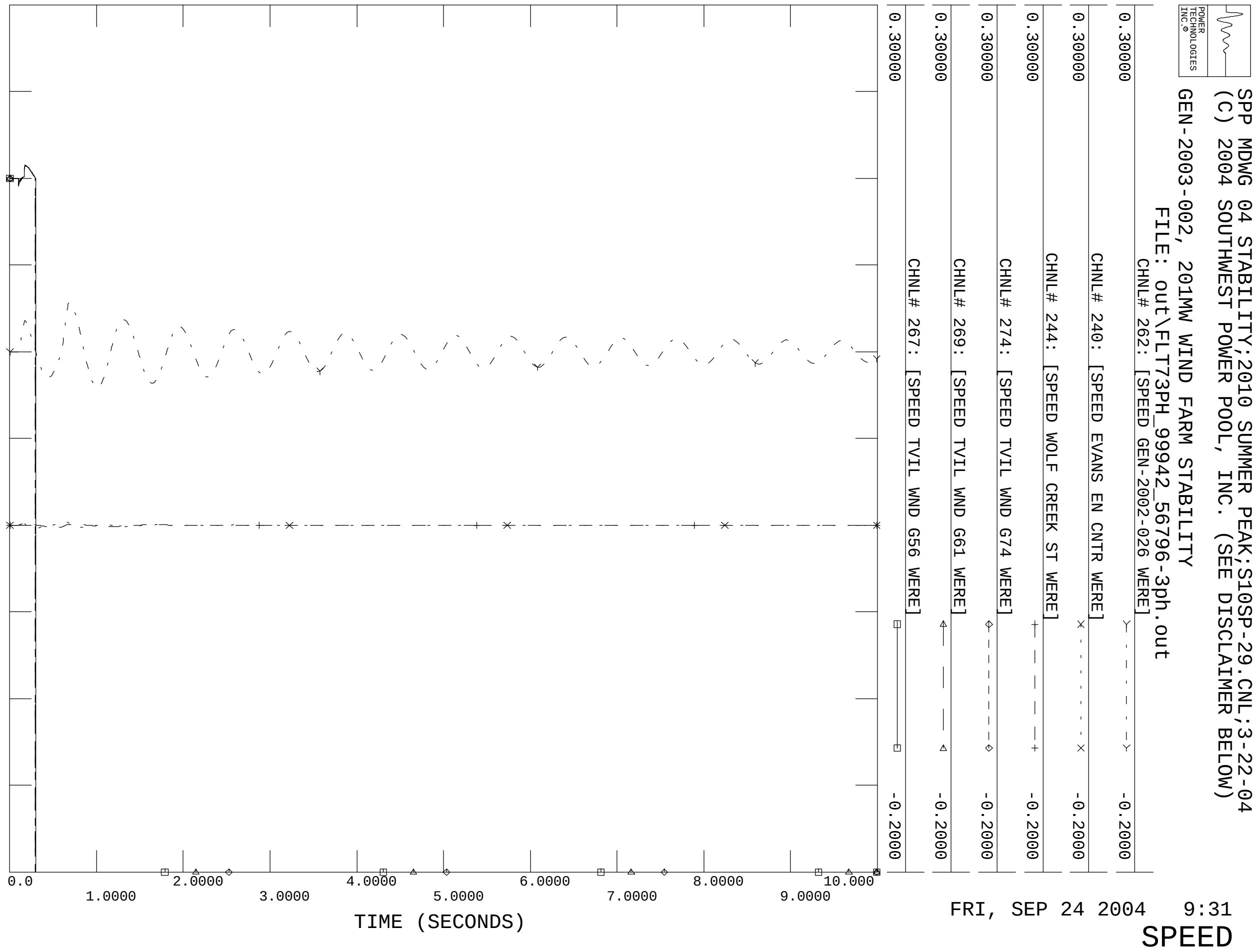


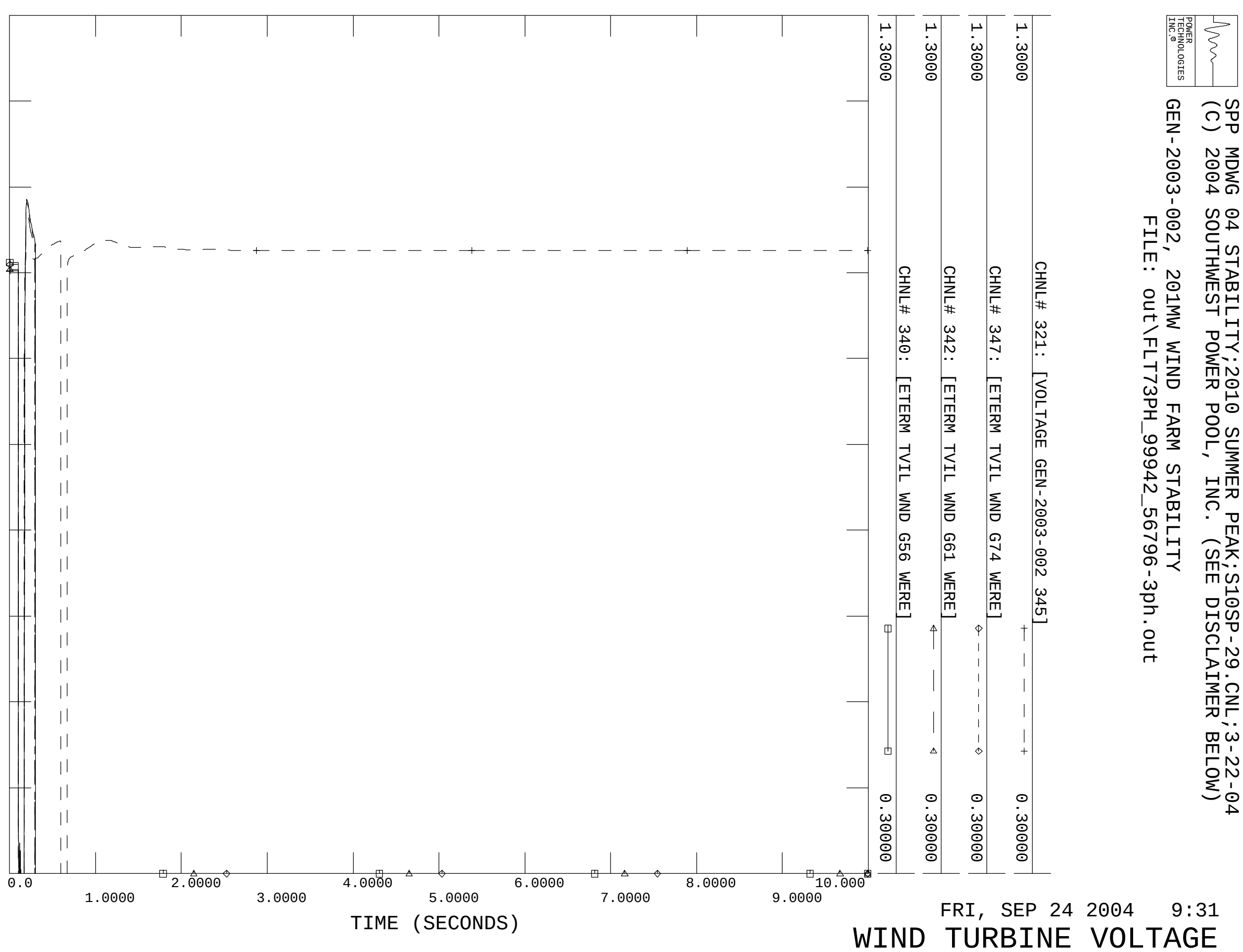


CASE ID: FLT73PH, 99942_56796-3ph (1 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT73PH_99942_56796-3ph.out
CHNL# 262: [SPEED GEN-2002-026 WERE]
CHNL# 240: [SPEED EVANS EN CNTR WERE]
CHNL# 244: [SPEED WOLF CREEK ST WERE]
CHNL# 274: [SPEED TVIL WND G74 WERE]
CHNL# 269: [SPEED TVIL WND G61 WERE]
CHNL# 267: [SPEED TVIL WND G56 WERE]
0.30000
-0.2000
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
SPEED


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT73PH_99942_56796-3ph.out
CHNL# 321: [VOLTAGE GEN-2003-002 345]
CHNL# 347: [ETERM TVIL WND G74 WERE]
CHNL# 342: [ETERM TVIL WND G61 WERE]
CHNL# 340: [ETERM TVIL WND G56 WERE]
1.3000
0.30000
0.0
1.0000
2.0000
3.0000
4.0000
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6.0000
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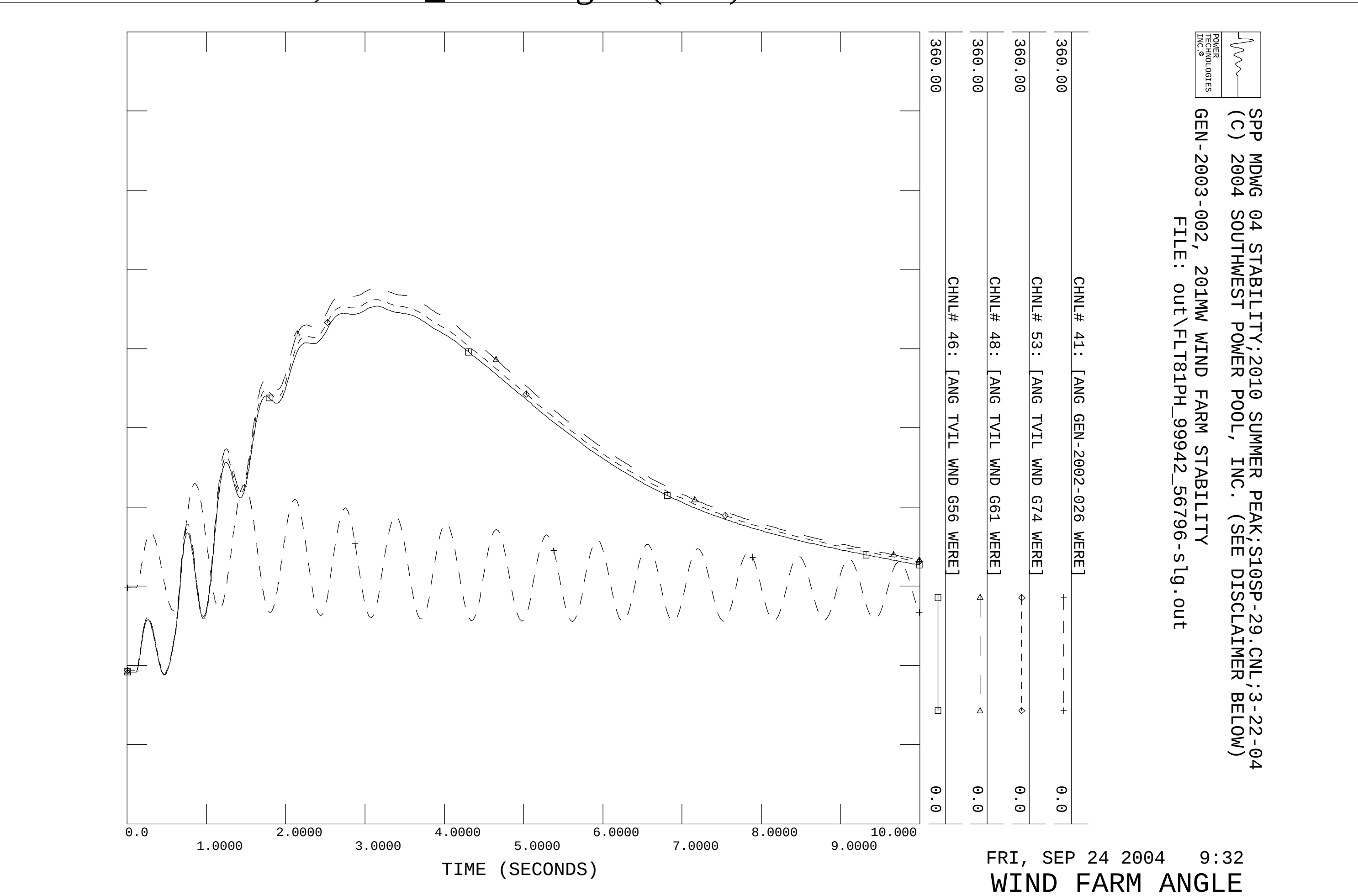
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
WIND TURBINE VOLTAGE


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT81PH_99942_56796-slg.out
CHNL# 41: [ANG GEN-2002-026 WERE]
CHNL# 53: [ANG TVIL WND G74 WERE]
CHNL# 48: [ANG TVIL WND G61 WERE]
CHNL# 46: [ANG TVIL WND G56 WERE]
360.00
0.0
0.0
1.0000
2.0000
3.0000
4.0000
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7.0000
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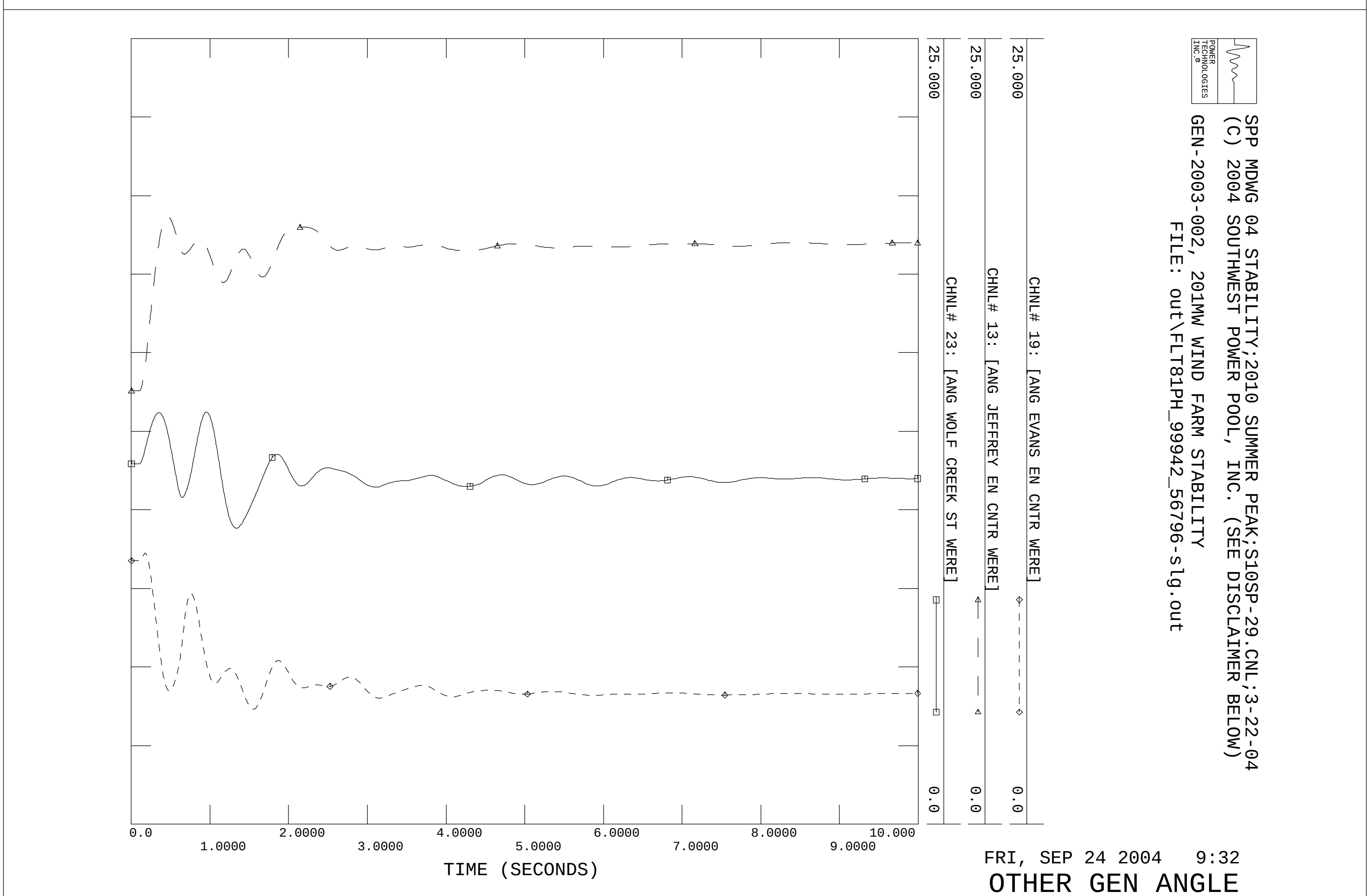
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
WIND FARM ANGLE


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT81PH_99942_56796-slg.out
CHNL# 19: [ANG EVANS EN CNTR WERE]
CHNL# 13: [ANG JEFFREY EN CNTR WERE]
CHNL# 23: [ANG WOLF CREEK ST WERE]
25.000
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
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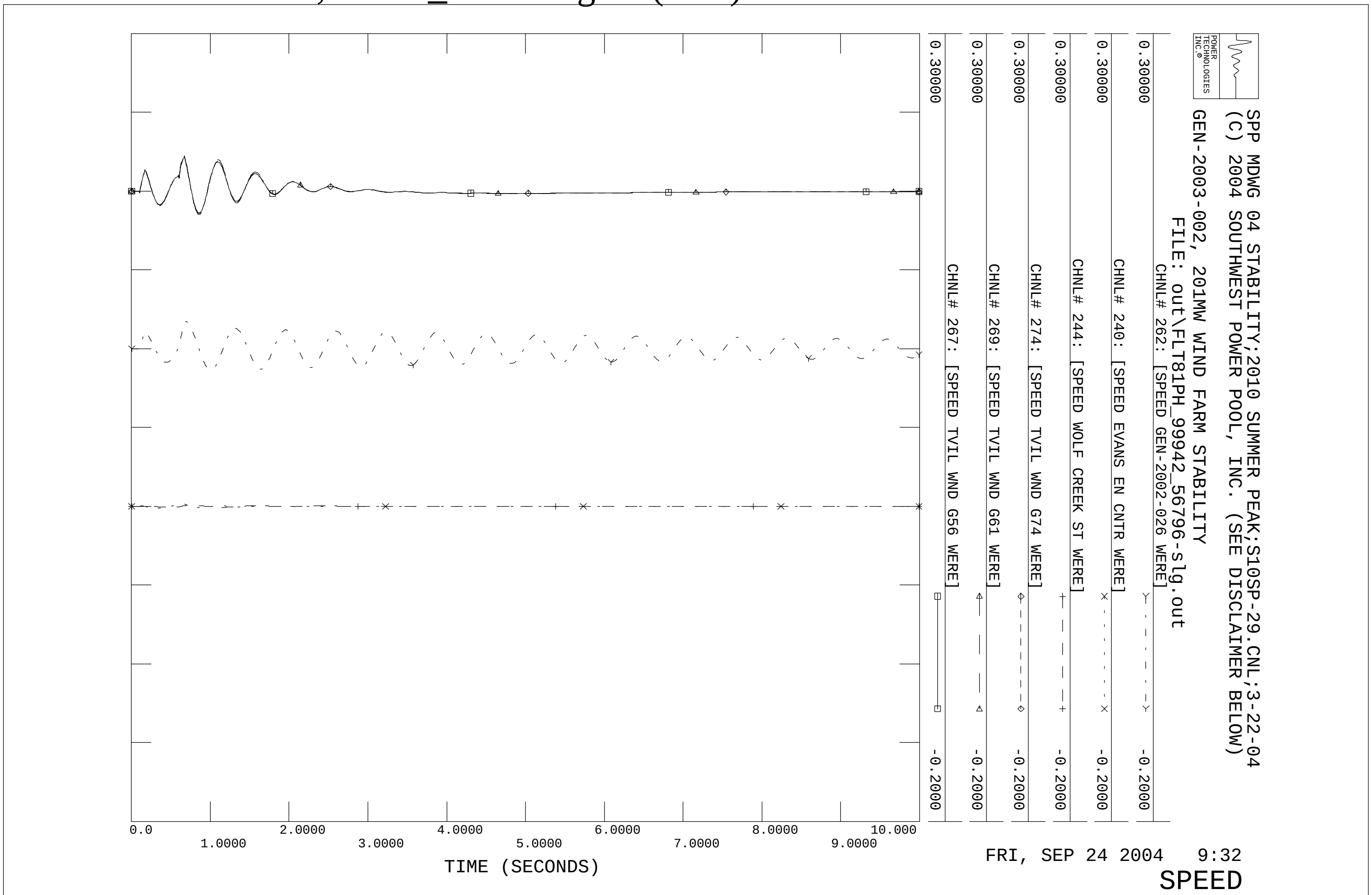
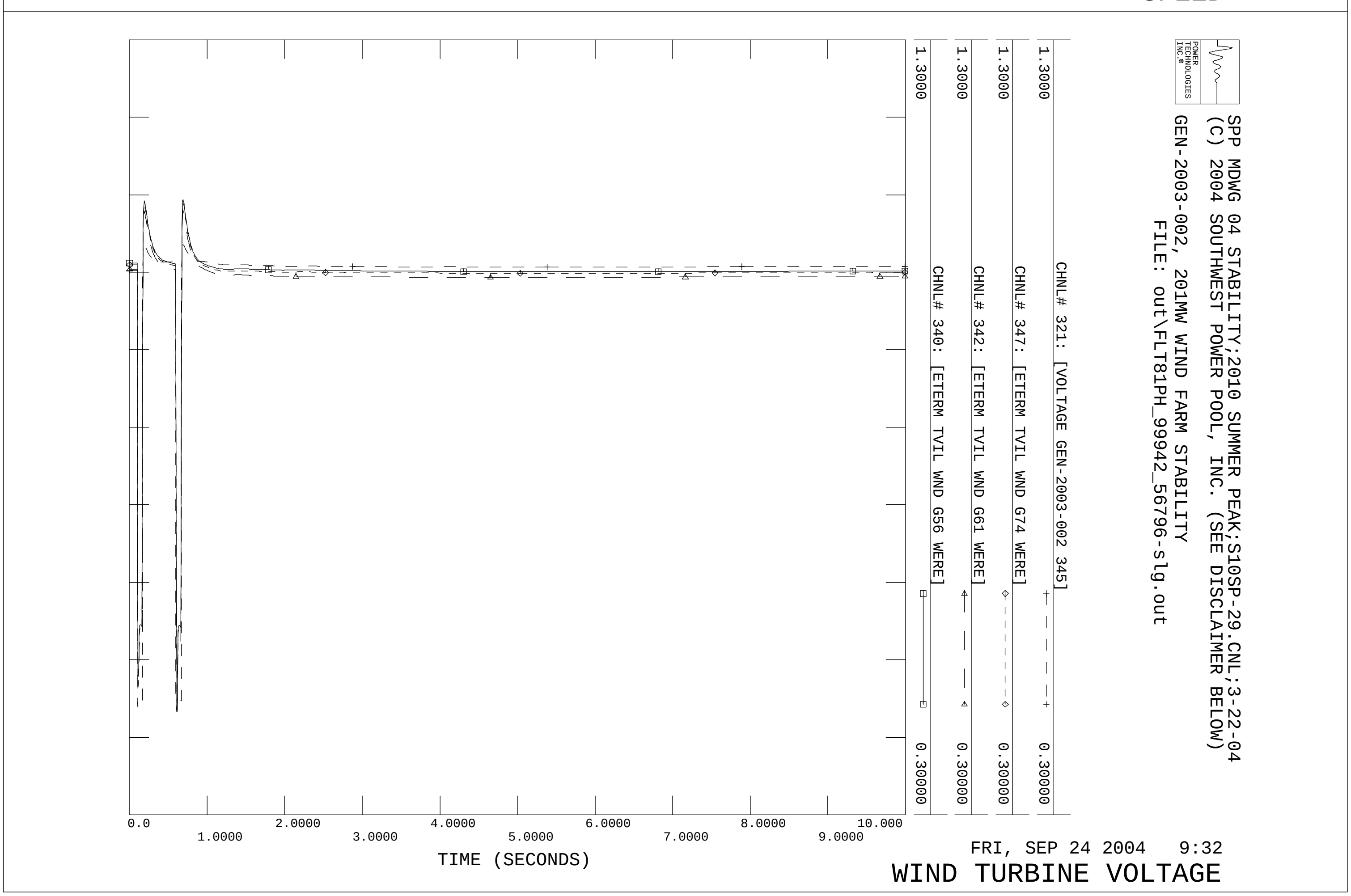
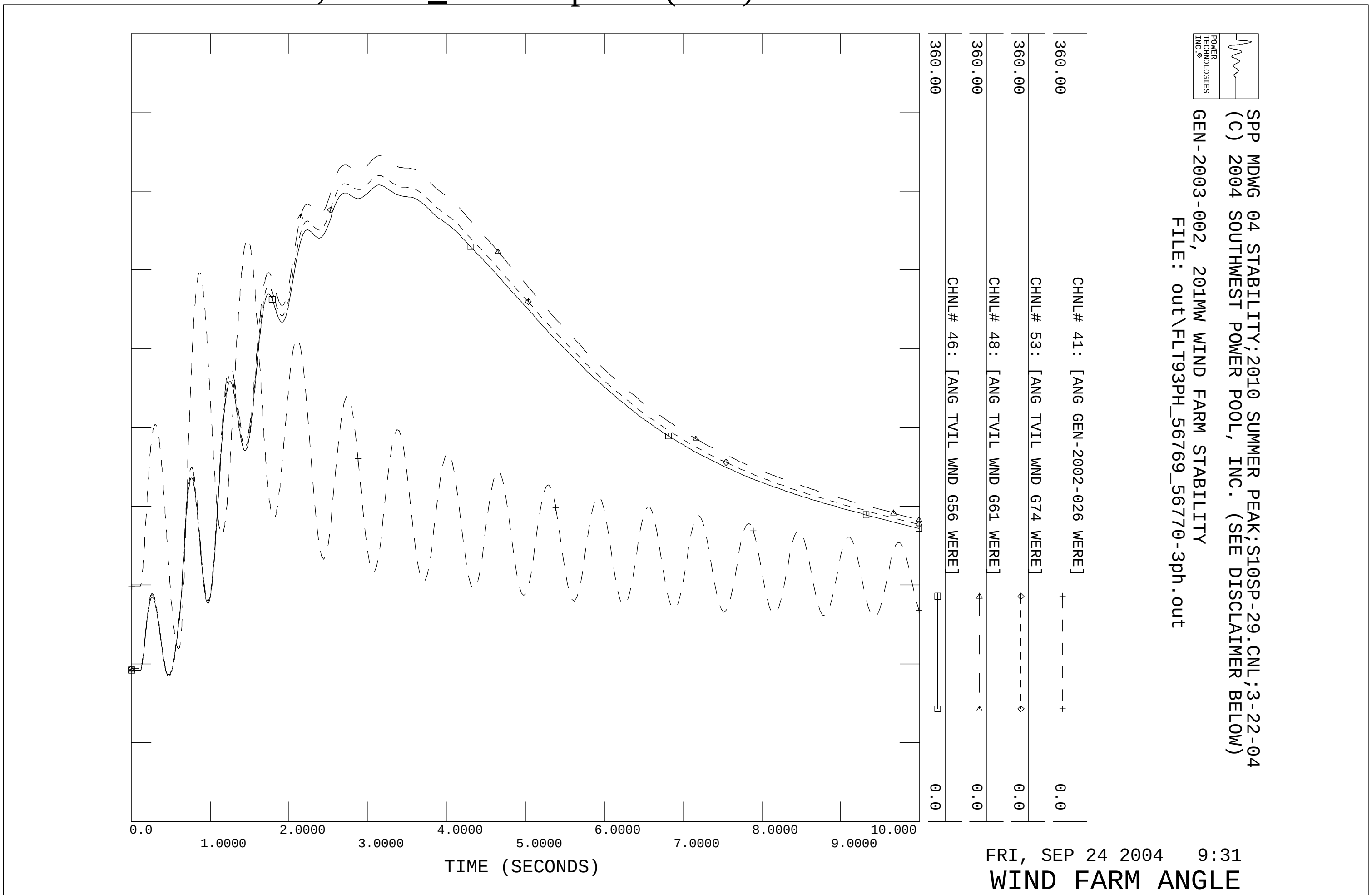
TIME (SECONDS)
FRI, SEP 24 2004 9:32
OTHER GEN ANGLE

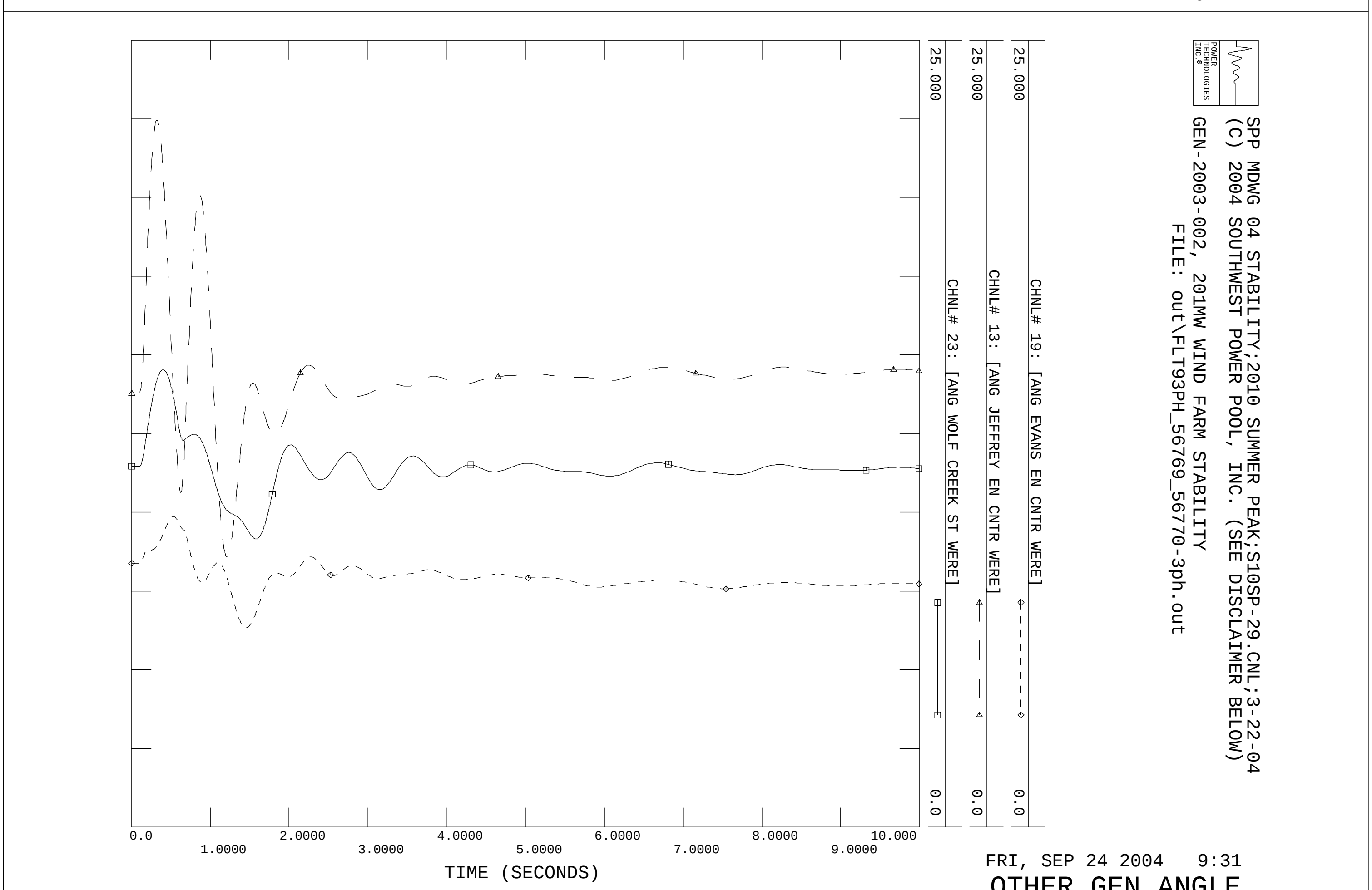
CASE ID: FLT81PH, 99942_56796-slg (2 / 2)

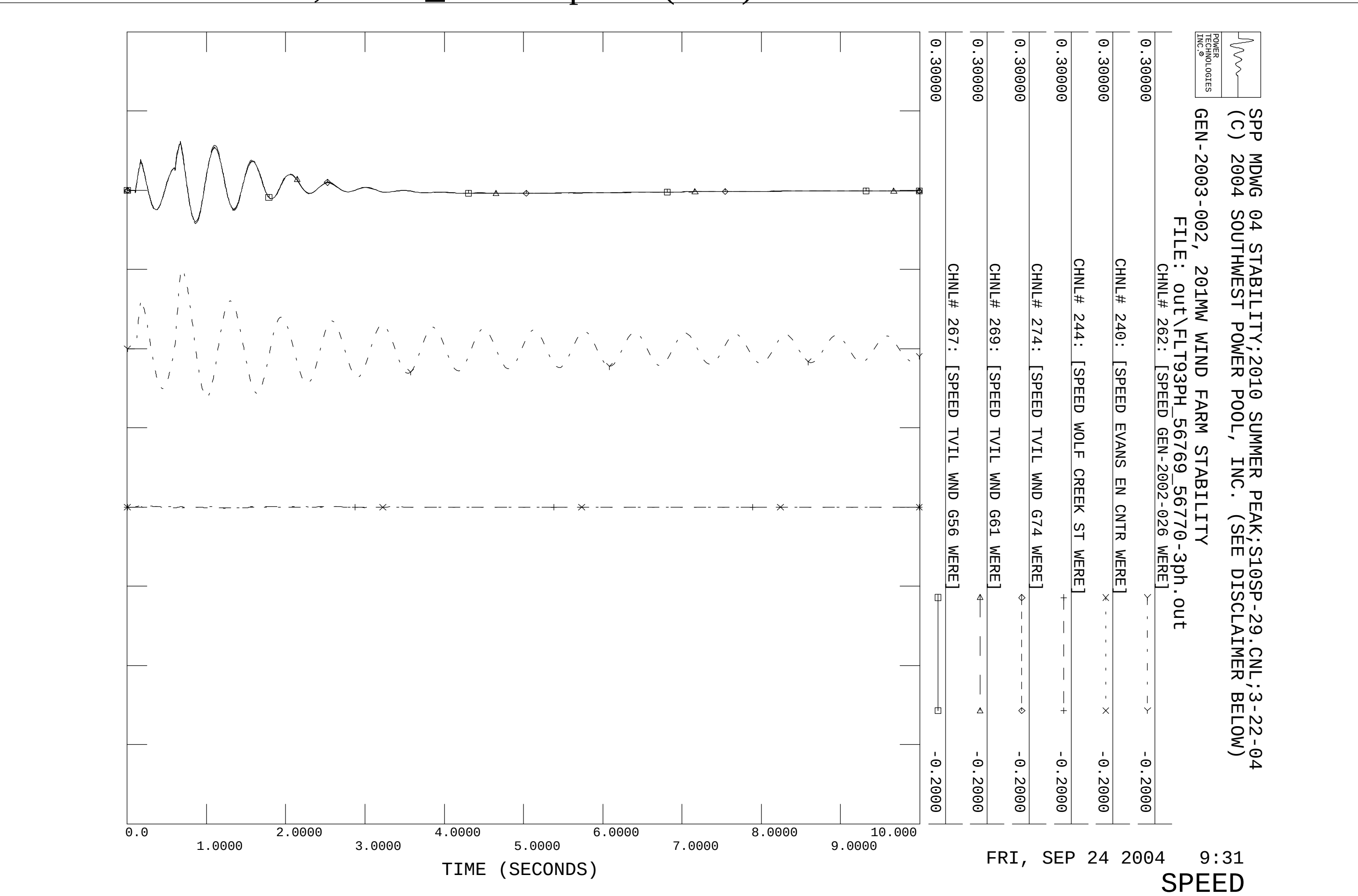


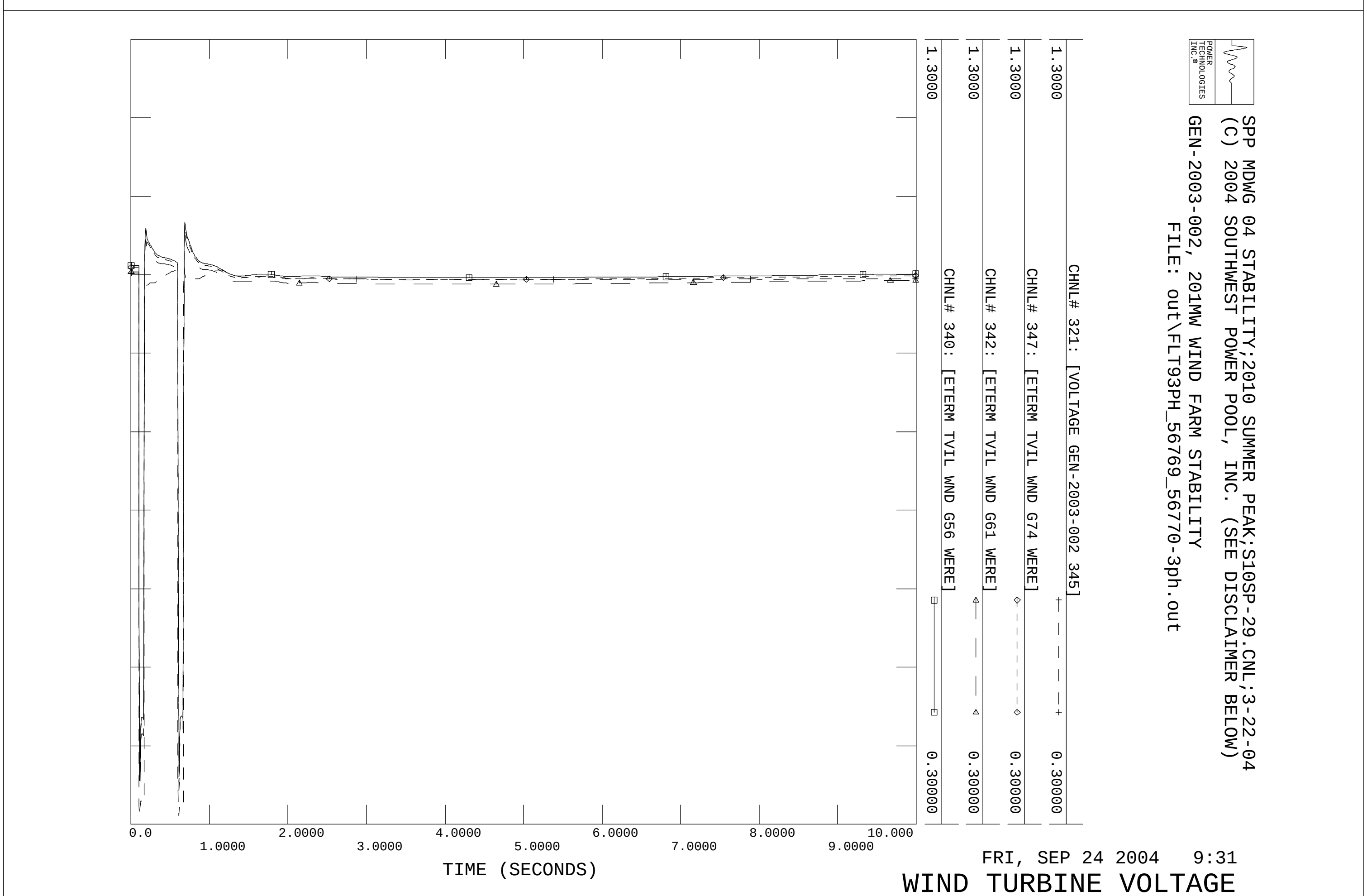


CASE ID: FLT93PH, 56769_56770-3ph (1 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT93PH_56769_56770-3ph.out
POWER TECHNOLOGIES INC.®
CHNL# 262: [SPEED GEN-2002-026 WERE]
0.30000
-0.2000
CHNL# 240: [SPEED EVANS EN CNTR WERE]
0.30000
-0.2000
CHNL# 244: [SPEED WOLF CREEK ST WERE]
0.30000
-0.2000
CHNL# 274: [SPEED TVIL WND G74 WERE]
0.30000
-0.2000
CHNL# 269: [SPEED TVIL WND G61 WERE]
0.30000
-0.2000
CHNL# 267: [SPEED TVIL WND G56 WERE]
0.30000
-0.2000
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
SPEED


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT93PH_56769_56770-3ph.out
POWER TECHNOLOGIES INC.®
CHNL# 321: [VOLTAGE GEN-2003-002 345]
1.3000
0.30000
CHNL# 347: [ETERM TVIL WND G74 WERE]
1.3000
0.30000
CHNL# 342: [ETERM TVIL WND G61 WERE]
1.3000
0.30000
CHNL# 340: [ETERM TVIL WND G56 WERE]
1.3000
0.30000
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
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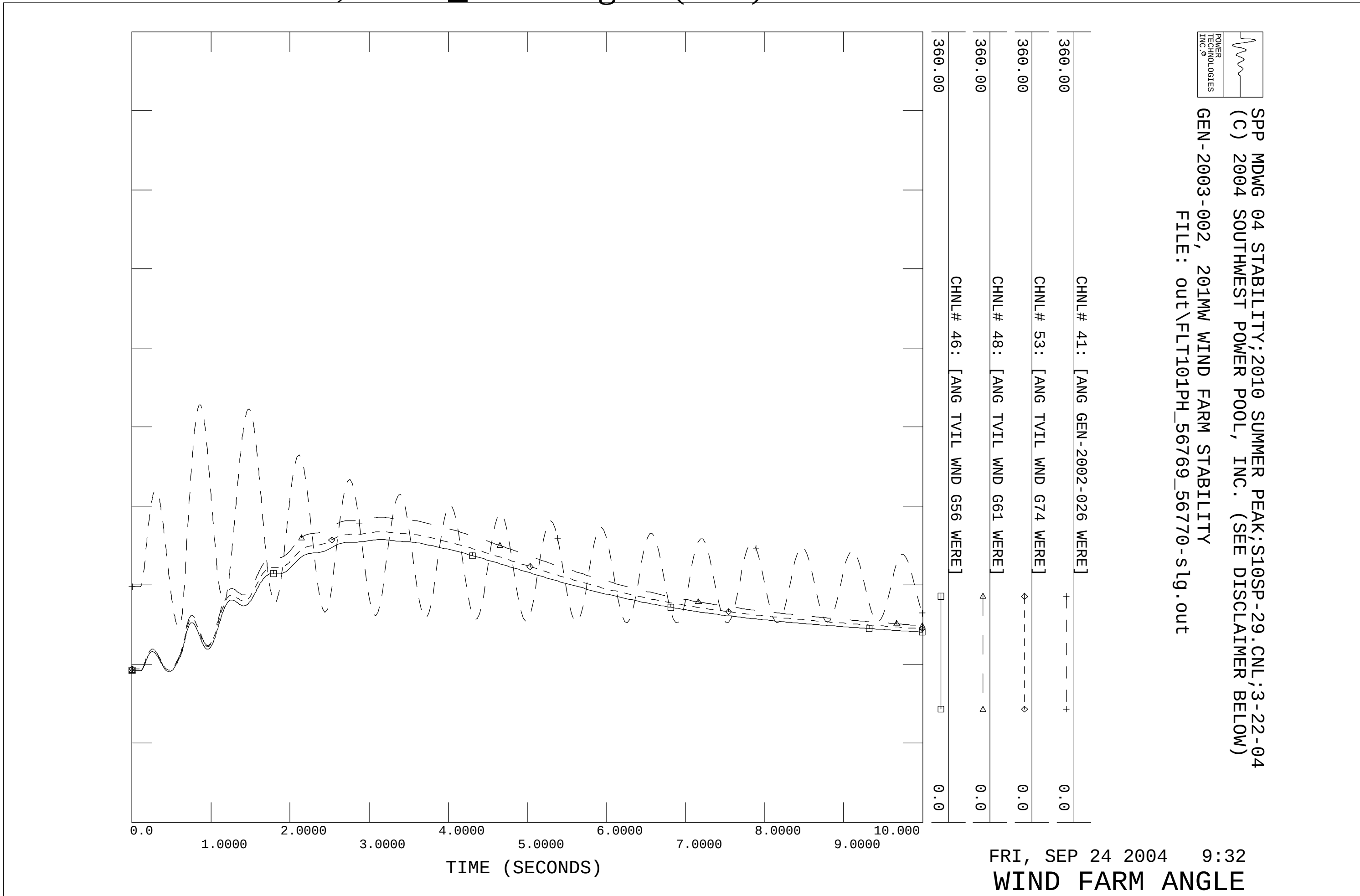
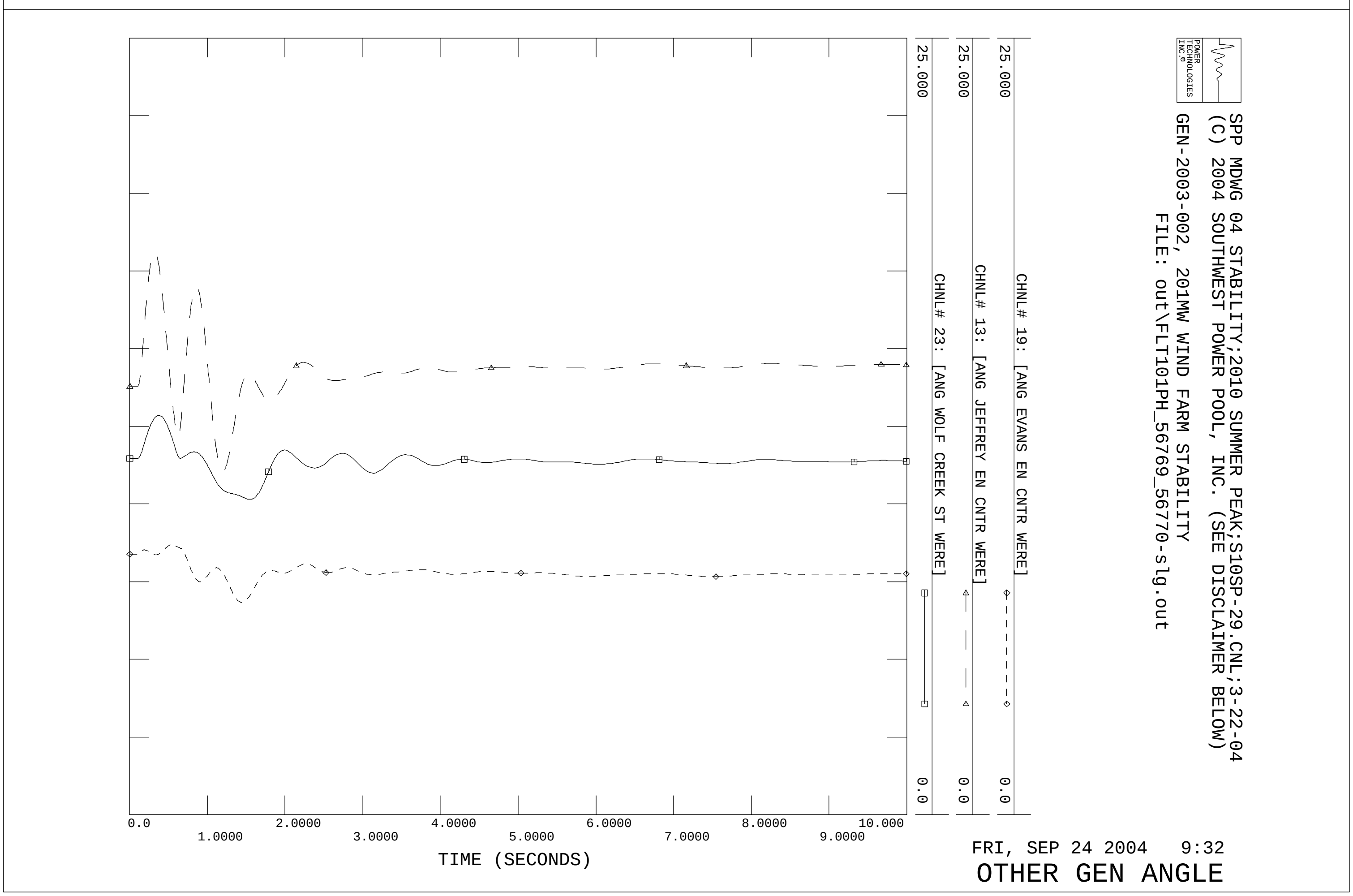
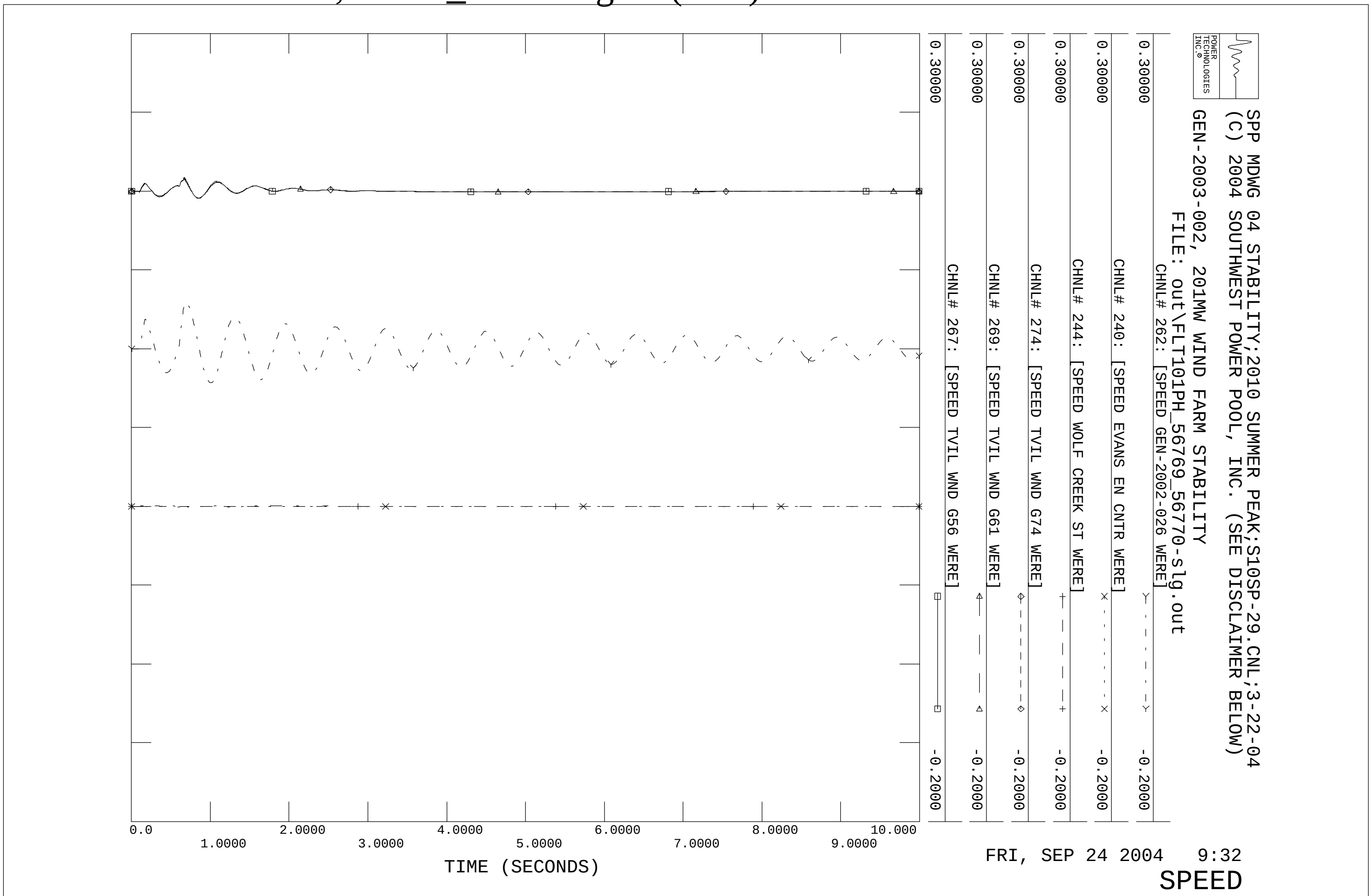
TIME (SECONDS)
FRI, SEP 24 2004 9:31
WIND TURBINE VOLTAGE

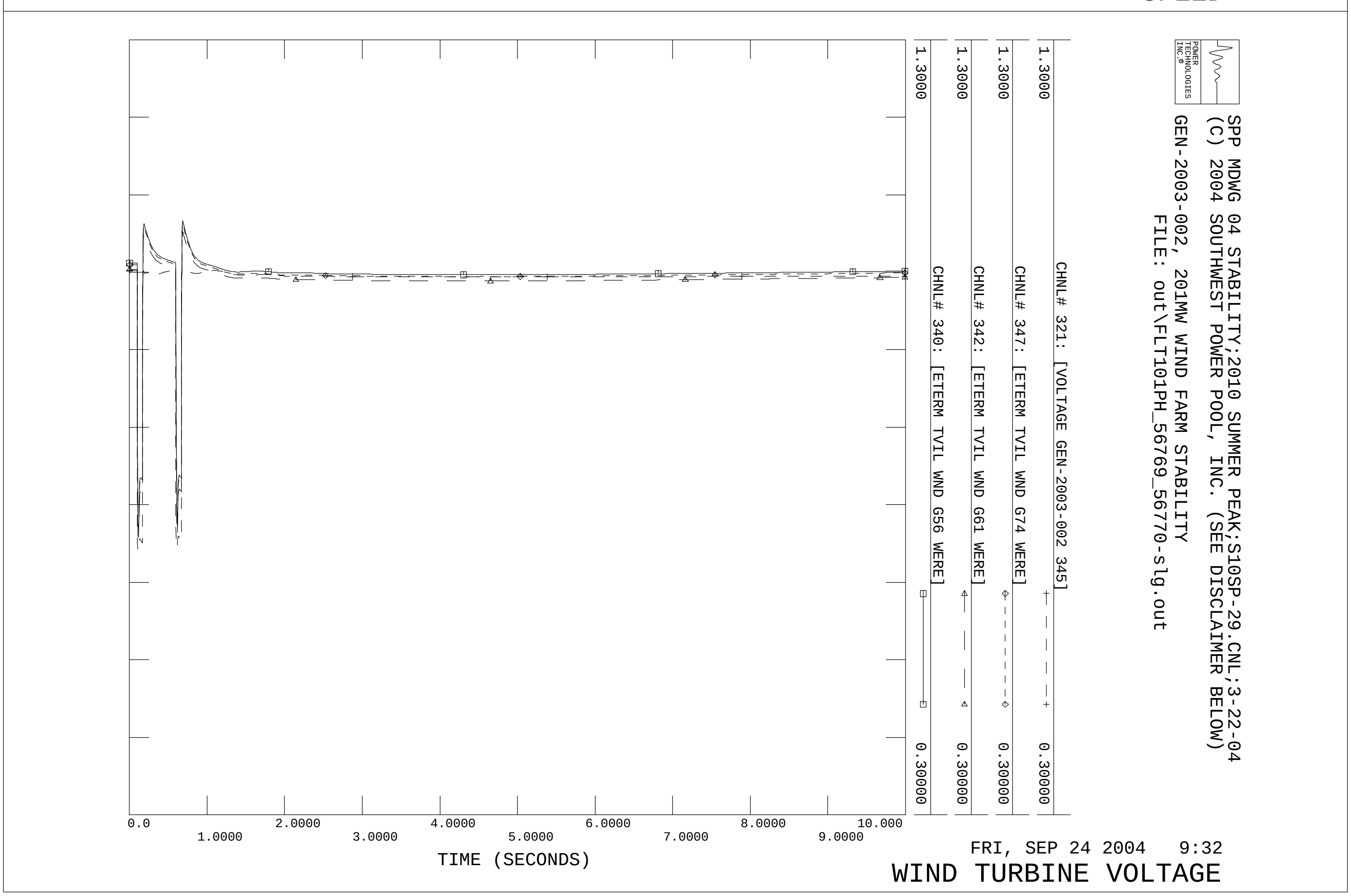
CASE ID: FLT101PH, 56769_56770-slg (1 / 2)



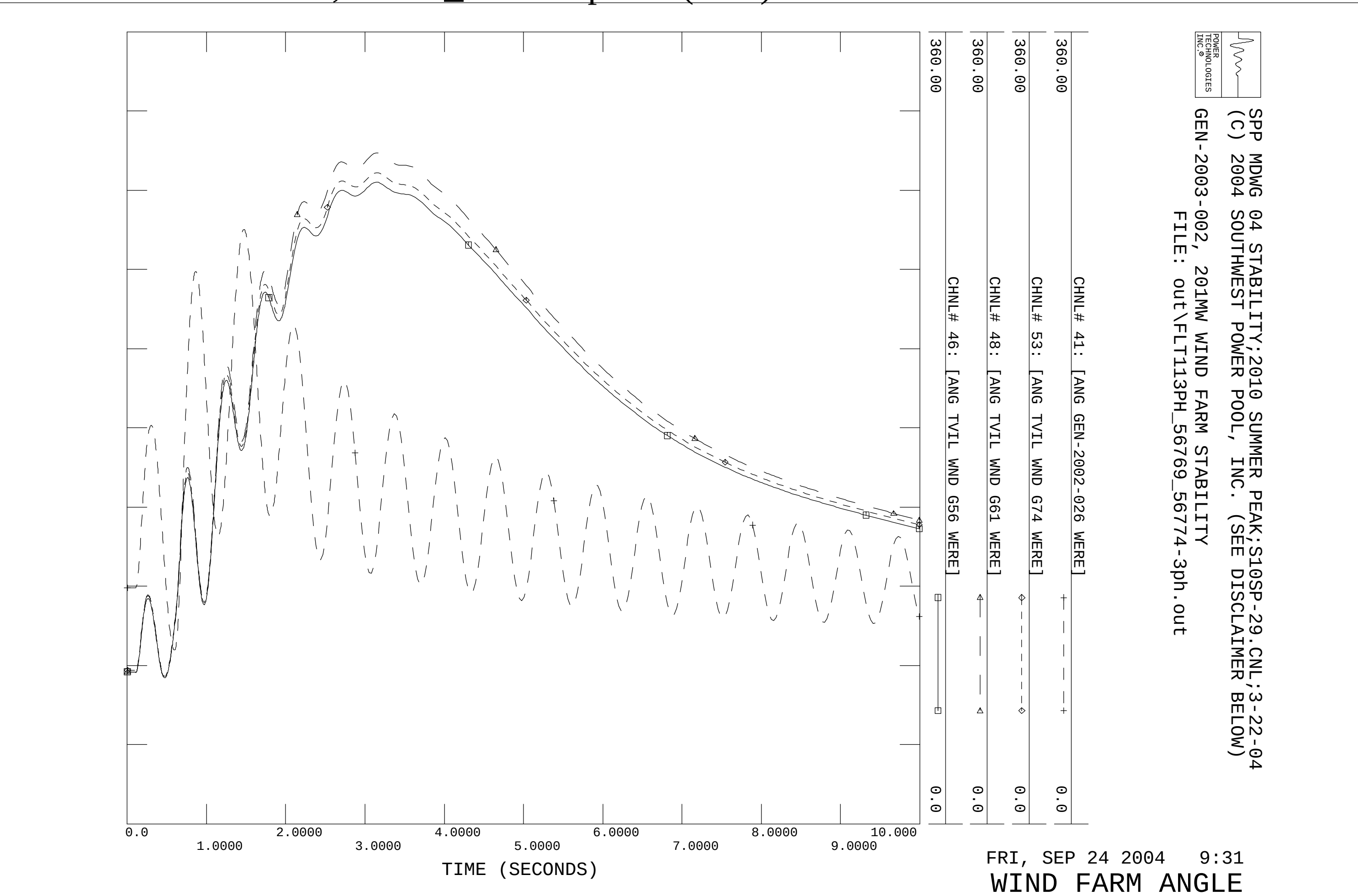


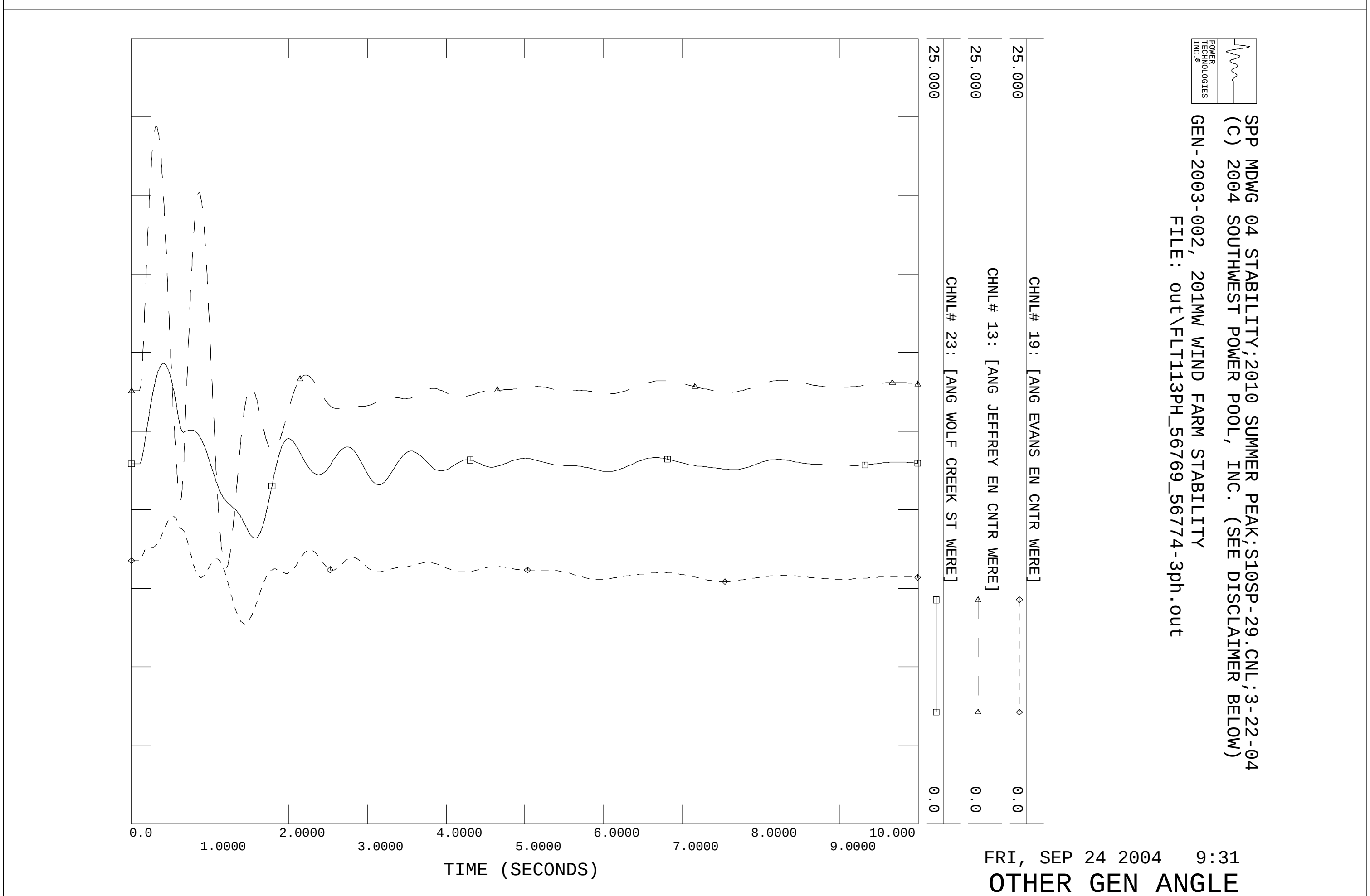
CASE ID: FLT101PH, 56769_56770-slg (2 / 2)



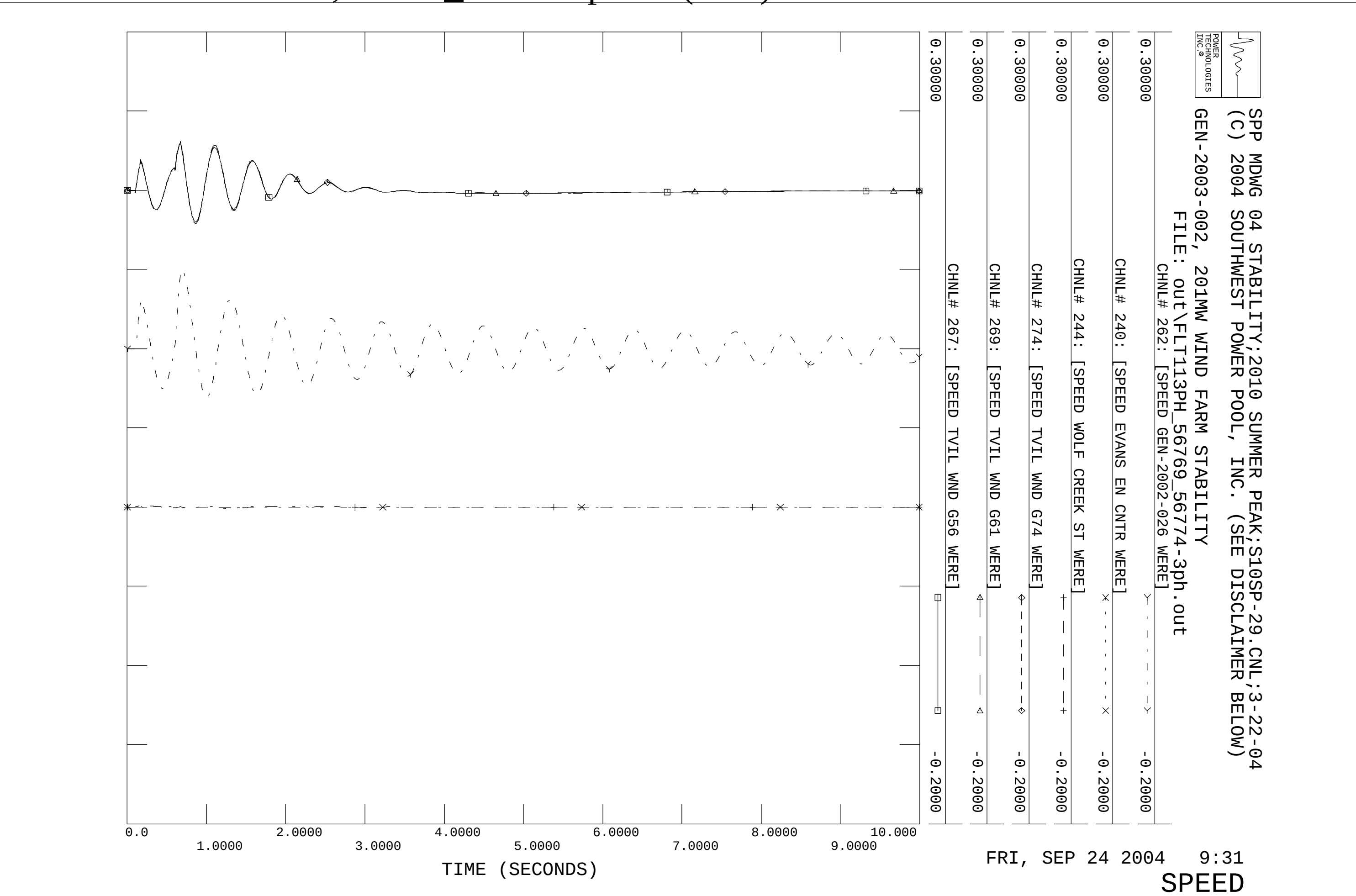


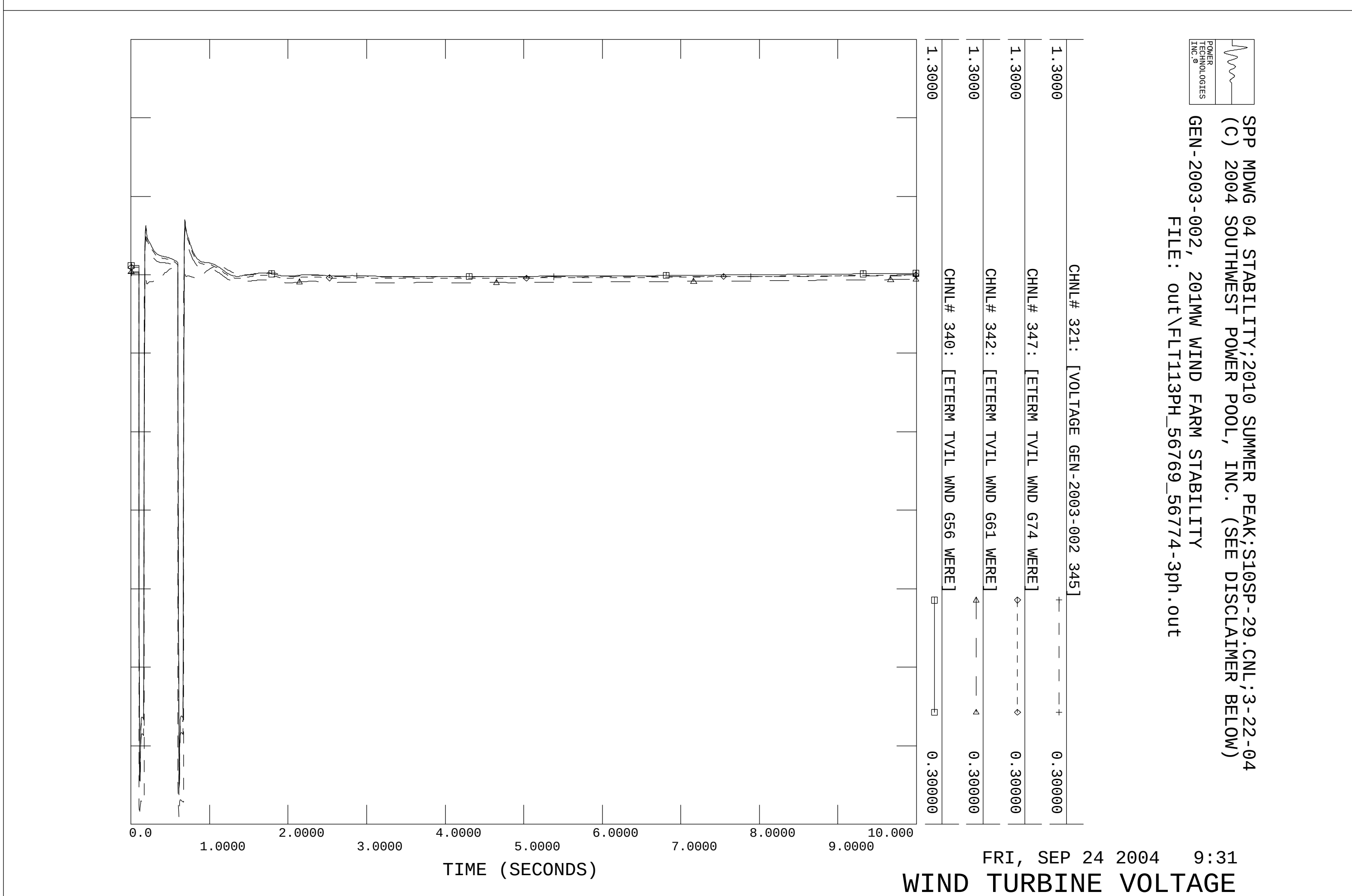
CASE ID: FLT113PH, 56769_56774-3ph (1 / 2)

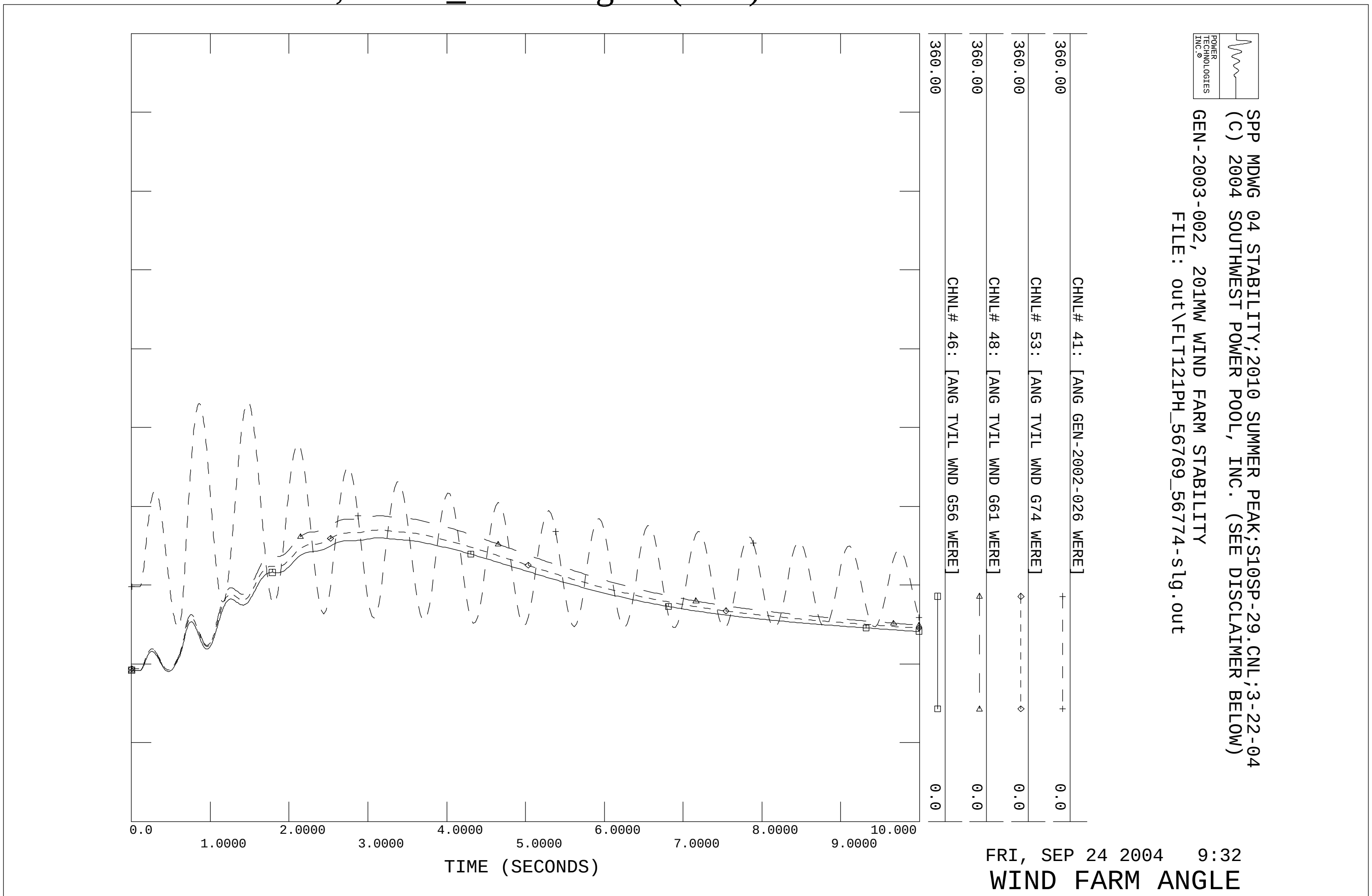




CASE ID: FLT113PH, 56769_56774-3ph (2 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT121PH_56769_56774-slg.out
CHNL# 41: [ANG GEN-2002-026 WERE]
CHNL# 53: [ANG TVIL WND G74 WERE]
CHNL# 48: [ANG TVIL WND G61 WERE]
CHNL# 46: [ANG TVIL WND G56 WERE]
360.00
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
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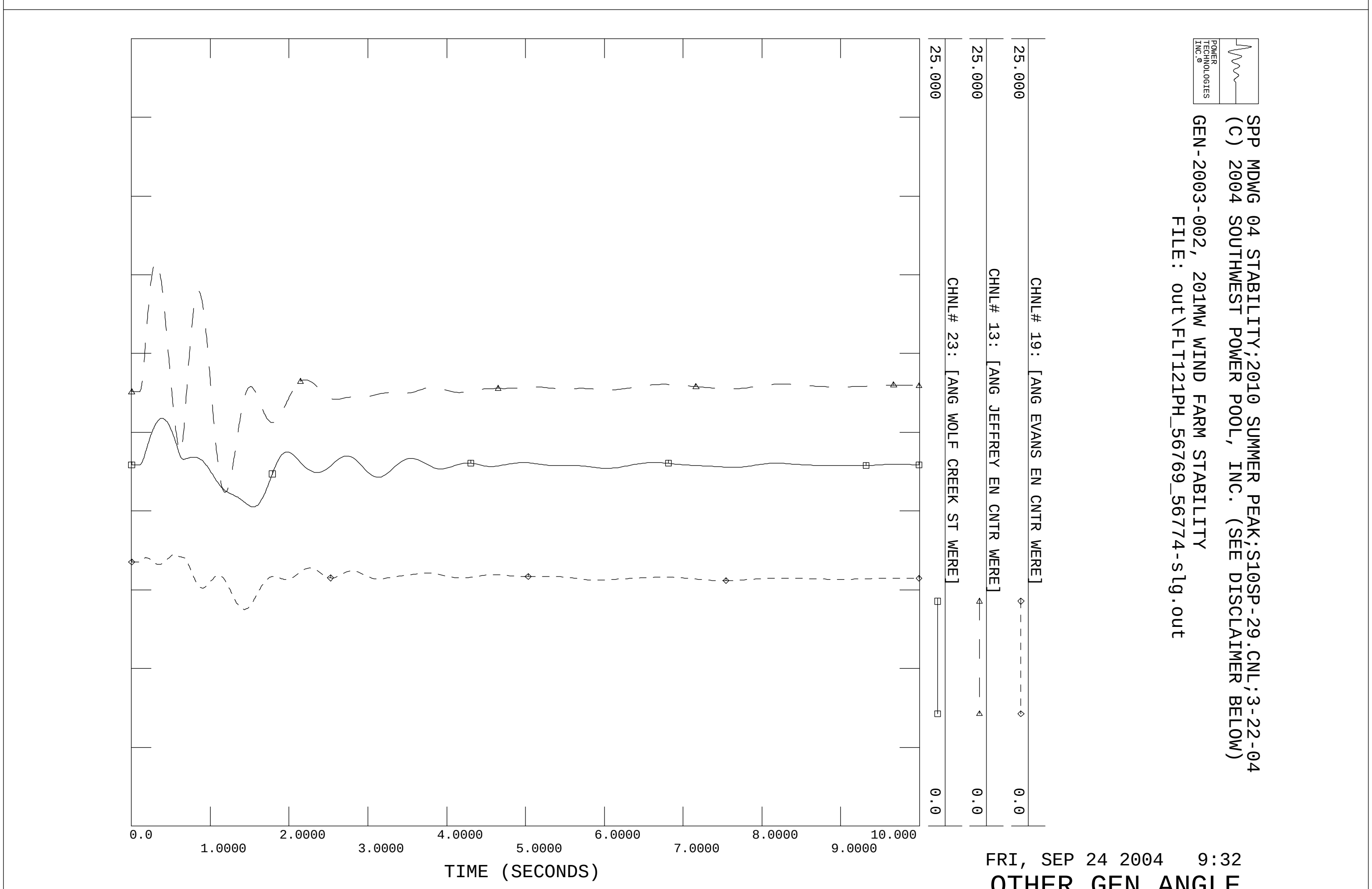
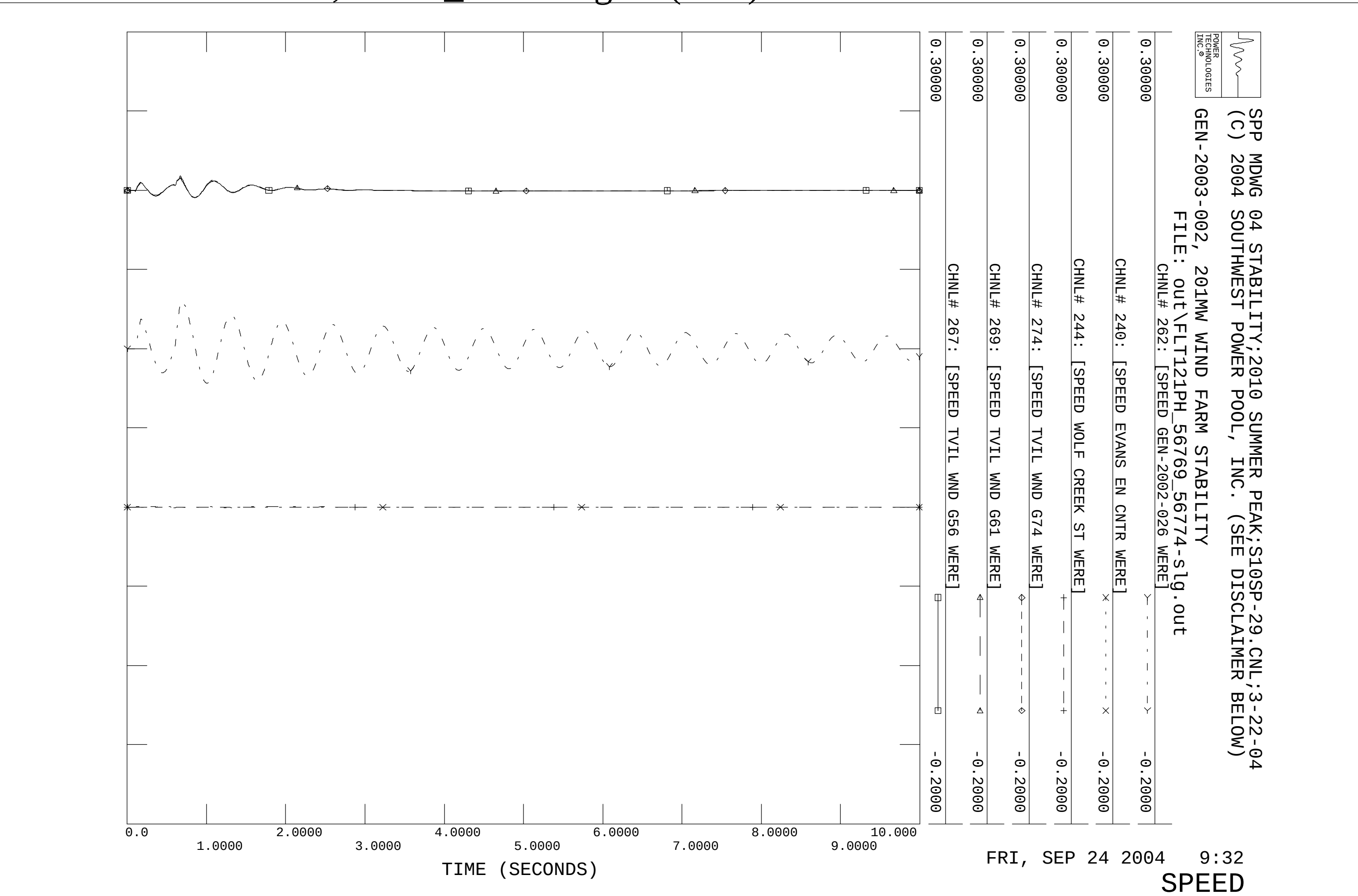
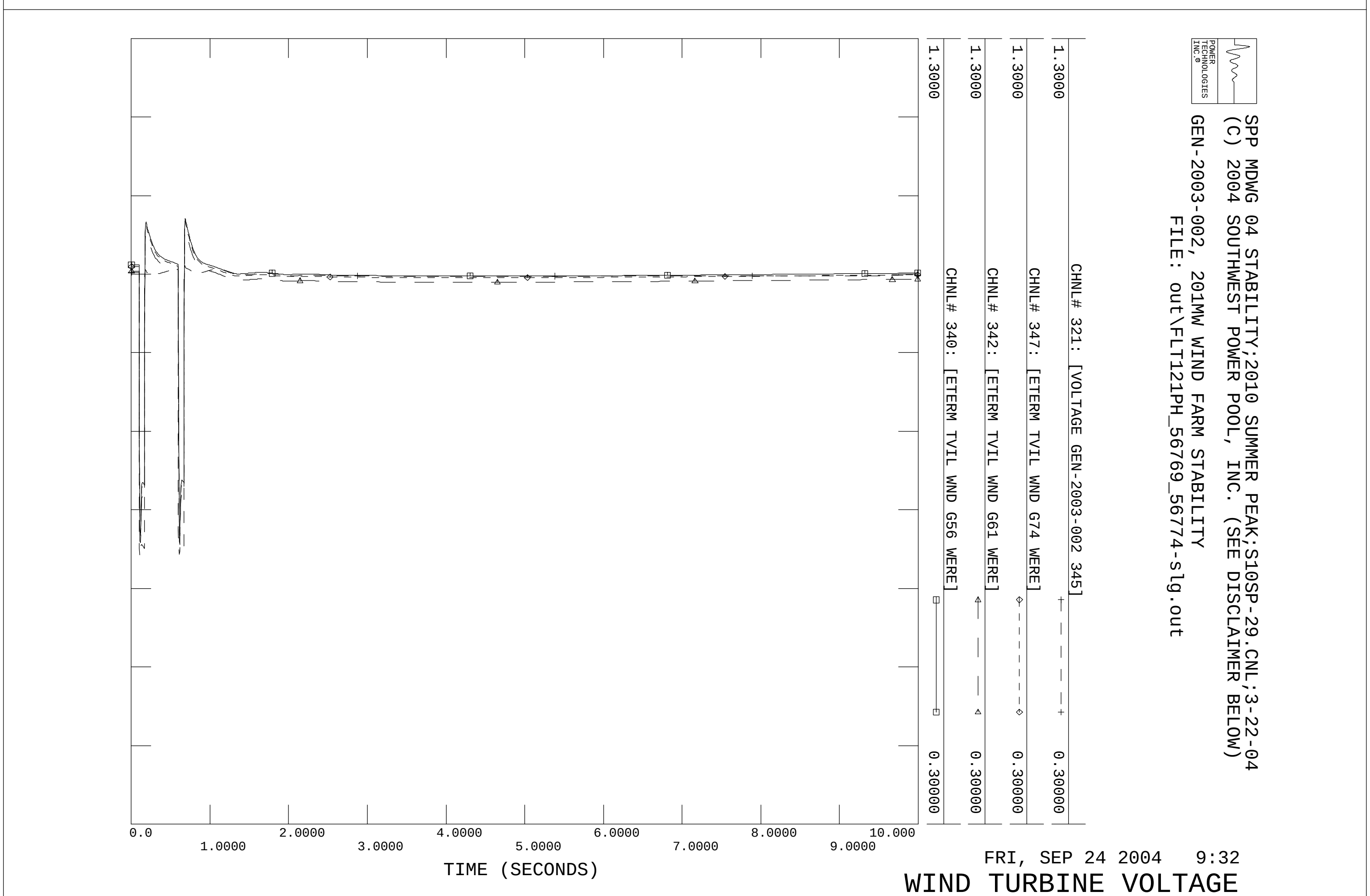
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
WIND FARM ANGLE

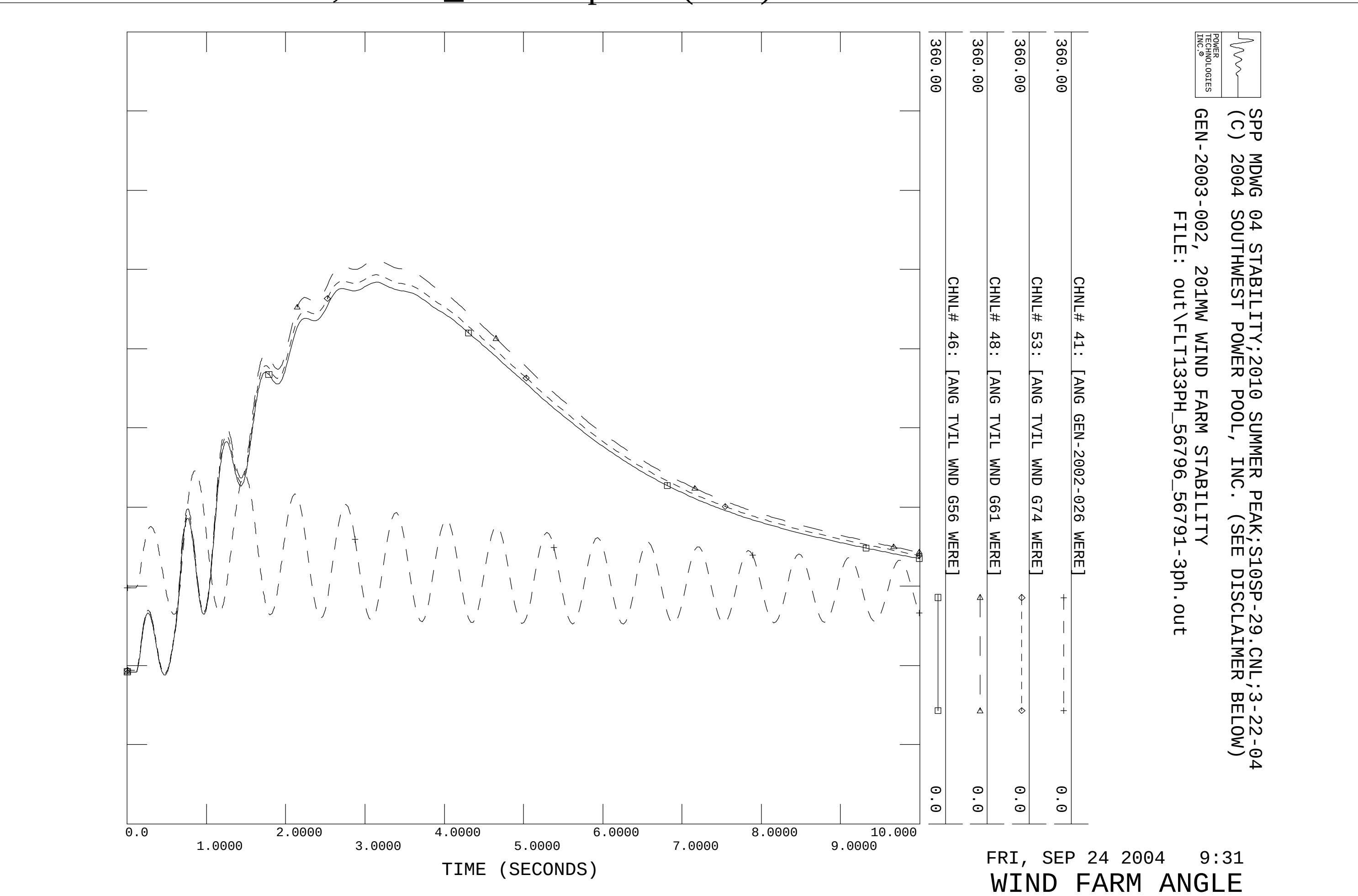

SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT121PH_56769_56774-slg.out
CHNL# 19: [ANG EVANS EN CNTR WERE]
CHNL# 13: [ANG JEFFREY EN CNTR WERE]
CHNL# 23: [ANG WOLF CREEK ST WERE]
25.000
0.0
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
OTHER GEN ANGLE

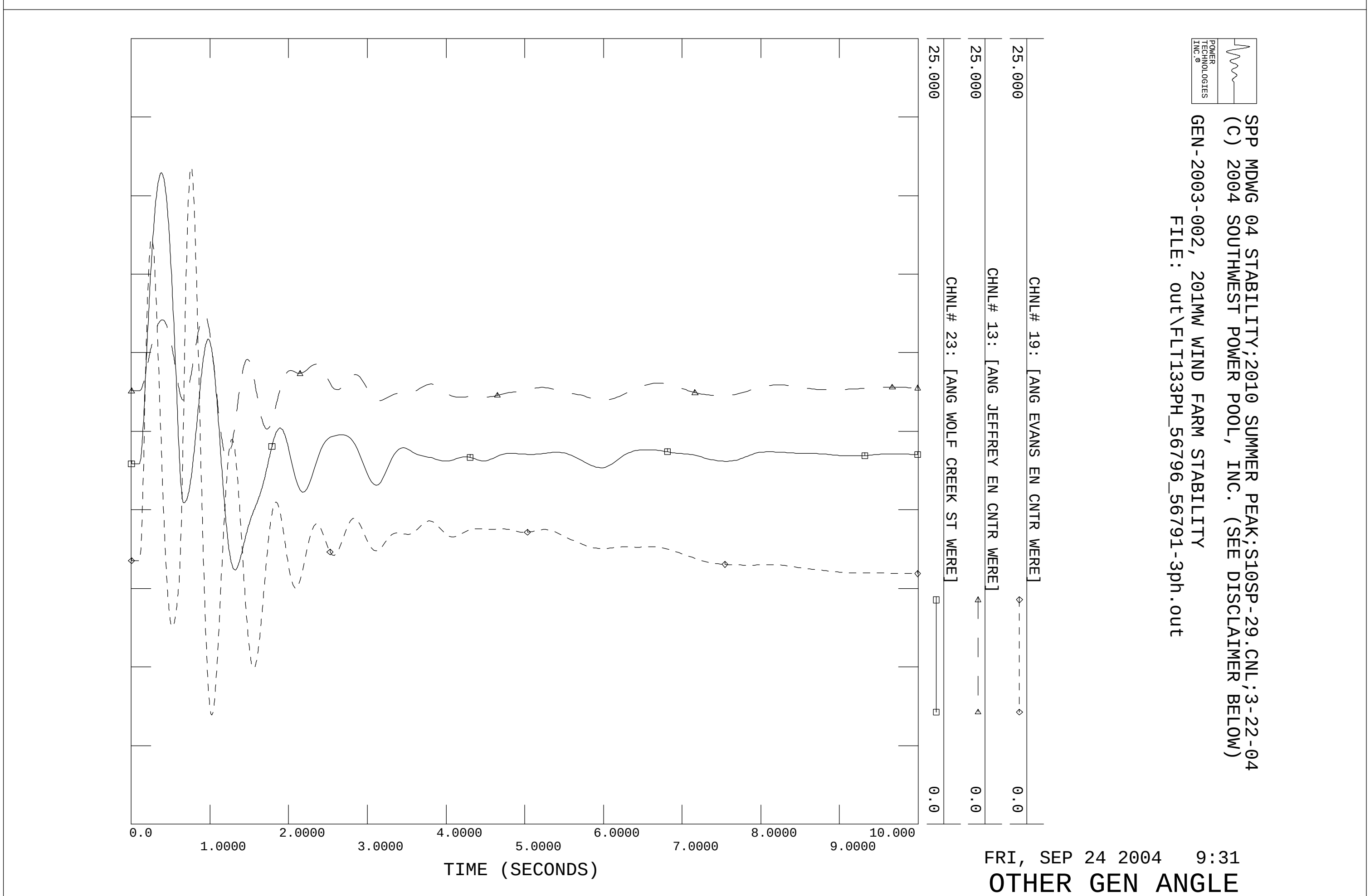
CASE ID: FLT121PH, 56769_56774-slg (2 / 2)



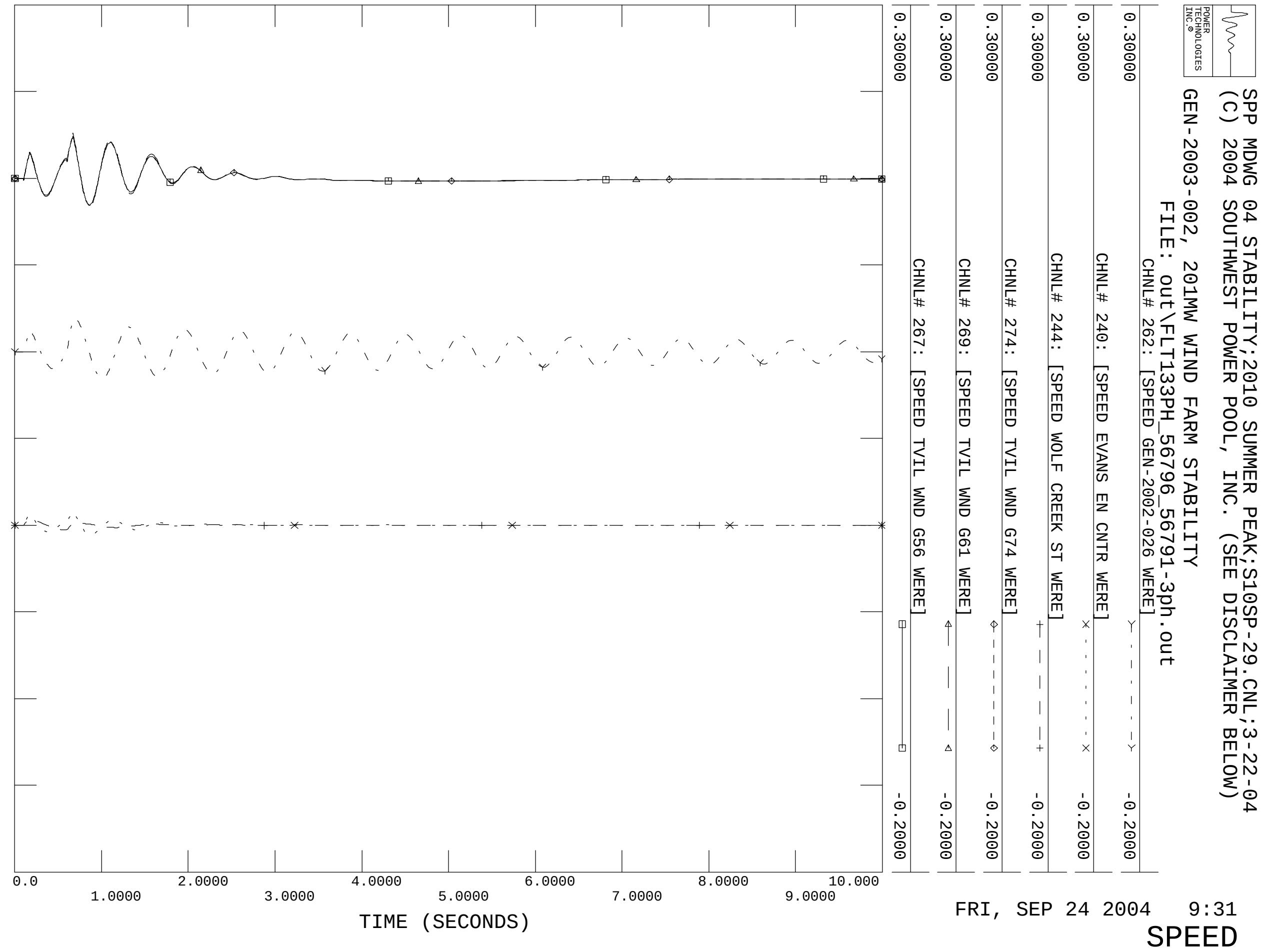


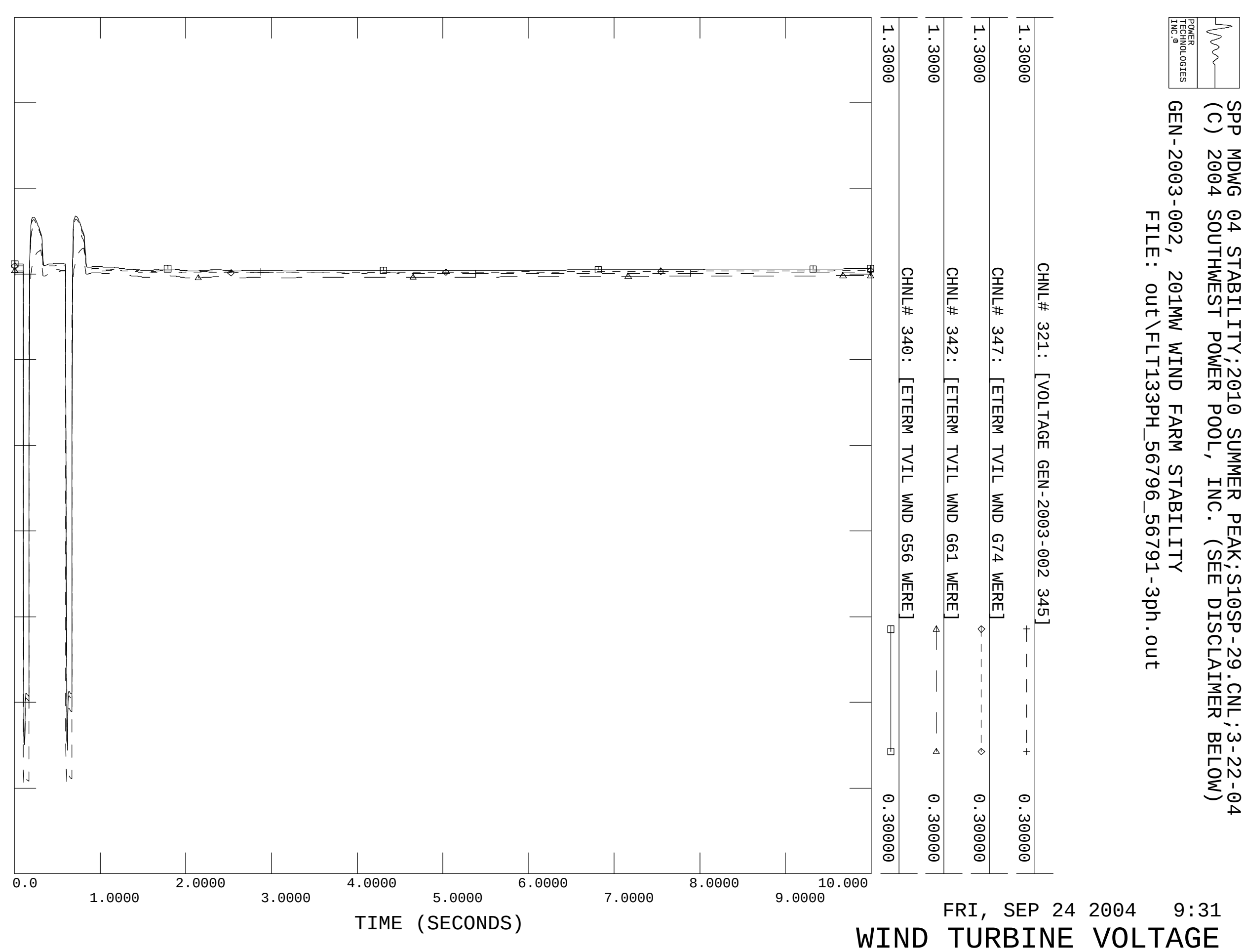
CASE ID: FLT133PH, 56796_56791-3ph (1 / 2)



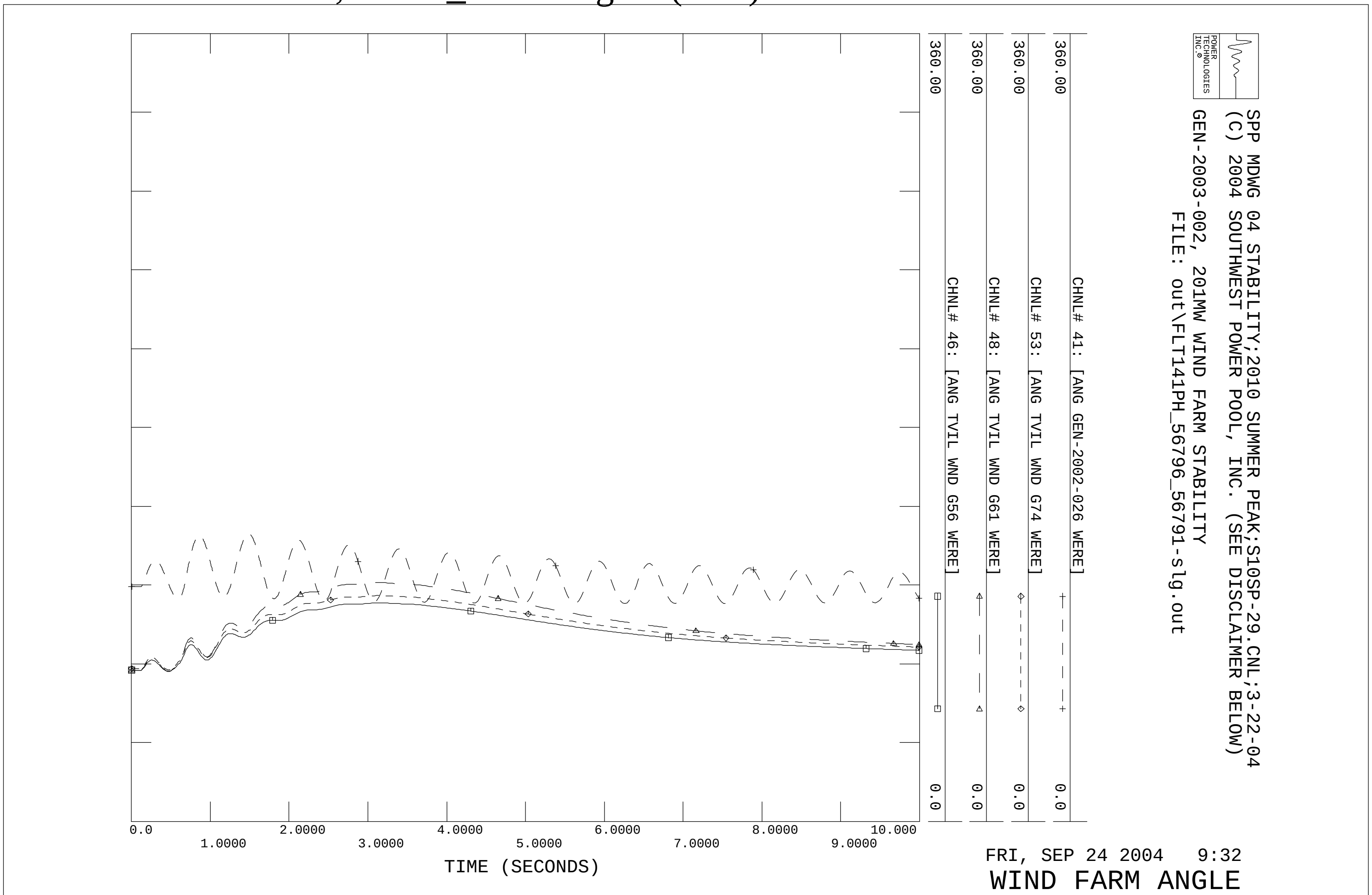


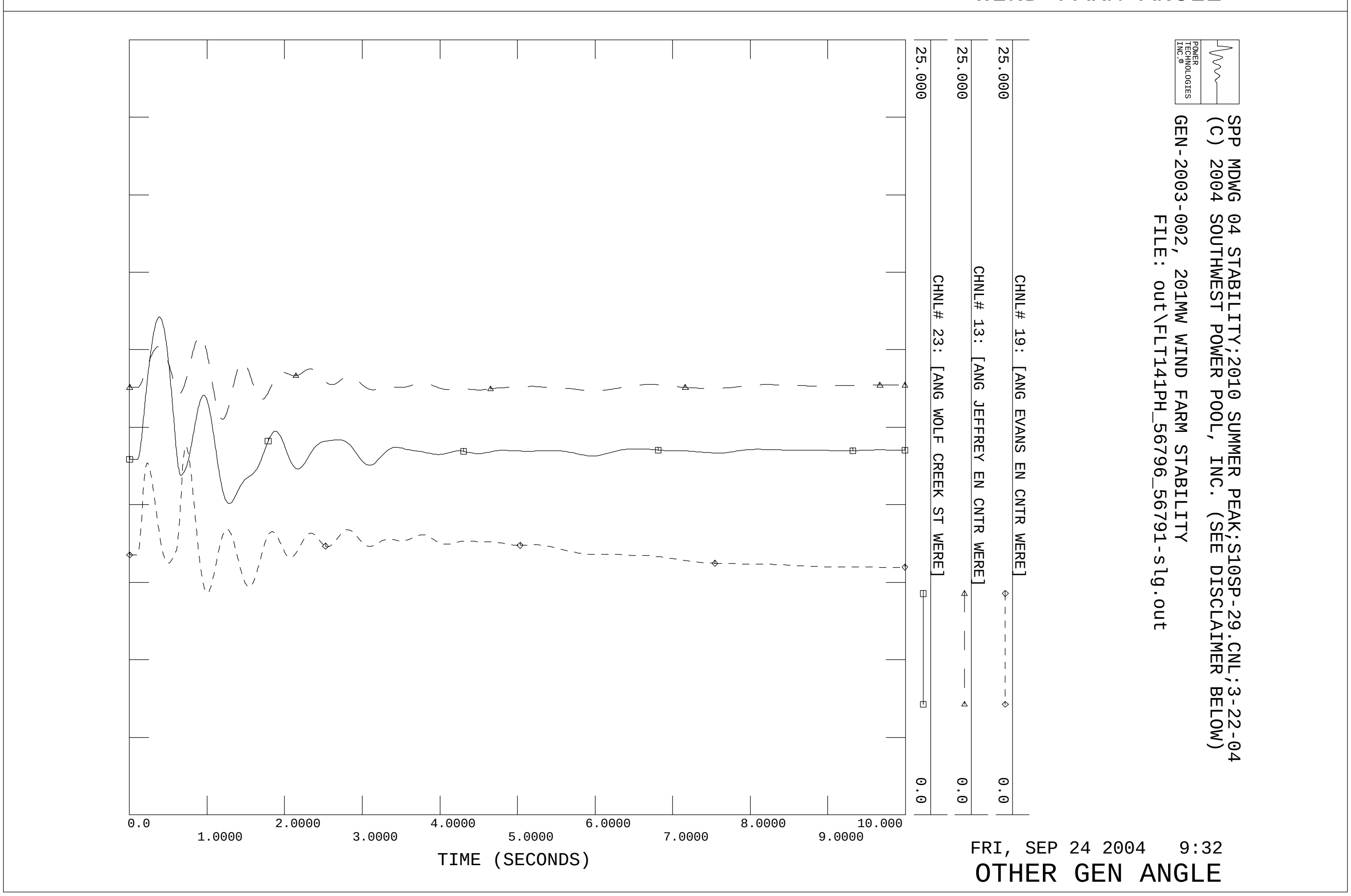
CASE ID: FLT133PH, 56796_56791-3ph (2 / 2)



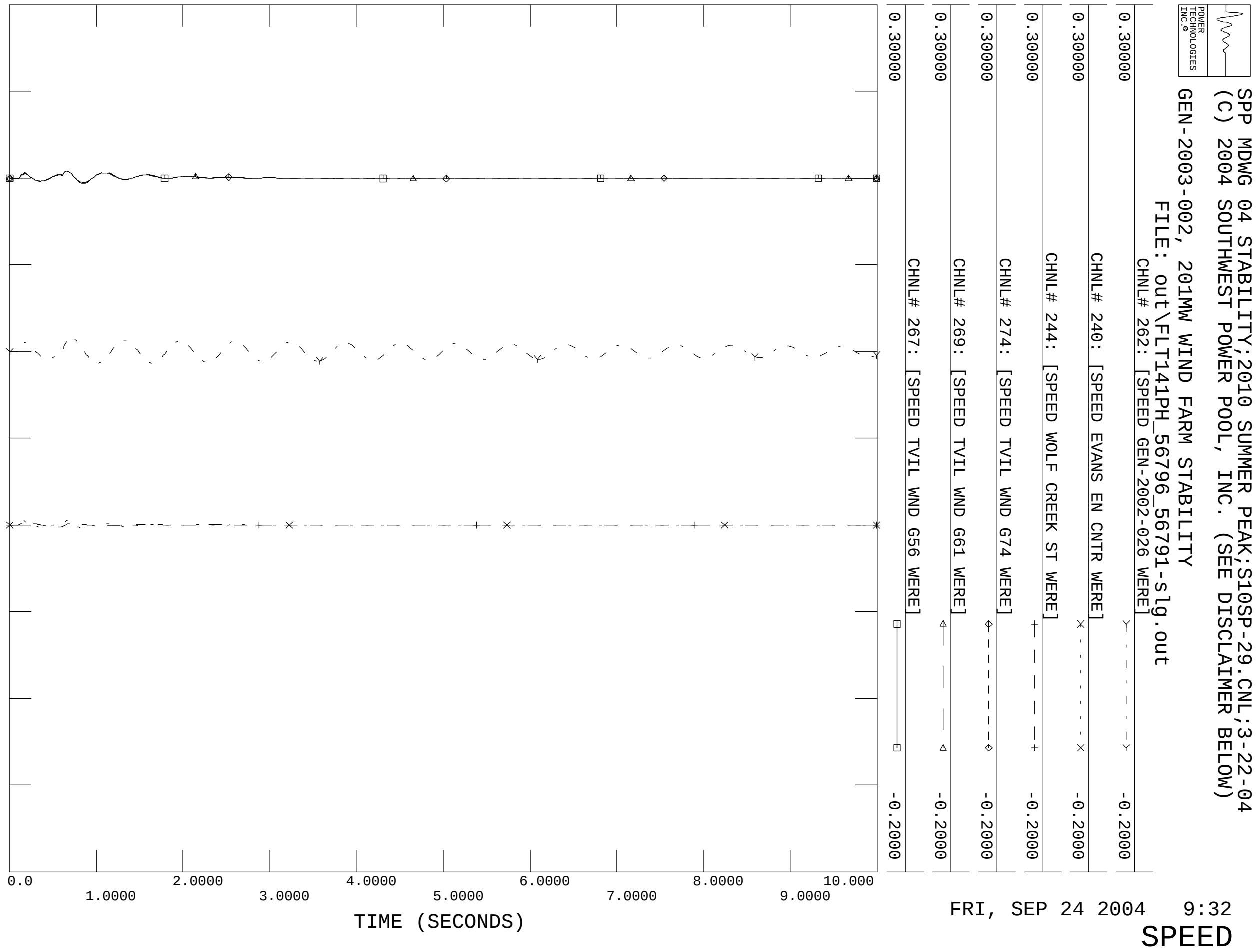


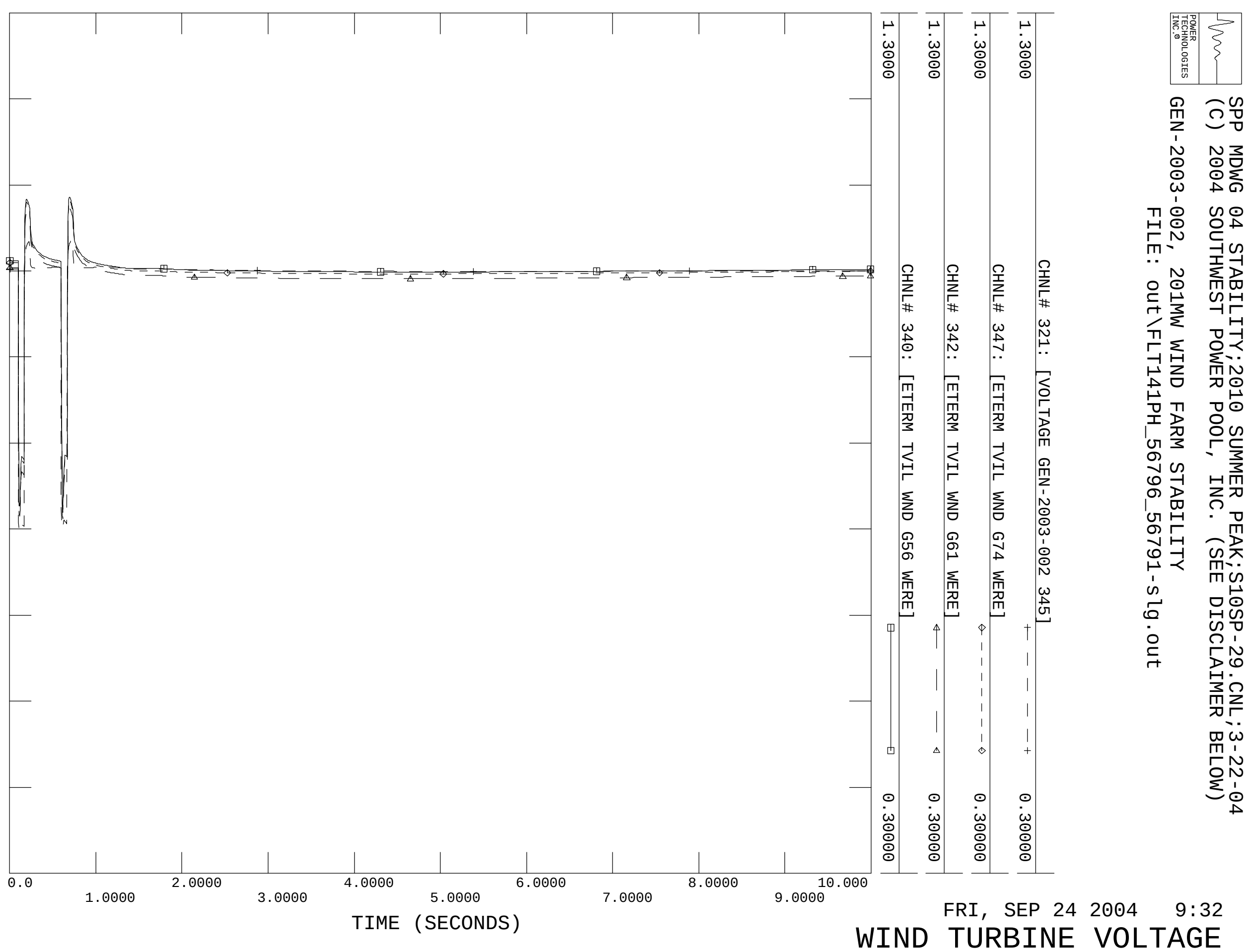
CASE ID: FLT141PH, 56796_56791-slg (1 / 2)



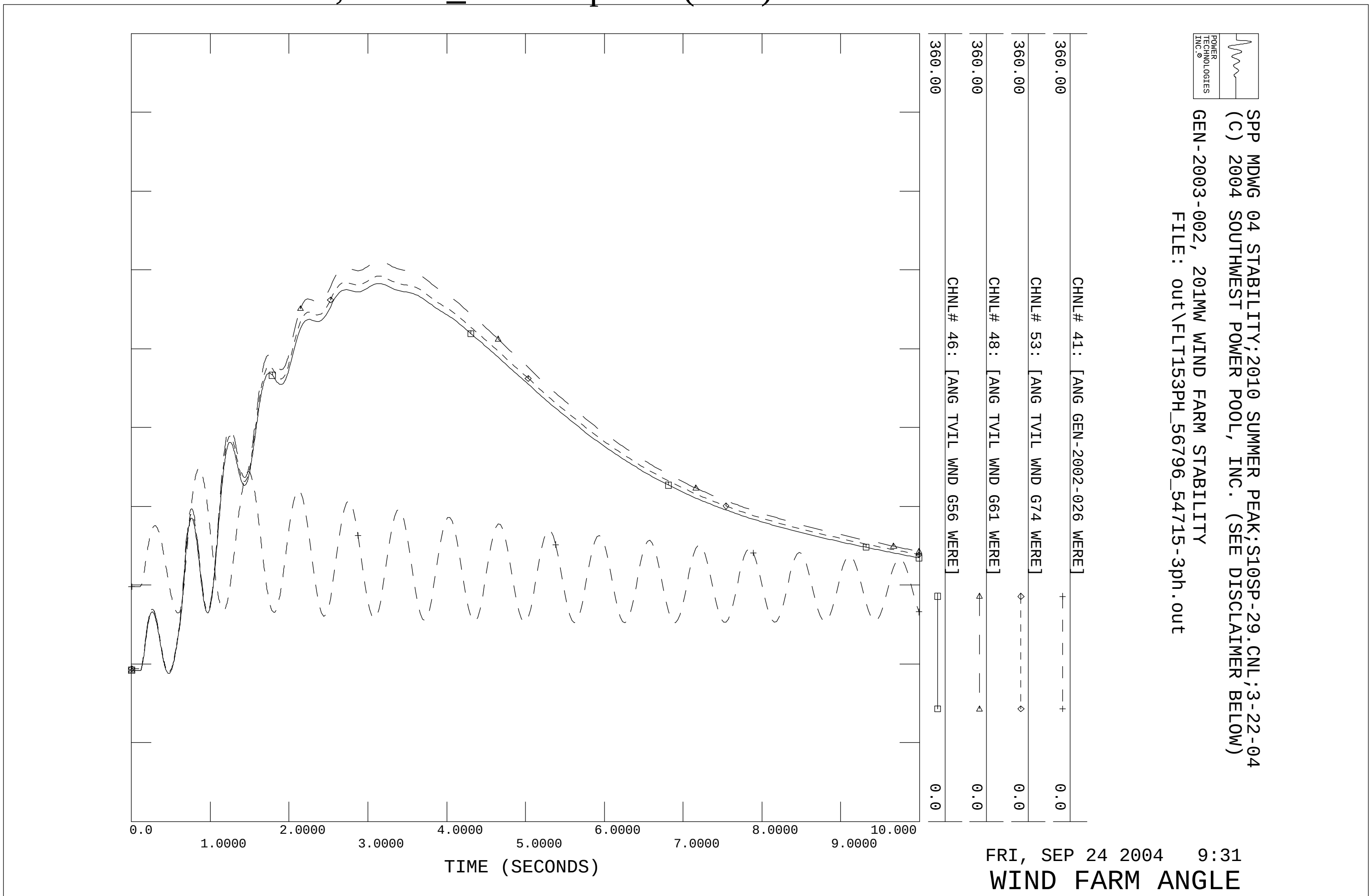


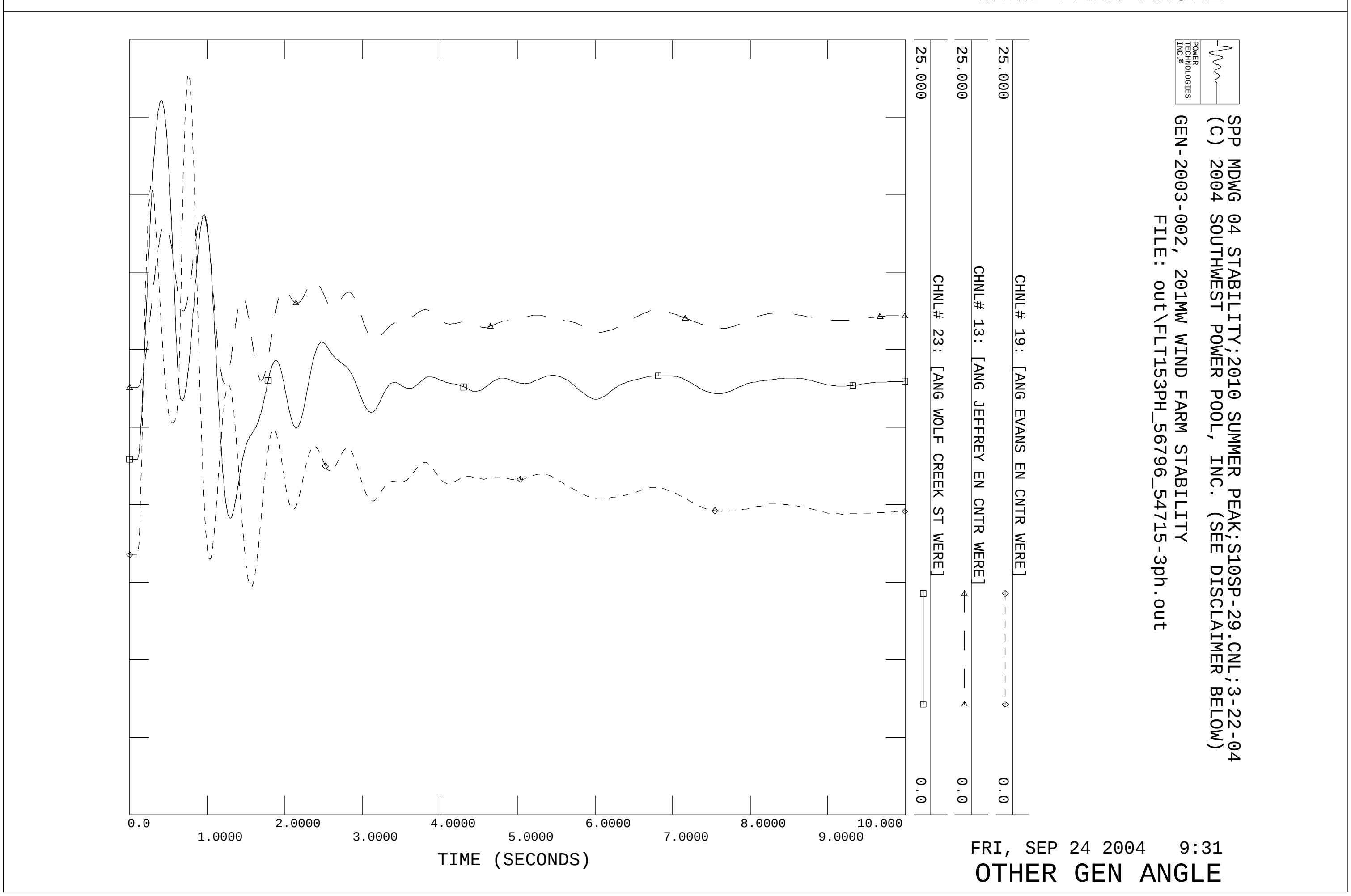
CASE ID: FLT141PH, 56796_56791-slg (2 / 2)

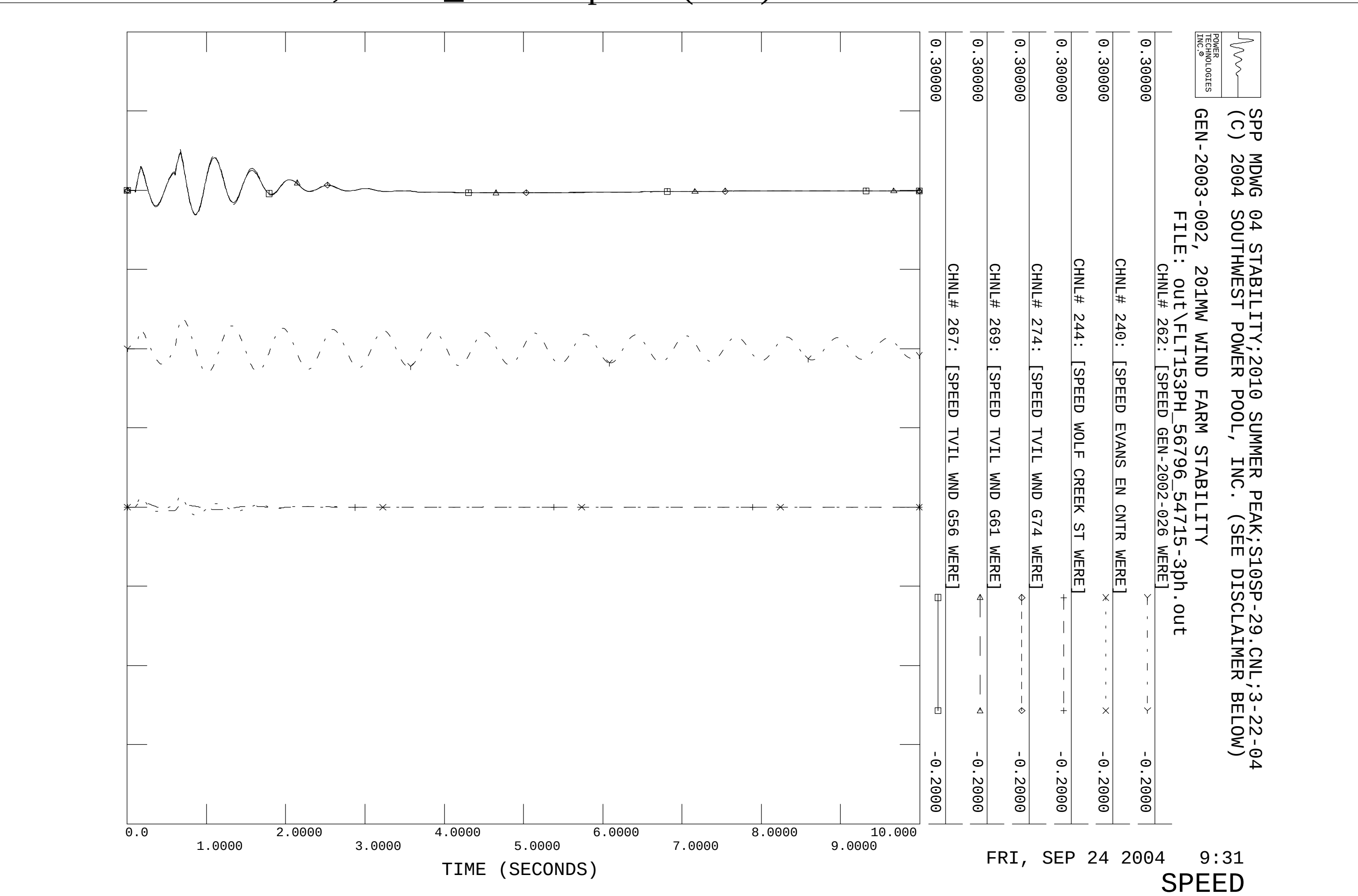




CASE ID: FLT153PH, 56796_54715-3ph   (1 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT153PH_56796_54715-3ph.out
CHNL# 262: [SPEED GEN-2002-026 WERE] 0.30000 -0.2000
CHNL# 240: [SPEED EVANS EN CNTR WERE] 0.30000 -0.2000
CHNL# 244: [SPEED WOLF CREEK ST WERE] 0.30000 -0.2000
CHNL# 274: [SPEED TVIL WND G74 WERE] 0.30000 -0.2000
CHNL# 269: [SPEED TVIL WND G61 WERE] 0.30000 -0.2000
CHNL# 267: [SPEED TVIL WND G56 WERE] 0.30000 -0.2000
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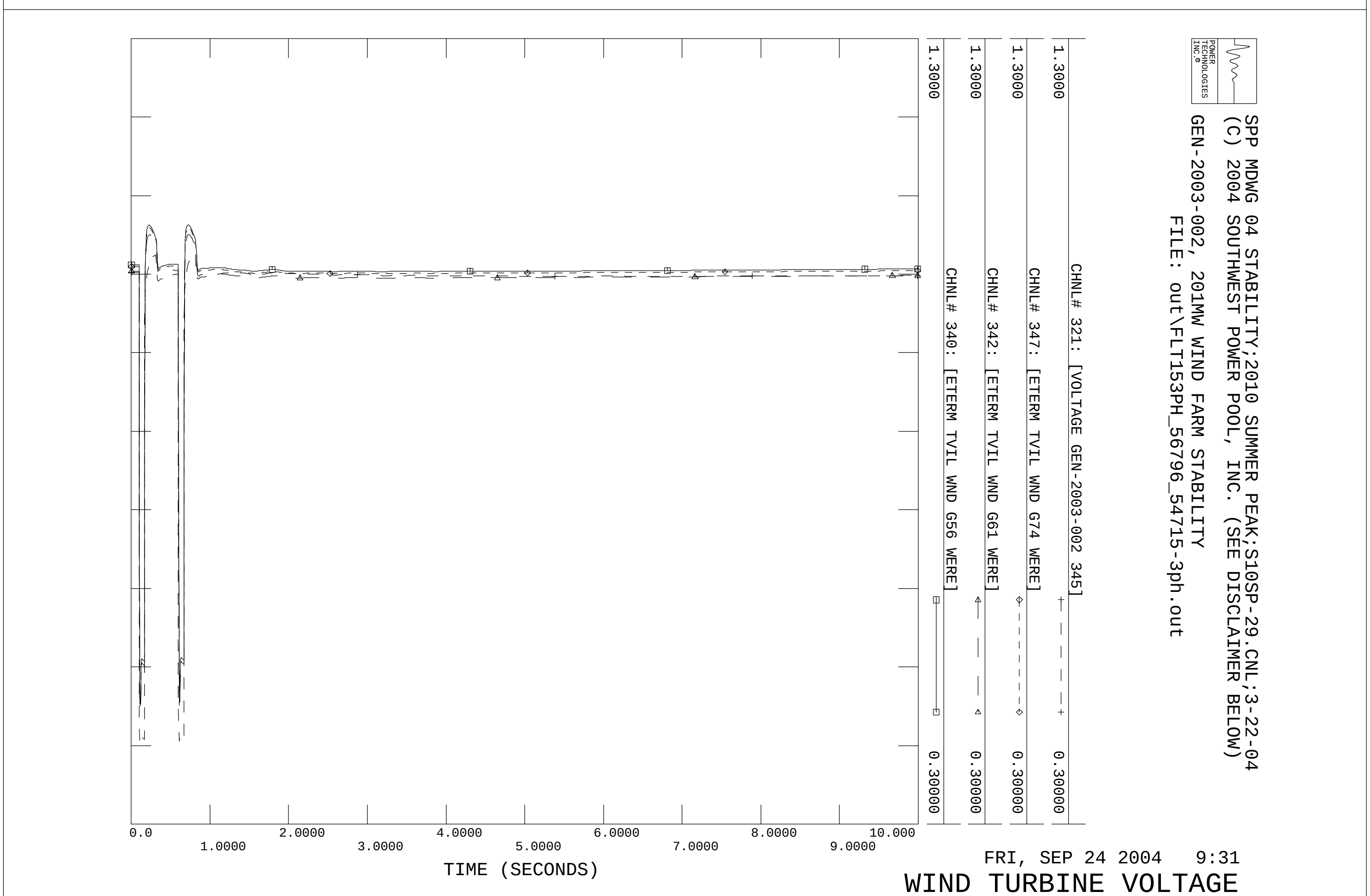
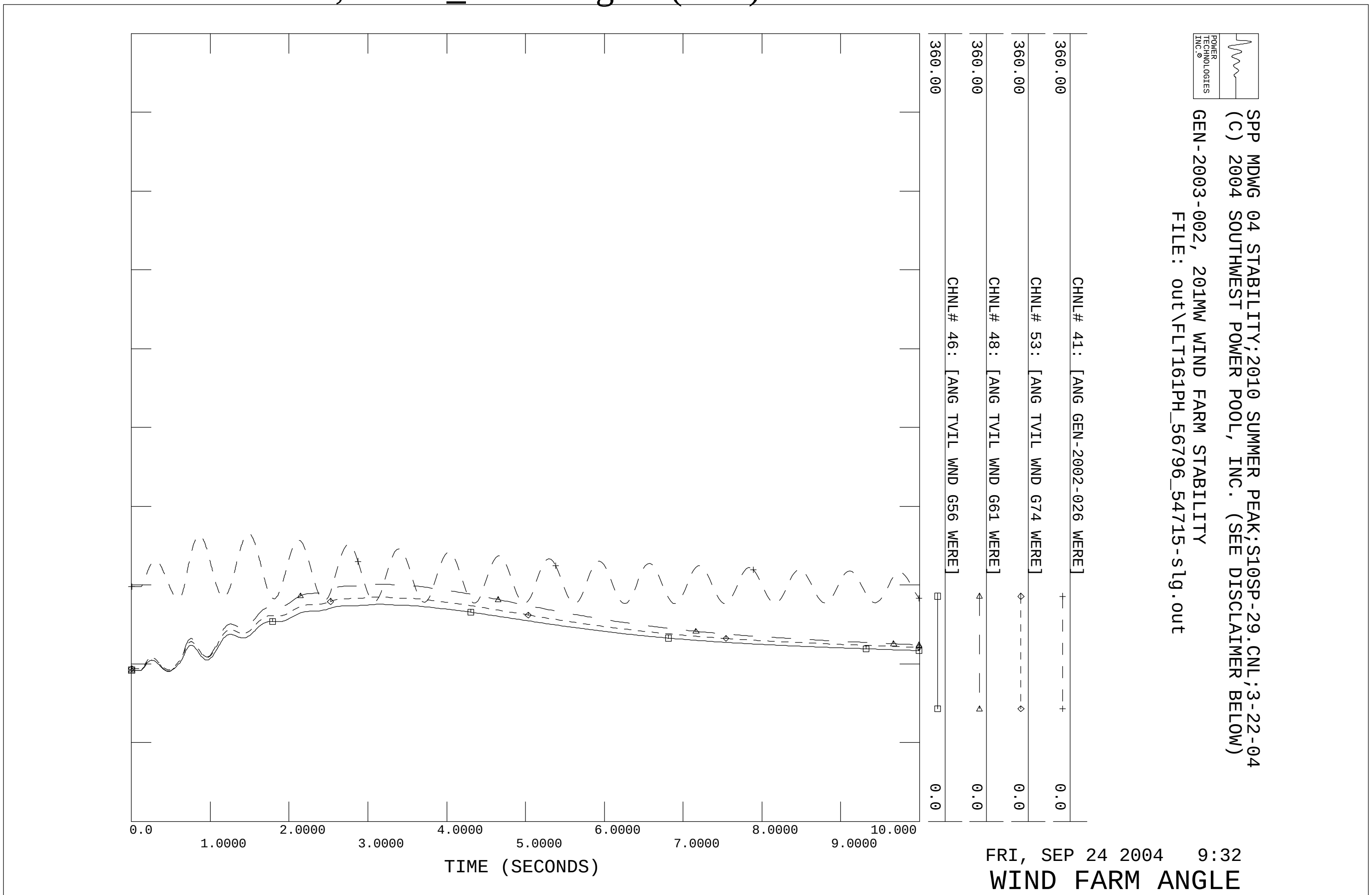
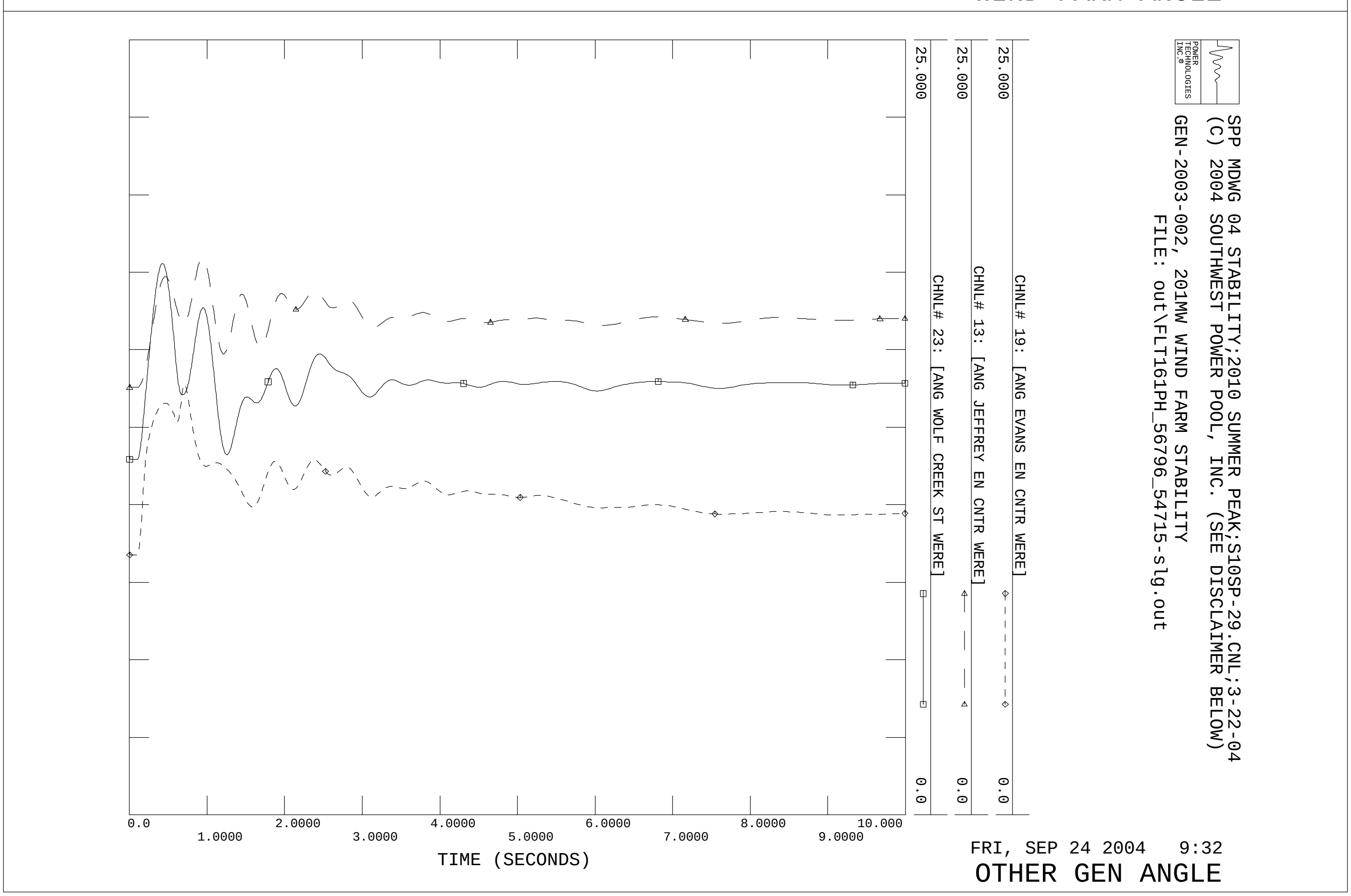
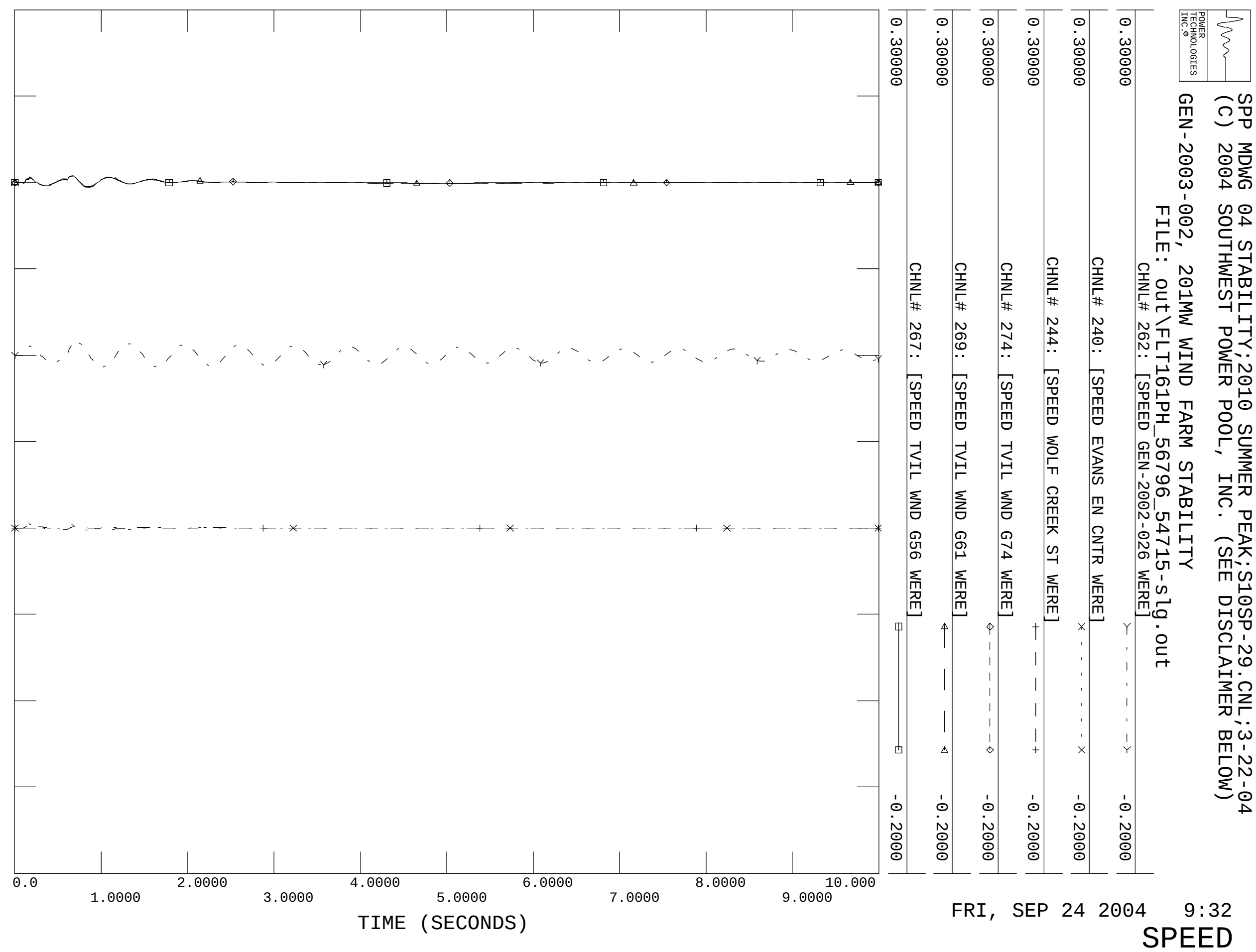
TIME (SECONDS)
FRI, SEP 24 2004 9:31
SPEED


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT153PH_56796_54715-3ph.out
CHNL# 321: [VOLTAGE GEN-2003-002 345] 1.3000 0.30000
CHNL# 347: [ETERM TVIL WND G74 WERE] 1.3000 0.30000
CHNL# 342: [ETERM TVIL WND G61 WERE] 1.3000 0.30000
CHNL# 340: [ETERM TVIL WND G56 WERE] 1.3000 0.30000
0.0 1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000 10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:31
WIND TURBINE VOLTAGE

CASE ID: FLT161PH, 56796_54715-slg (1 / 2)






SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT161PH_56796_54715-slg.out
CHNL# 262: [SPEED GEN-2002-026 WERE] 0.30000 -0.2000
CHNL# 240: [SPEED EVANS EN CNTR WERE] 0.30000 -0.2000
CHNL# 244: [SPEED WOLF CREEK ST WERE] 0.30000 -0.2000
CHNL# 274: [SPEED TVIL WND G74 WERE] 0.30000 -0.2000
CHNL# 269: [SPEED TVIL WND G61 WERE] 0.30000 -0.2000
CHNL# 267: [SPEED TVIL WND G56 WERE] 0.30000 -0.2000
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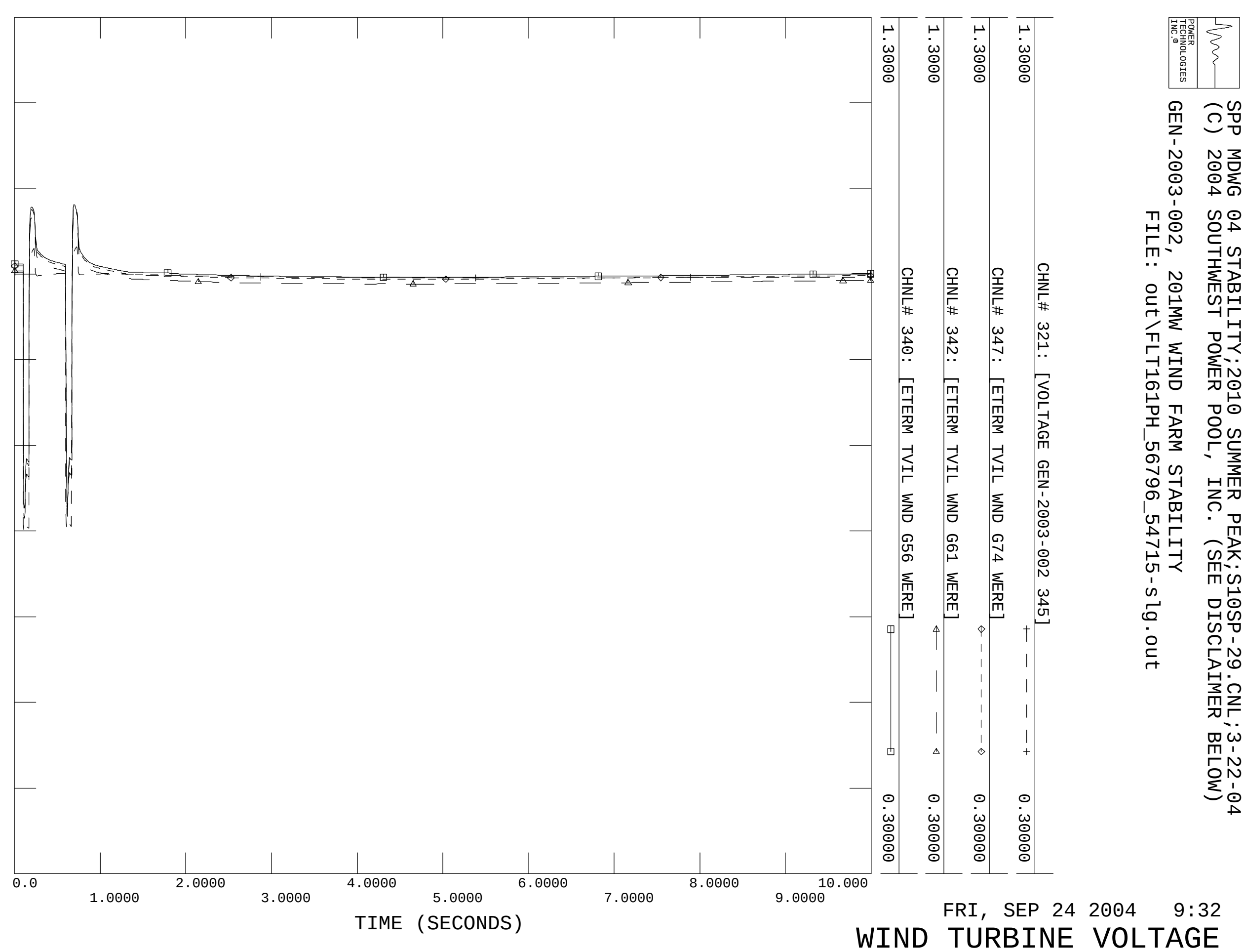
TIME (SECONDS)
FRI, SEP 24 2004 9:32
SPEED


SPP MDWG 04 STABILITY;2010 SUMMER PEAK;S10SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)
GEN-2003-002, 201MW WIND FARM STABILITY
FILE: out\FLT161PH_56796_54715-slg.out
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CHNL# 347: [ETERM TVIL WND G74 WERE] 1.3000 0.30000
CHNL# 342: [ETERM TVIL WND G61 WERE] 1.3000 0.30000
CHNL# 340: [ETERM TVIL WND G56 WERE] 1.3000 0.30000
0.0 1.0000 2.0000 3.0000 4.0000 5.0000 6.0000 7.0000 8.0000 9.0000 10.000
TIME (SECONDS)
FRI, SEP 24 2004 9:32
WIND TURBINE VOLTAGE