IESO_REP_0011

CONNECTION ASSESSMENT
& APPROVAL PROCESS

System Impact Assessment Report
Andrews GS – Excitation System and Governor System Replacements

Applicant: Great Lakes Power - Generation

***CAA ID* 2004-136**

Final Report

Long Term Forecasts & Assessments Department & Consistent Information Set Department

December 8, 2004

System Impact Assessment Report
Andrews GS – Excitation System and Governor Replacement

1. Project Description

Great Lakes Power – Generation Division submitted a connection assessment application in which they indicate their intention to replace the generator control systems for units G1 and G2 at Andrews GS. The proposed project includes:

- Replacement of the existing excitation systems with full-static excitation systems (type IEEE ST1A); and
- Replacement of the existing governor systems with modern digital governor systems (type PTI WEHGOV).

The new excitations system will be equipped with power system stabilizers that could be connected and tuned to provide additional damping if the need is identified during commissioning tests.

2. Assessment

The IMO has assessed the impact of the proposed modifications and concluded that they are not expected to have a material impact on the reliability of the IMO-controlled grid.

This report provides the results of the impact assessment, which demonstrates that the performance of the new control systems is within the IMO market rules requirements.

Transient Stability Analysis

Based on equipment data made available by GLP, the IMO has performed dynamic simulations to verify that the transient response of the new control systems meets the market rules requirements. This modelling data is shown in Appendix A.

The results of the simulations indicate that the proposed changes for units G1 and G2 satisfy the market rules requirements. Specifically, the response ratio test and the open circuit step response test (figures 1 and 2) indicate that:

- The excitation system voltage response time is less than 50 ms (the exciter field voltage reaches 95% of the excitation ceiling voltage in less than 50 ms); and
- Following a step change in the voltage regulator reference, the proposed exciter adequately damps the field voltage and the generator terminal voltage.

The governor response test demonstrated that the governor reacted adequately to a step change in load and damped well the transient variation in turbine power. This result of this test is shown in figure 3.

The new control systems of two units at Andrews GS have also been tested for a three-phase fault on one of the Gartshore 115 kV lines between Gartshore GS and MacKay TS. The test revealed that:

- The oscillations in rotor angle, MW and MVar output, and terminal voltage at Andrews GS, Gartshore GS, MacKay GS and Hogg GS were well damped and the machines remained stable after the fault;
- The bus voltages at Third Line TS and MacKay TS recovered and were well damped after the fault;
- The MW and MVar flows on Gartshore 1 and 2, and Sault 1, 2 and 3 lines recovered and were well damped after the fault.

The plots of rotor angles, voltages, MW and MVar flows are provided in Appendix B.

3. Conclusions and IMO Requirements

The IMO's assessment concluded that the proposed project is not expected to have any adverse impact on the reliability of the IMO-controlled grid. Furthermore, the tests revealed that Andrews G1 and G2 perform adequately in dynamic conditions and there is no need to enable the power system stabiliser function of the new exciters.

4. Notification of Approval

Notification of approval is granted for the proposed upgrade project.

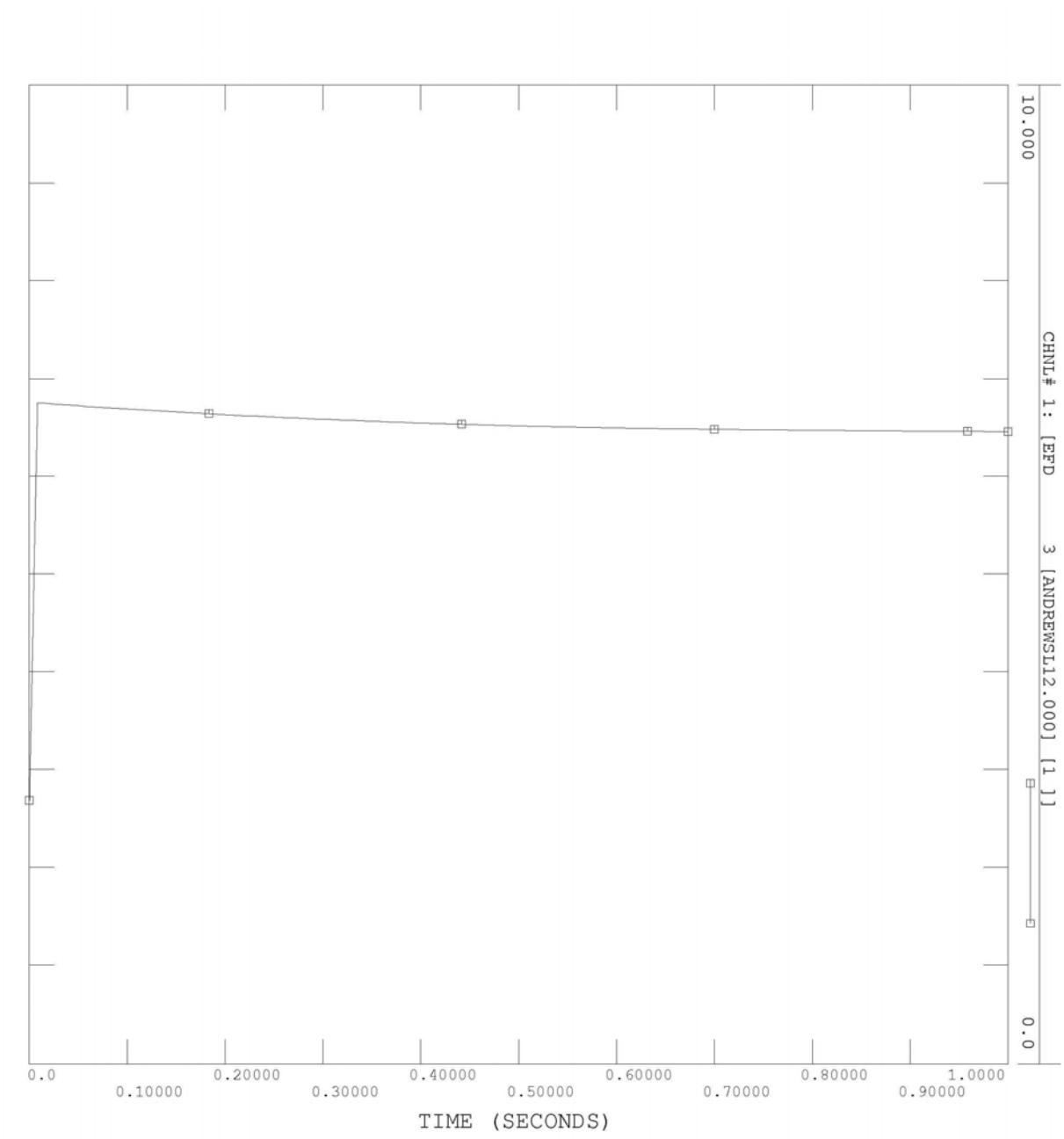

Figure 1: Exciter Response Ratio Test

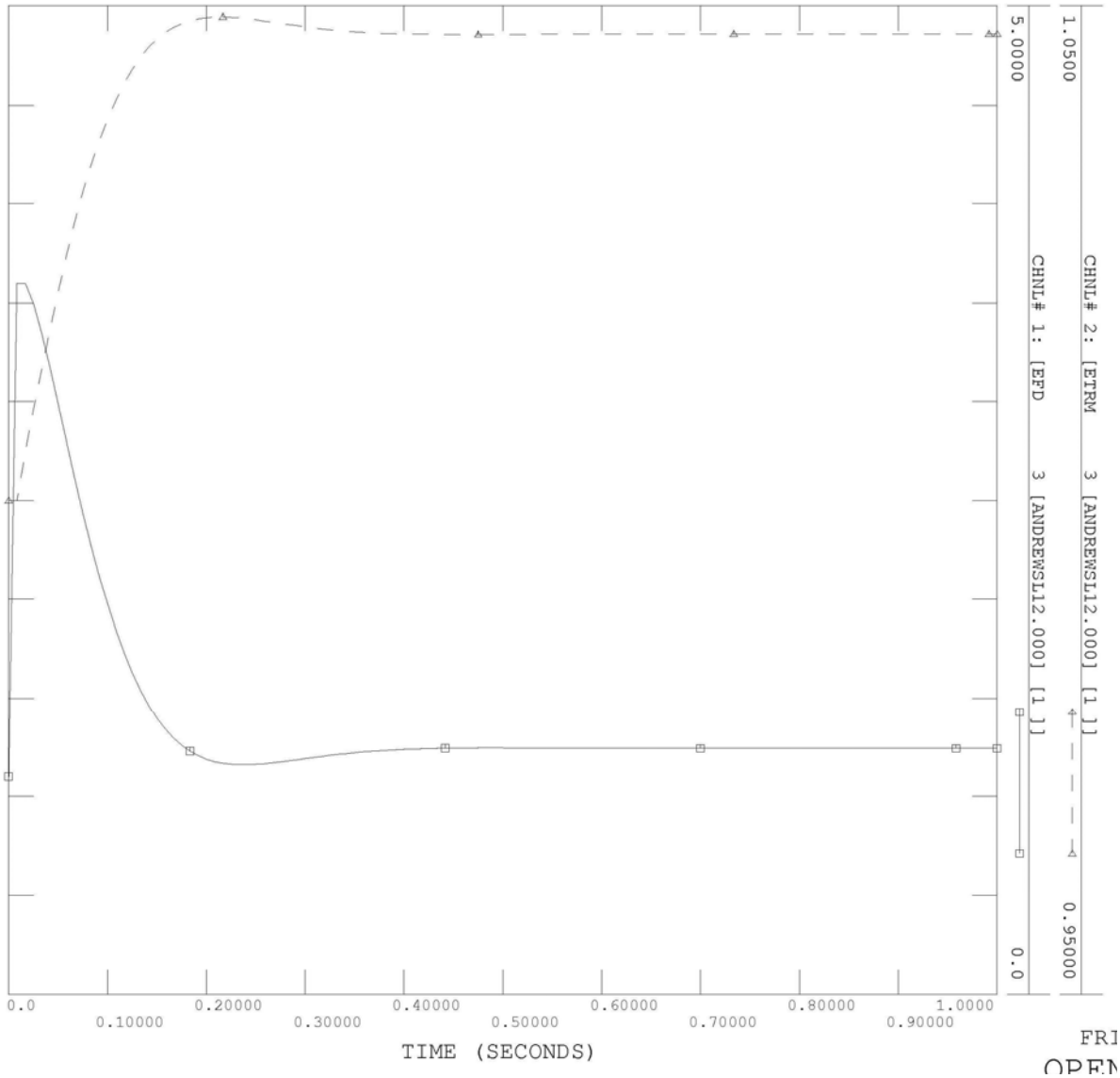

Figure 2: Exciter Open Circuit Test

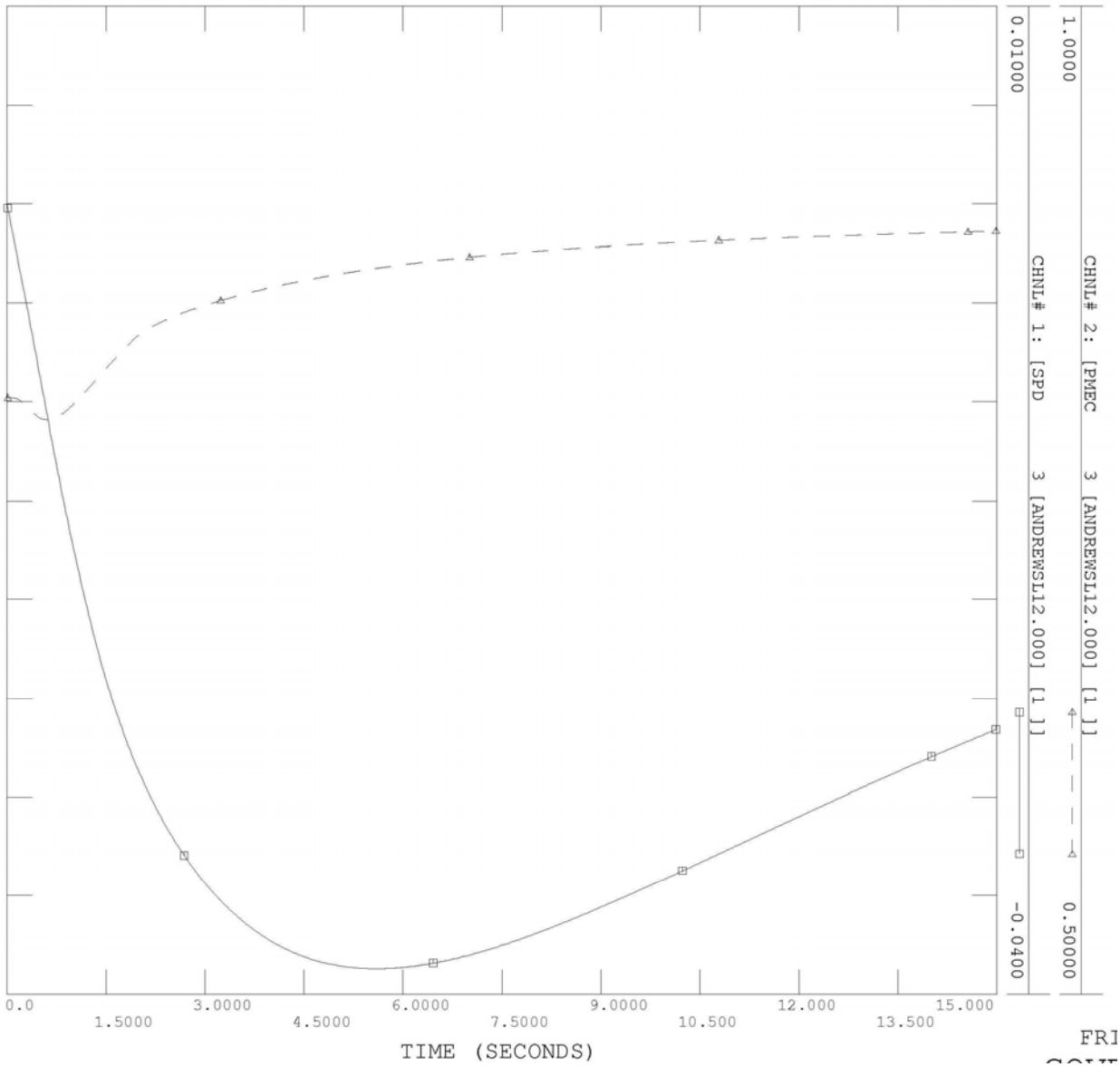

Figure 3: Governor Response Test

Appendix A

Andrews G1 modelling data

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** GENSAL **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            10175     ANDREWG1 12.000 1  221803-221814  82204-82208

            MBASE     Z S O R C E         X T R A N       GENTAP
             11.2  0.00300+J 0.27500  0.00000+J 0.00000  1.00000

  T'D0   T''D0   T''Q0     H    DAMP    XD      XQ      X'D    X''D     XL
 3.700   0.045   0.035   2.88   0.00  1.2860  0.6400  0.3900  0.2750  0.1000

                            S(1.0)  S(1.2)
                            0.1000  0.6000


** ESST1A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S    I C O N S
            10175     ANDREWG1 12.000 1  221833-221850  82214-82218    8749-8750

   UEL VOS     TR    VIMAX   VIMIN     TC      TB     TC1     TB1     KA
    0   0    0.015 999.000-999.000   0.000   0.000   0.000   0.000   50.0

    TA    VAMAX   VAMIN   VRMAX   VRMIN    KC     KF     TF    KLR    ILR
 0.000 999.000-999.000   6.960  -6.830  0.080  0.000  1.000  0.000  0.000


** WEHGOV **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S      ICON
            10175     ANDREWG1 12.000 1  221900-221948  82226-82232   16427-16430    8752

      R-GATE  R-PE   TPE      KP     KI      KD    TD   TP      TDV     TG  GTMXOP
       0.040  0.000  1.000  2.000  0.200  0.500  0.050  0.100  0.100  0.300  0.100

               GTMXCL  GMAX   GMIN   DTURB   TW    DBAND   DPV    DICM
               -0.100  1.000  0.000  0.000  0.800  0.001  0.000  0.040

                          FLOW VERSUS GATE TABLE
                            G1      G2      G3      G4      G5
                          0.000   1.000   0.000   0.000   0.000
                            F1      F2      F3      F4      F5
                          0.000   1.000   0.000   0.000   0.000

                          POWER VERSUS FLOW TABLE
        F1      F2      F3      F4      F5      F6      F7      F8      F9     F10
      0.000   0.100   0.450   0.500   0.550   0.600   0.650   0.750   1.000   1.050
        P1      P2      P3      P4      P5      P6      P7      P8      P9     P10
     -0.125   0.000   0.550   0.650   0.750   0.800   0.850   0.900   1.000   1.050

                  ICON(M)= 0; SIGNAL FOR DROOP IS THE GATE SIGNAL
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Andrews G2 modelling data

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** GENSAL **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            10174     ANDREWG2 12.000 1  221791-221802  82199-82203

            MBASE     Z S O R C E         X T R A N       GENTAP
             11.2  0.00300+J 0.27500  0.00000+J 0.00000  1.00000

  T'D0   T''D0   T''Q0     H    DAMP    XD      XQ      X'D    X''D     XL
 3.700   0.045   0.035   2.88   0.00  1.2860  0.6400  0.3900  0.2750  0.1000

                            S(1.0)  S(1.2)
                            0.1000  0.6000


** ESST1A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S    I C O N S
            10174     ANDREWG2 12.000 1  221815-221832  82209-82213    8747-8748

   UEL VOS      TR    VIMAX   VIMIN     TC      TB     TC1     TB1     KA
    0   0    0.015 999.000-999.000   0.000   0.000   0.000   0.000   50.0

    TA    VAMAX   VAMIN   VRMAX   VRMIN    KC     KF     TF    KLR    ILR
 0.000 999.000-999.000   6.960  -6.830  0.080  0.000  1.000  0.000  0.000


** WEHGOV **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S      ICON
            10174     ANDREWG2 12.000 1  221851-221899  82219-82225   16423-16426    8751

      R-GATE  R-PE   TPE      KP     KI      KD    TD   TP      TDV     TG  GTMXOP
       0.040  0.000  1.000  2.000  0.200  0.500  0.050  0.100  0.100  0.300  0.100

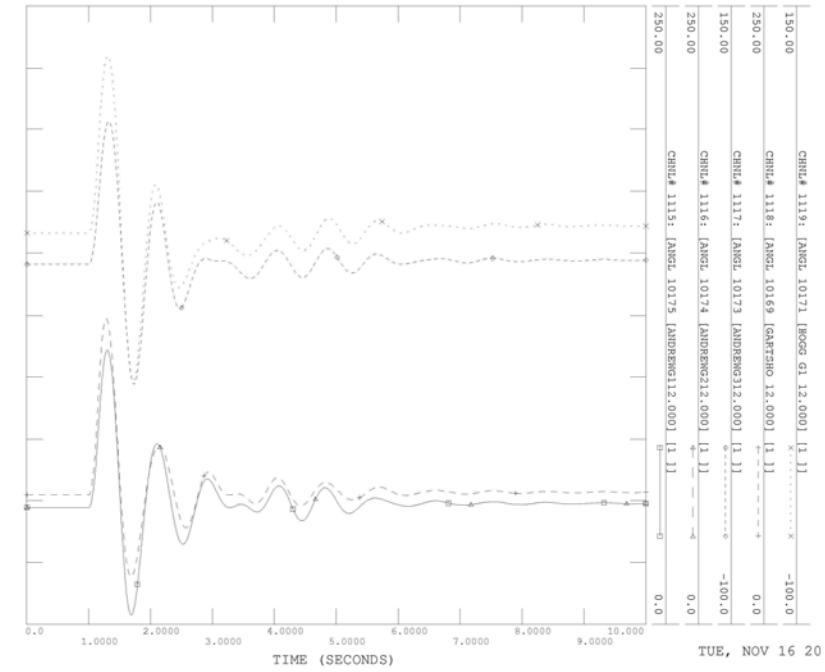
              GTMXCL  GMAX   GMIN   DTURB   TW    DBAND   DPV    DICM
              -0.100  1.000  0.000  0.000  0.800  0.001  0.000  0.040

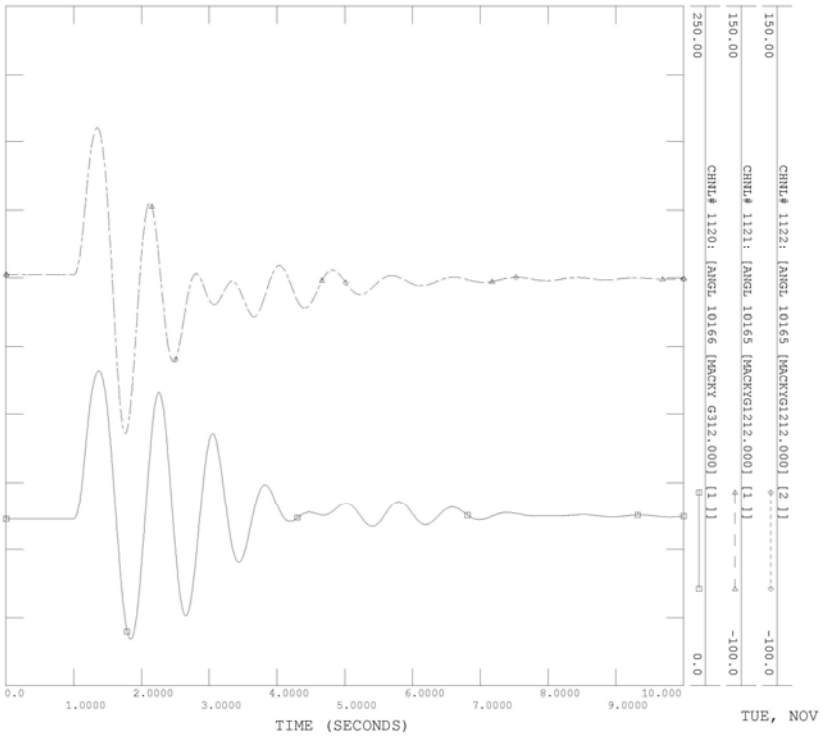
                          FLOW VERSUS GATE TABLE
                            G1      G2      G3      G4      G5
                          0.000   1.000   0.000   0.000   0.000
                            F1      F2      F3      F4      F5
                          0.000   1.000   0.000   0.000   0.000

                          POWER VERSUS FLOW TABLE
        F1      F2      F3      F4      F5      F6      F7      F8      F9     F10
       0.000   0.100   0.450   0.500   0.550   0.600   0.650   0.750   1.000   1.050
        P1      P2      P3      P4      P5      P6      P7      P8      P9     P10
      -0.125   0.000   0.550   0.650   0.750   0.800   0.850   0.900   1.000   1.050

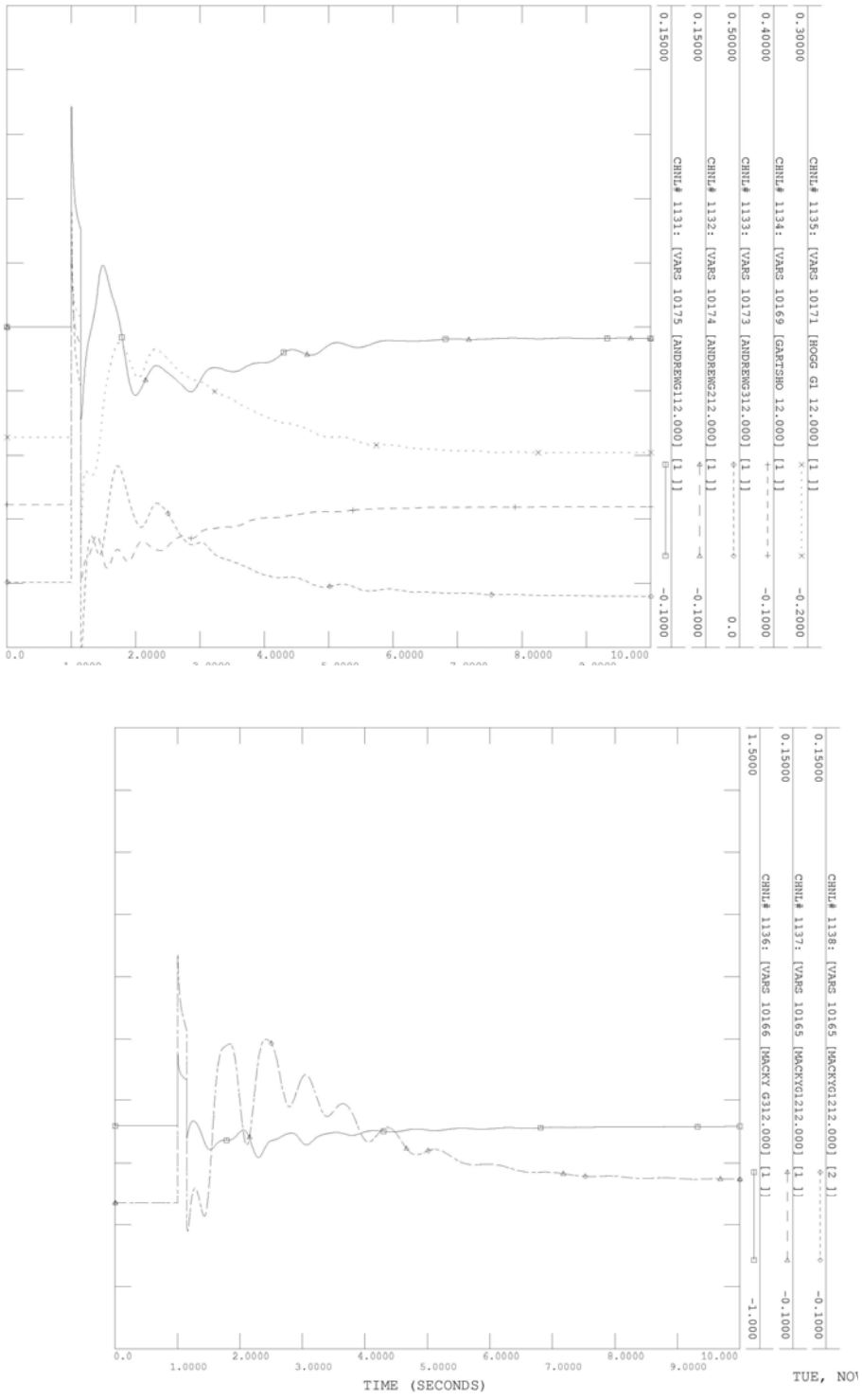
                  ICON(M)= 0; SIGNAL FOR DROOP IS THE GATE SIGNAL
```

Appendix B

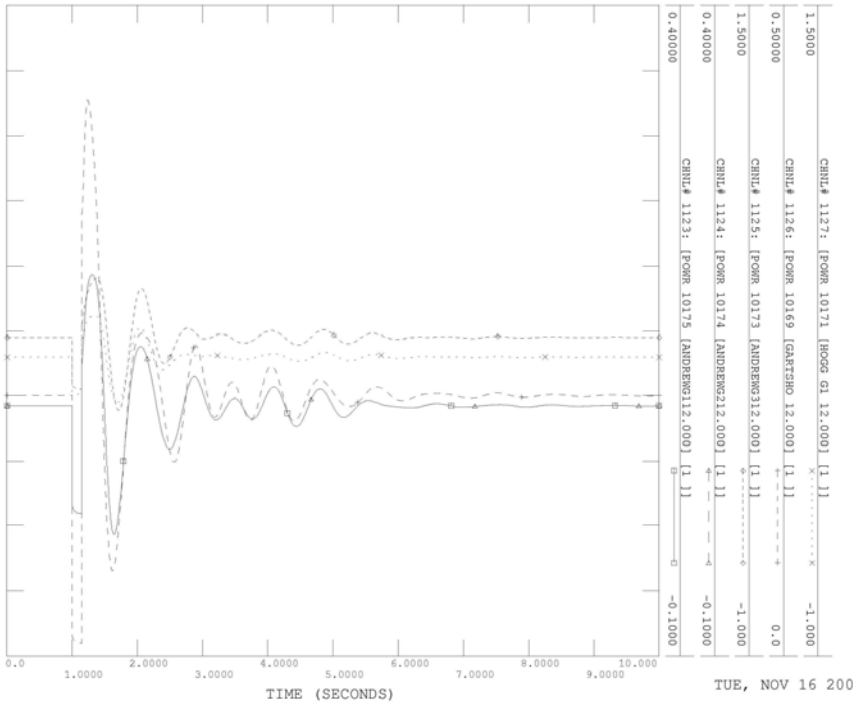


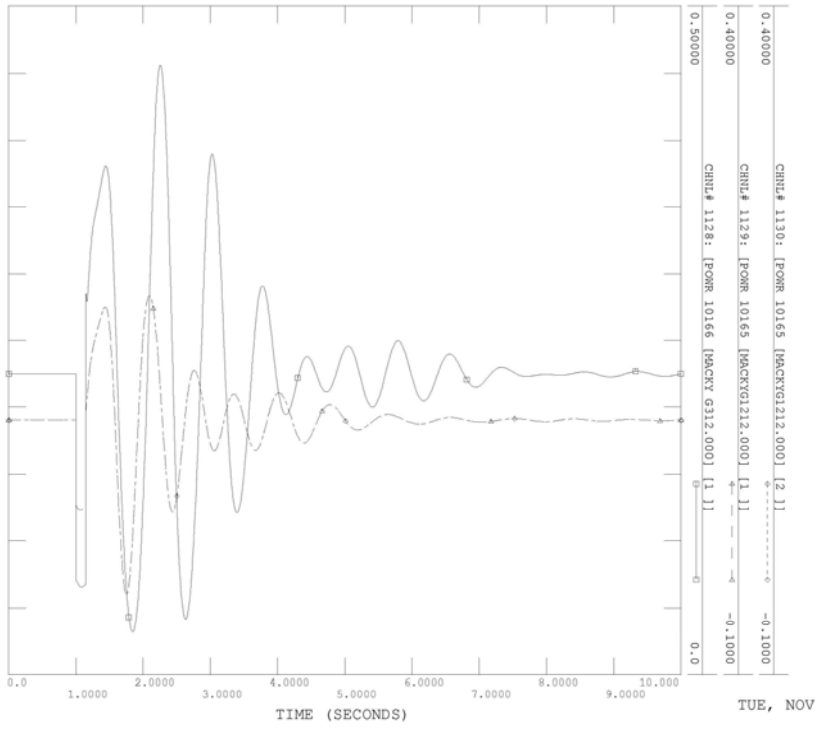


Rotor Angle Diagrams

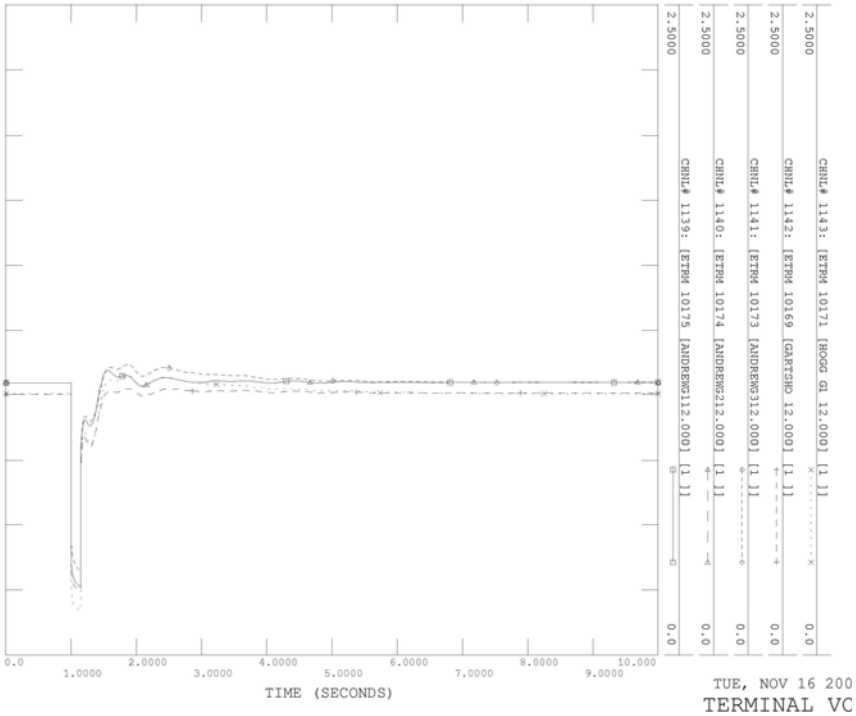


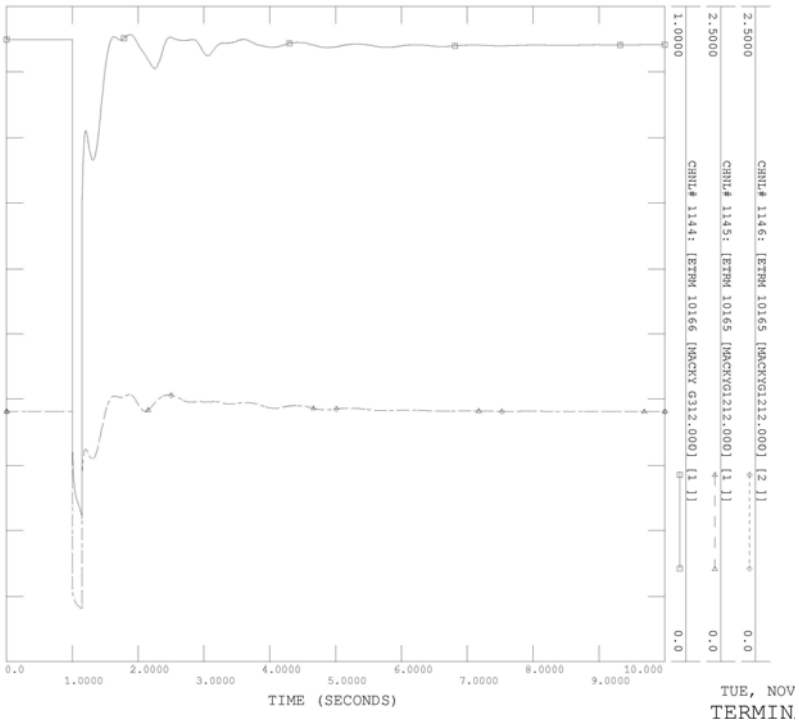
Generator MVar output diagrams



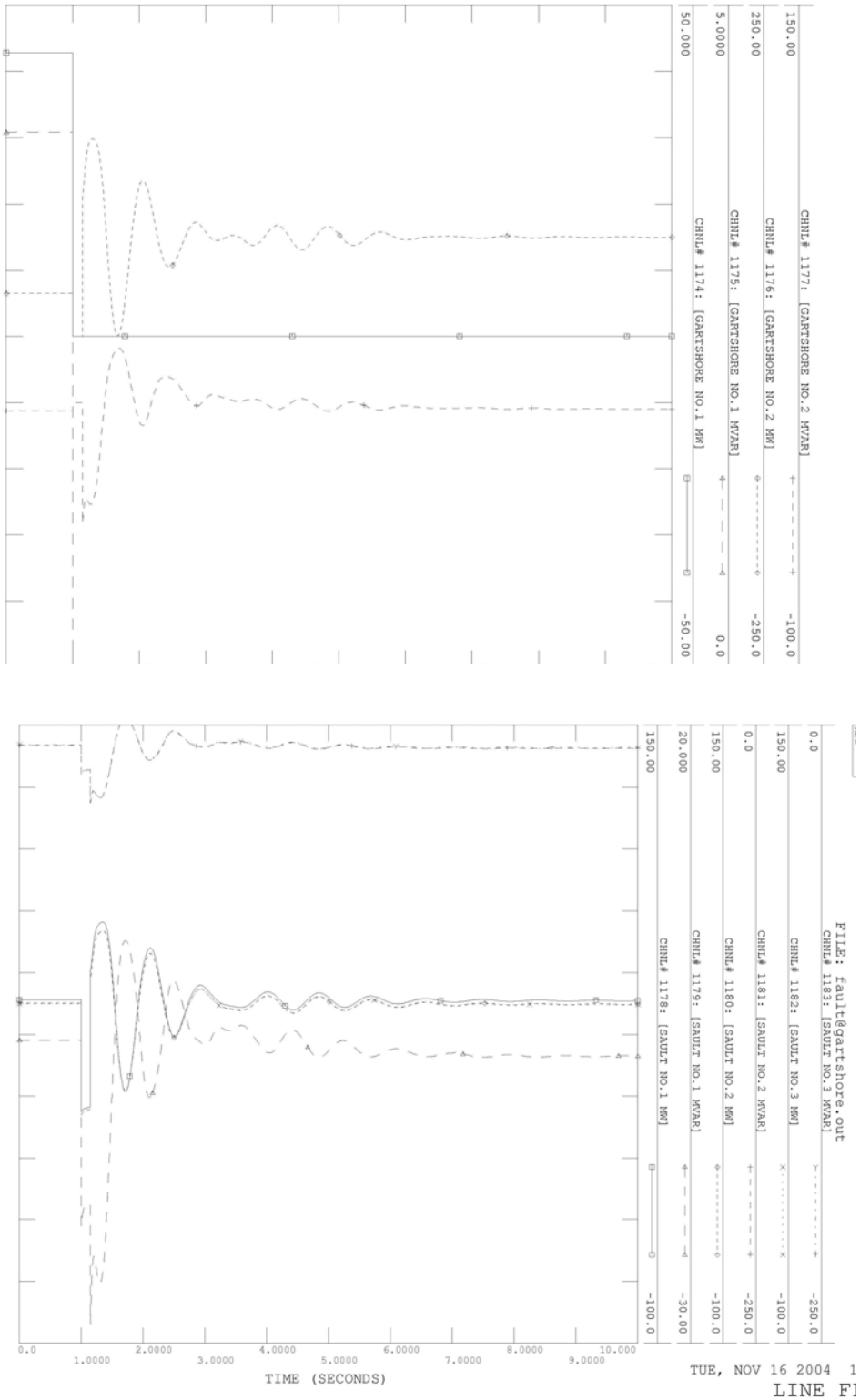


Generator MW output diagrams

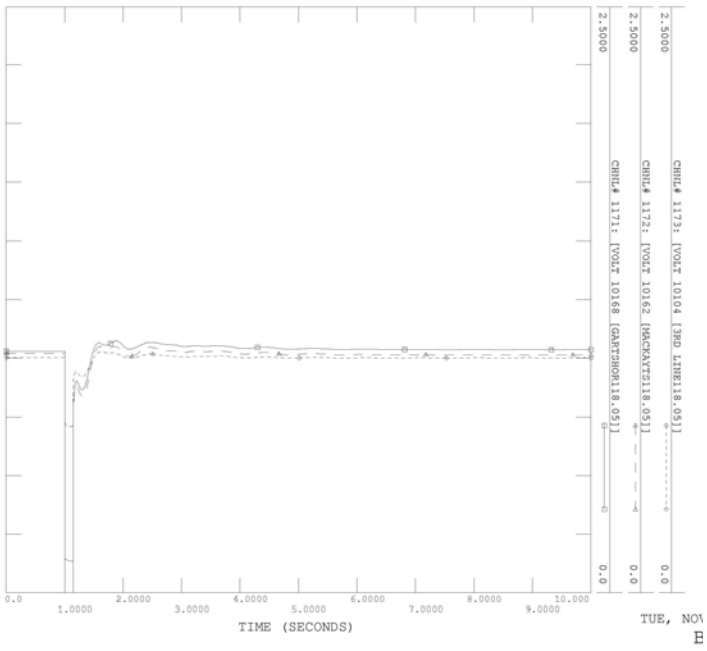




Generator Terminal Voltage Diagrams



Line Flow Diagrams



Bus Voltage Diagrams