

Gamesa V87 Stability Model for GE Stability Program
E/PRO Consulting
January 3, 2006

Based on discussions between UPC and their representatives and ISO-NE, the following assignment was provided to E/PRO.

1. Prepare documentation describing the strategy and analysis that was done to develop a PSLF dynamic model based on the existing P/SSE model of the Gamesa 2 MW wind turbines. Among other things, the documentation is to describe voltage response to faults, recovery and other significant characteristic variations from the P/SSE results.

In November, E/PRO launched a brief investigation into dynamic data modeling of the Gamesa Wind Machine. The problem statement was centered on the lack of a stability model in the GE power system stability program for the Gamesa V87 machine. Therefore, it was necessary to determine if the GE wind model would be a suitable replacement for the system impact stability study. To accomplish this, P/SSE's stability program was used since it has both models and performance following a fault could be compared. The GE 1.65MW machine model in P/SSE was set-up with the Gamesa V87 machine characteristics and compared to the Gamesa V87 wind machine in PSS/E. The low-voltage ride-through characteristics and prime-mover models were ignored for the purposes of this evaluation.

Attached in Appendix A is the model data sheets used in the Gamesa representation on the GE 1.65 machine model. Gamesa impedances were inserted into the various data points (La, Lm, R1, and L1) to match representations. Gamesa's P/SSE model is mostly hard-coded in the model flex code and therefore not obtainable from their data sheets. This is the only information that appeared to correspond directly.

Also, attached in Appendix B is a comparison of the fault at remote bus to show the dynamic performance of the Gamesa V87 machine in PSS/E with its own model and one using the modified GE 1.65MW machine.

This documentation will be forwarded to the ISO-NE staff to aid them in assessing whether the GE wind model would be a suitable proxy for the Gamesa turbines for the system impact stability model.

APPENDIX A

GE 1.65 MW Model Data Sheets with Gamesa V87 Modifications

GEDFA

GE Wind Turbine Doubly-Fed (Wound Rotor) Induction Generator
Refer Figure 3.2 - GE Wind Turbine Controls

This model is located at system bus # _____ IBUS
Machine # _____ I
This model uses CONs starting with # _____ J
and STATEs starting with # _____ K
and VARs starting with # _____ L
and ICONs starting with # _____ M

CONs	#	Value	Description
J			X_{eq} , Equivalent reactance, pu
J+1			L_a , Stator Inductance, pu
J+2			L_m , Mutual Inductance, pu
J+3			R_r , Rotor Resistance, pu
J+4			L_r , Rotor Inductance, pu
J+5			H, generator inertia constant, seconds
J+6			D, Damping Factor, pu
J+7			-SLIP, initial rotor negative slip
J+8			$T_{I_{pcmd}}$, converter time constant for I_{pcmd} , sec.
J+9			$T_{E_{qcmd}}$, converter time constant for E_{qcmd} , sec.
J+10			KPLL, PLL gain, pu
J+11			PLLMX, PLL max limit
J+12			PLLMN, PLL min limit

STATEs	#	Description
K		Rotor Speed Deviation, pu
K+1		Rotor Angle deviation, degrees
K+2		Converter lag for I_{pcmd}
K+3		Converter lag for E_{qcmd}
K+4		PLL angle

VARs	#	Description
L		E_d , initial Rotor Voltage, pu on MBASE

VARs	#	Description
L+1		E_q , initial Rotor Voltage, pu on MBASE
L+2		Rotor Speed, pu
L+3		Rotor Slip, pu
L+4		Initial I_d , Stator Current, pu on MBASE
L+5		Initial I_q , Stator Current, pu on MBASE
L+6		Initial RTR_P, Rotor Real Power, pu on MBASE
L+7		Initial RTR_ I_d , Rotor Current, pu on MBASE
L+8		Initial RTR_ I_q , Rotor Current, pu on MBASE
L+9		Initial Machine internal Angle (radians)
L+10		Initial Slip, pu
L+11		Initial Mechanical Torque, pu
L+12		Initial Ψ_D , Stator Flux Linkage, pu
L+13		Initial Ψ_Q , Stator Flux Linkage, pu
L+14		Initial λ'_D , Transient Flux Linkage, pu
L+15		Initial λ'_Q , Transient Flux Linkage, pu
L+16		Initial desired net power, pu on MBASE
L+17		Initial desired net reactive power, pu on MBASE

PSS/E Wind Data Sheets
GEDFA

VARs	#	Description
L+18		V_x , real component of V_{term} in generator reference frame, pu
L+19		V_y , imaginary component of V_{term} in gen. ref. frame, pu
L+20		I_{xinj} , active component of the injected current, pu
L+21		I_{yinj} , reactive component of the

VARs	#	Description
		injected current, pu

ICONS	#	Description
M		Memory

IBUS 'USRMDL' ID 'GEDFA' 1 1 1 13 5 22 0 CONs from (J) to (J+12) /

Note:

IPLAN programs (part of this PSS/E Wind Package) create this dyre data record.

APPENDIX B

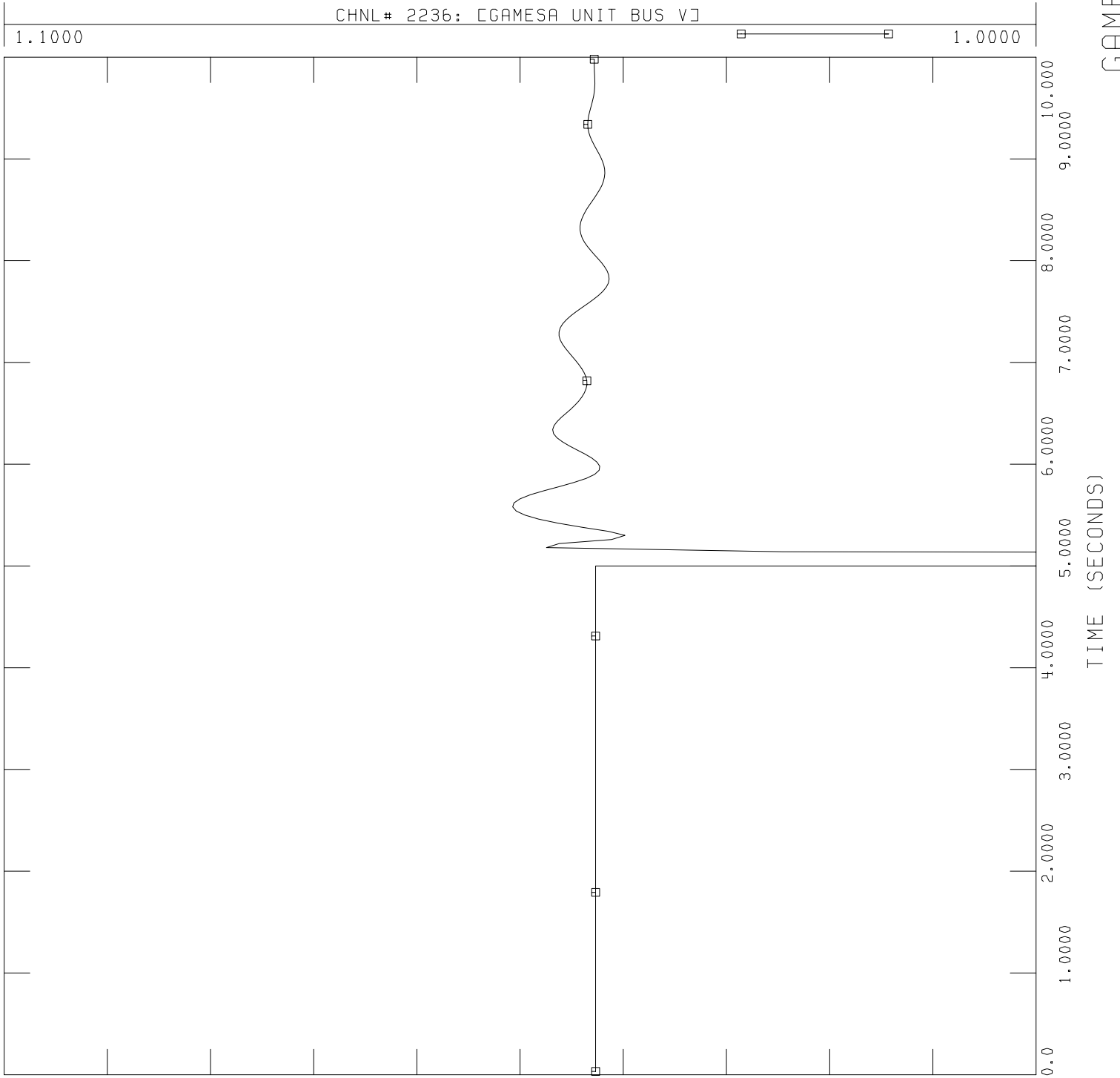
Comparison of Response between:

1. Actual Gamesa V87 PSS/E model
2. GE 1.65 MW model with Gamesa Machine Impedances



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ISO NE CONTROL AREA LD+LOSS↑12308, NYNE= -1200, 2 A.L. CABLE

MON, OCT 31 2005 16:10
GAMESA MACHINE BUS V

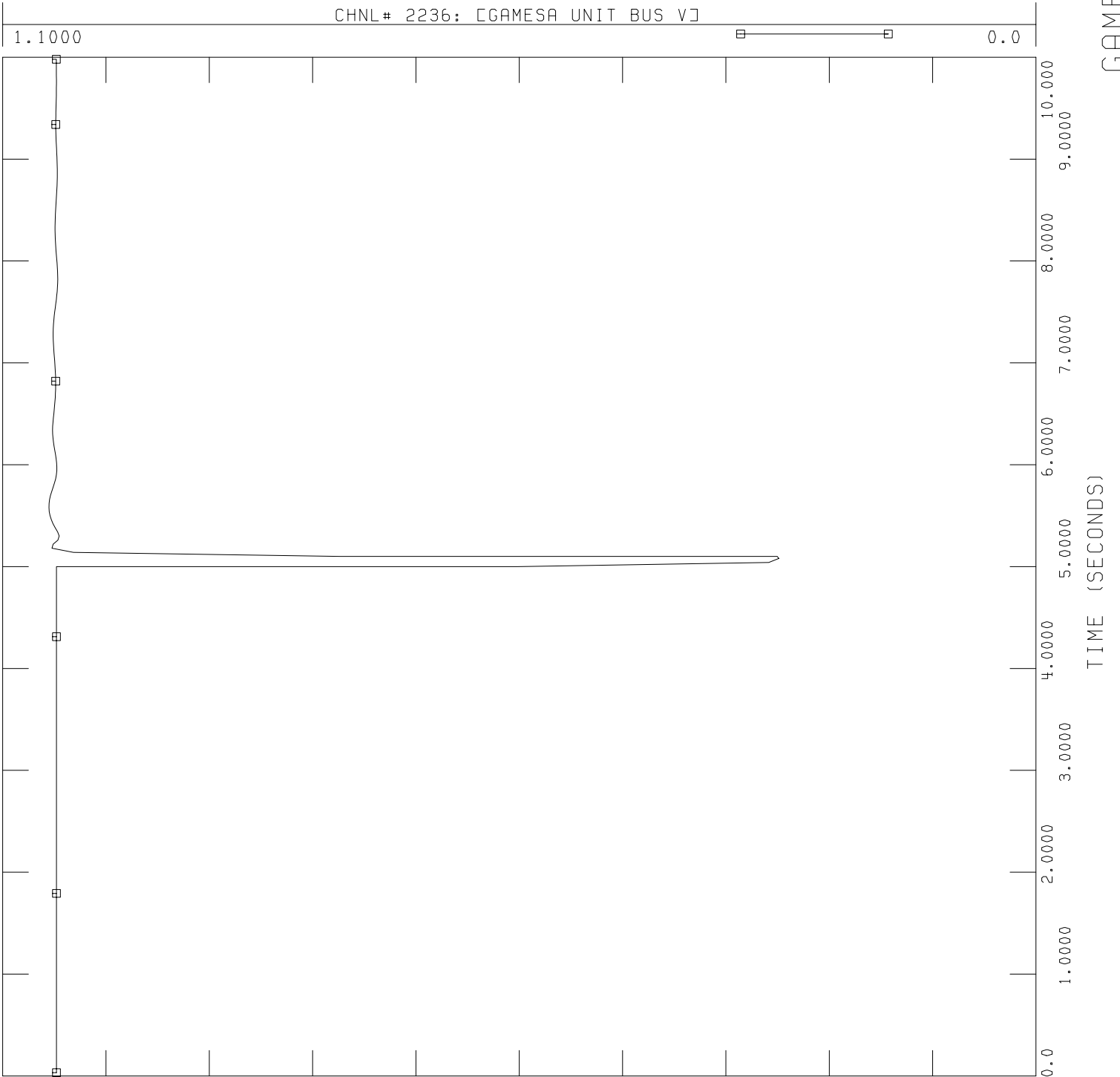




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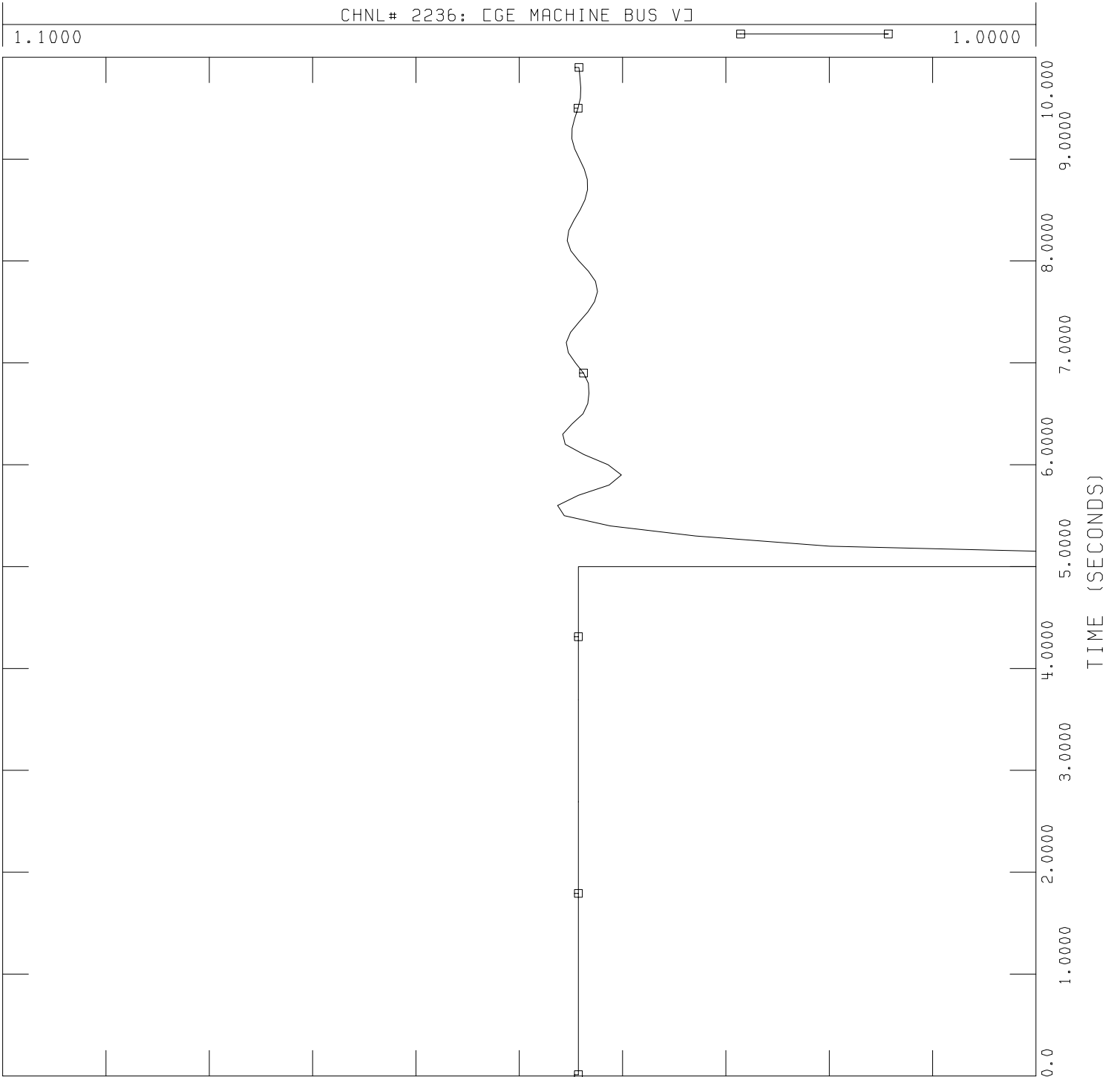




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GE MACHINE BUS V

CHNL# 2236: [GE MACHINE BUS V]

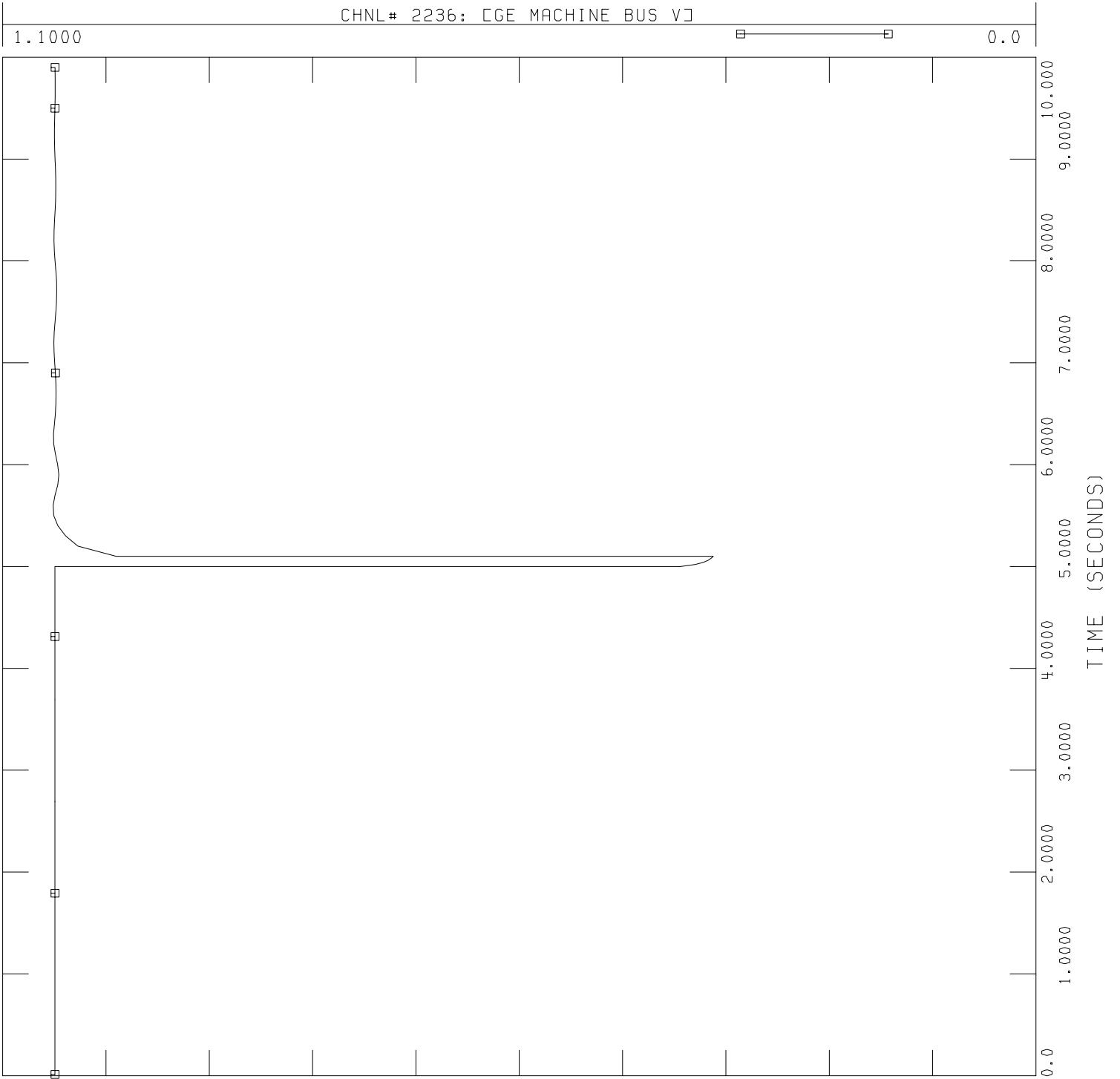




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GE MACHINE BUS V

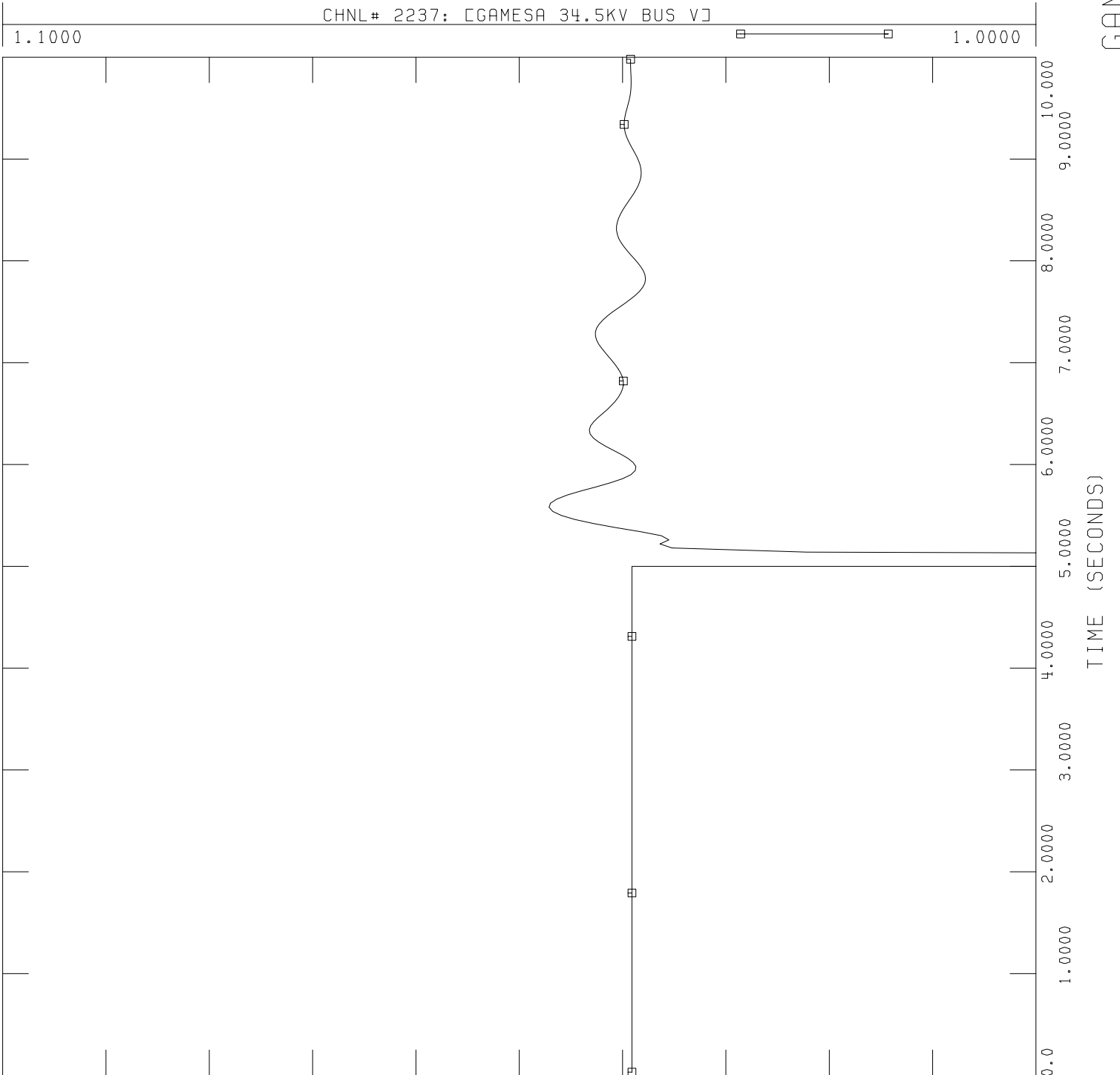
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45% 2000 NE LIB, PROJECTED 2007 50/50, PHASE 1
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GAMESA 34.5KV BUS V

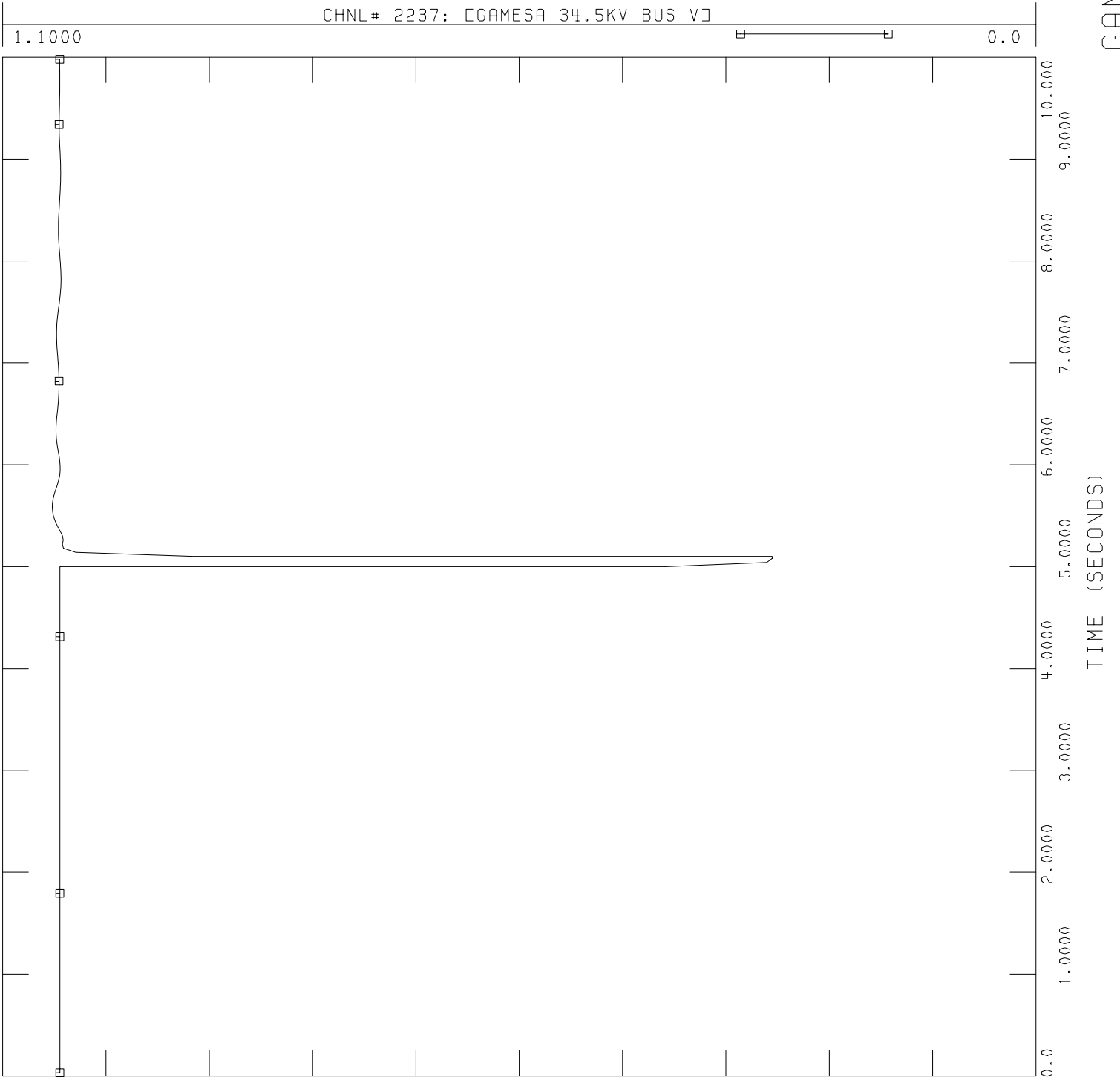


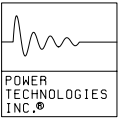


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GAMESA 34.5KV BUS V

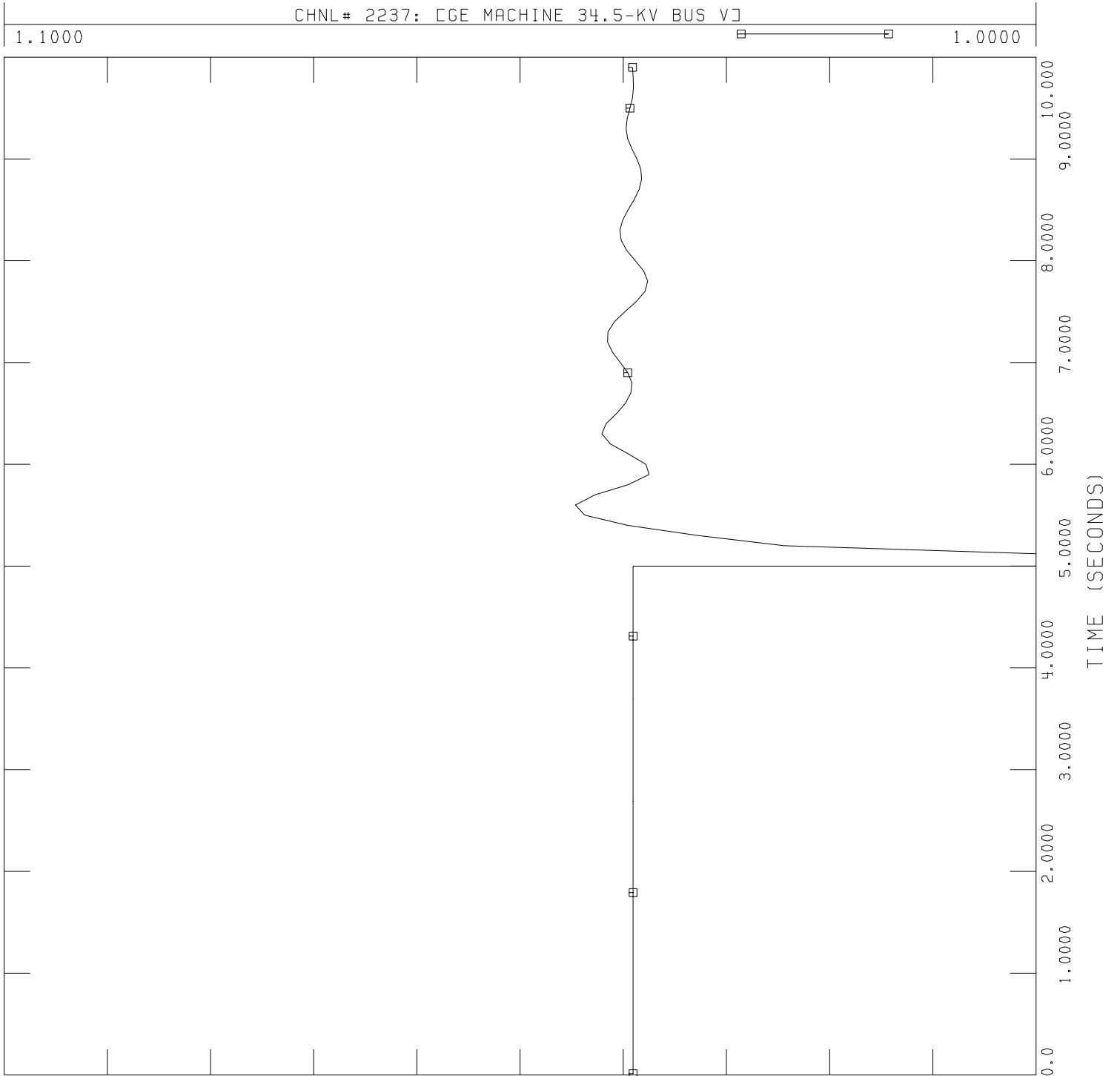
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45% 2000 NE LIB, PROJECTED 2007 50/50, PHASE 1
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MON, OCT 31 2005 16:00
GE 34.5-KV BUS V





45% 2000 NE LIB, PROJECTED 2007 50/50, PHASE 1
ISO NE CONTROL AREA LD+LOSS↑12308, NYNE= -1200, 2 A.L. CABLE

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GE MACHINE 34.5KV BUS V

