IESO_REP_0330

REPORT

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System Impact Assessment Report - Ripley Wind Generation Station (WGS)

Connection Assessment & Approval Process

CAA ID 2004-125

Applicant: Suncor Energy Products Inc.

Transmission Assessments & Performance Department

August 30, 2006

Document ID	IESO_REP_0330
Document Name	System Impact Assessment Report - Ripley WGS
Issue	Issue 1.0
Reason for Issue	First Issue
Effective Date	August 30, 2006

Ripley WGS

Acknowledgement

The IESO wished to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This Report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of conditional approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, the conditional approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This Report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This Report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this Report. Any liability which the IESO may have to the connection applicant in respect of this Report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this Report to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this Report at any time in its sole discretion without notice to the connection applicant. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this Report is being used.

Hydro One

The results reported in this Report are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of this transmission system reinforcement proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed facilities on load and generation customers.

In this Report, short circuit adequacy is assessed only for Hydro One breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection proponent upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed facilities have been identified to the extent permitted by a preliminary assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

Summary

Suncor Energy Products Inc. ("Suncor") and Acciona Wind Energy Canada Inc. have signed a contract with the Ontario Power Authority for the Ripley wind generation station (WGS) to supply energy as part of the Ontario Government's Renewables II RFP.

The proposed connection of the 76 MW facility in the vicinity of the Bruce nuclear generation station, subject to the requirements specified in this report, is expected to have no material adverse effect on the reliability of the IESO-controlled grid.

Provided the generator's facilities are designed and constructed to satisfy the Ontario Electricity Market Rules (Market Rules) requirements for generators, including the requirements specified in this report, and provided the generation facilities are connected as described in this report, the Ripley facility will be approved to connect to the IESO-controlled grid.

The facility will consist of thirty-eight wind turbine generators (WTGs) rated at 2 MW each and two substations called Ripley North and Ripley South. The Ripley North substation will be located in the Municipality of Kincardine and the Ripley South substation will be located in the Township of Huron-Kinloss.

The Ripley North substation is to be connected via new 230 kV line taps to the existing 230 kV circuits B22D and B23D. The thirty-eight WTGs are to be connected via collector systems to the Ripley South substation. The Ripley North and South substations are to be connected together via a new 69 kV transmission circuit. Since this circuit will be greater than 2 km long, Suncor will need to obtain an Ontario Energy Board Leave to Construct.

This assessment finds that no network additions or modifications are required to satisfy IESO reliability standards for the incorporation of Ripley.

The Ripley WGS must connect to and participate in the Bruce Special Protection System (BSPS).

The proposed connection arrangement for Ripley is acceptable to the IESO subject to the specific requirements identified below.

The proposed reactive power compensation devices for Ripley are adequate to supply the reactive power requirements at the 230 kV connection point for all active power outputs.

The voltage performance and thermal loading of the power system in the Bruce area with the Ripley facility as proposed is expected to be acceptable in both the pre-contingency and post-contingency states.

The voltage ride through (VRT) capability of the WTGs is expected to be sufficient to allow Ripley to remain connected to the IESO-controlled grid for recognized system contingencies that do not remove the facility by configuration.

Transient stability studies show that the power system and the Ripley WTGs and D-VAR inverter remain stable for all examined fault conditions with acceptable damping.

Conclusions and IESO Requirements

Notification of Approval

It is recommended that a *Notification of Conditional Approval for Connection* be issued for the Ripley wind generation station subject to the IESO receiving from Suncor written acknowledgement that the requirements described below under the heading "IESO Requirements" will be implemented.

The proposed connection of the Ripley 76 MW wind generation station, subject to the requirements specified in this report, is expected to have no material adverse effect on the reliability of the IESO-controlled grid.

IESO Requirements

Provided the generator's facilities are designed and constructed to satisfy the Market Rule requirements for generators, including the requirements specified in this report, and provided the generation facilities are connected as described in this report, the Ripley WGS will be approved to connect to the IESO-controlled grid and allowed to participate in the IESO-administered market.

Final connection of these projects may also be subject to additional requirements specified in the Customer Impact Assessment performed by Hydro One.

The IESO requires the following requirements:

1. Suncor must complete the IESO Facility Registration process in a timely manner before IESO final approval for connection is granted. Finalized models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted to the IESO at least seven months before first synchronization of any unit to allow the IESO to perform any additional reliability studies.

   PSS/E ENERCON E-82 wind turbine generator model: The model provided by ENERCON for this assessment is a 'confidential' model. ENERCON is obligated to provide to the IESO a 'public' model by December 31, 2006. Otherwise, the IESO is released of its obligation to treat the provided model as 'confidential' and may disclose the model with other parties as required.

   PSS/E D-VAR model: The model should be a self-contained user model with one single FLECS file (not several files that have to be placed in the working directory) and have states whose derivatives initialize correctly to zero at the start of the simulation. The model should also simulate the complete operation of the overall system involving the D-VAR inverter and any switching of static reactive compensation devices. The IESO understands that American Superconductor has plans to improve the model in 2007.

2. During commissioning, Suncor must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in the finalized models and data. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided, Suncor must accept any restrictions the IESO may impose upon their participation in IESO-administered market or connection to the IESO-controlled grid.

3. The Ripley WGS must satisfy the Generator Facility requirements in Appendix 4.2, References 1 to 11, Reference 13 and the voltage response time requirement in Reference 12 of the Market Rules.

4. The WTGs must be able to ride through recognized contingencies on the IESO-controlled grid that do not disconnect the facility by configuration. This will require adequate low and high voltage ride through capability.

5. The connection and disconnection of the WTGs must minimize any adverse effects on the IESO-controlled grid.

6. High voltage 230 kV equipment connected to terminal stations must be capable of continuously operating in the range between 220 kV and 250 kV (Appendix 4.1, Reference 2 of the Market Rules).

   In particular, the IESO requires that the 230 kV connection equipment have the following requirements:

   - connection equipment must have a maximum continuous voltage rating of at least 250 kV in southern Ontario,

   - equipment must be able to interrupt rated fault current for voltages up to the maximum continuous rating, and

   - equipment must remain in service, and not automatically trip, for voltages up to 5% above the maximum continuous rating, for up to 30 minutes, to allow the system to be re-dispatched to return voltages within their normal range.

7. As stated in the Transmission System Code (TSC), Appendix 2, 230 kV connection equipment should have a rated 3-phase symmetrical short circuit capability of 63 kA and a rated single line to ground (SLG) symmetrical short circuit capability of 80 kA (usually limited to 63 kA). The TSC also requires that 230 kV breakers have a rated interrupting time of three cycles (50 ms) or less.

8. Connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated. This includes ensuring that all breakers fail in the open position.

   Connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions. This includes ensuring that SF6 breakers are equipped with heaters to prevent freezing.

9. Faults within the facility must not trip 230 kV circuits B22D and/or B23D except for the failure of a Ripley 230 kV connection breaker. After the facility begins commercial operation, if the tripping of B22D and/or B23D occurs due to events within Ripley, the facility may be required to be disconnected until the problem is solved.

10. Protection systems must be designed to meet all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 (Version B) and any additional requirements identified by Hydro One. Where required by Hydro One, protection systems at Ripley must be coordinated with Hydro One protections systems.

The Ripley WGS must connect to and participate in the Bruce Special Protection System (BSPS). The facility must disconnect from B22D and B23D via the Ripley North 230 kV breakers with no intentional delay upon receipt of generation rejection signals from the BSPS.

The special protection system facilities installed at Ripley must also comply with the NPCC Criteria Document A-11 for Type 1 special protection systems. In particular, separate ‘A’ and ‘B’ component racks are required to be physically separated by at least one rack between racks, and dual trip coils are required on the 230 kV breakers.

Suncor must also provide two dedicated communication channels, separated physically and geographically diverse, between the Ripley North substation and the Bruce nuclear generation station.

11. The facility must be capable of operating continuously in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.1, Reference 3 of the Market Rules.

12. The facility must be capable of operating at full active power for a limited period of time for frequencies as low as 58.8 Hz. The wind turbine generators (WTGs) must not trip for under-frequency system conditions that are below 60 Hz but above 57.0 Hz and above the curve shown in Figure 2.

13. The following minimum items must be telemetered to the IESO from Ripley WGS:

    - Bi-directional 230 kV active and reactive power flows at the B22D and B23D connection points,
    - Bi-directional 34.5 kV active and reactive power flows of transformer T3,
    - Reactive power flow of 34.5 kV D-VAR inverter,
    - Voltages at the 230 kV connection points on B22D and B23D,
    - Voltages on the Ripley North 69 kV bus,
    - Voltages on the 34.5 kV collector bus,
    - Status of 230 kV line disconnects 89-B22D and 89-B23D,
    - Status of 230 kV breakers 52-T1 and 52-T2,
    - Status of 69 kV breakers 52-MV1, 52-MV2 and 52-T3,
    - Status of 34.5 kV breakers F1, F2 and F3, and
    - Status of 69 kV capacitor bank breakers, and 34.5 kV D-VAR inverter and reactor breakers.

    The IESO will finalize items to be telemetered during the IESO Market Entry Process.

14. The facility must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable unless required by the IESO.

15. All plant auxiliaries must be capable of operating continuously within the 230 kV system voltage range of 220 kV to 250 kV.

16. Suncor is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 230 kV system in order to verify the dynamic response of the D-VAR inverter and WTGs. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One

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1. Introduction

This report documents the IESO assessment of the adequacy of the proposed connection arrangement, compares the performance characteristics of the generators and associated equipment against the Market Rules standards, analyzes the adequacy of the short circuit and thermal capability of the local transmission system, and assesses the voltage and stability performance of the IESO-controlled grid with the new facility connected. This report provides Suncor Energy Products Inc. (“Suncor”) a list of requirements to the proposal to ensure that the new facility, when connected, will not have a material adverse effect on the reliability of the IESO-controlled grid, and also points out significant Market Rules requirements for wind generation stations.

This System Impact Assessment has been conducted to examine the effect of the Ripley 76 MW wind generation station (WGS) on the reliability of the IESO-controlled grid.

This project was selected by the Ontario Government in November 2005 as part of the Renewables II RFP, and is scheduled to be in commercial operation by the third quarter of 2007.

– End of Section –

2. Proposed Connection Arrangement

The Ripley WGS is to be connected to 230 kV circuits B22D and B23D via a new tap near tower #50, approximately 11 km from the Bruce A transformer station (TS). The length of the tap connection segment from the proposed facility to B22D and B23D will be approximately 200 m.

The 76 MW facility will consist of two substations called Ripley North and Ripley South and employ thirty-eight ENERCON E-82 variable speed wind turbine generators (WTGs) rated at 2.0 MW, 60 Hz and 400 V each. Each ENERCON unit employs a direct-drive synchronous generator with a power converter interfacing the variable speed generator to the station network.

The wind generated power is to be stepped up from 400 V to 34.5 kV by means of an individual pad-mounted, generator step-up transformer located at the base of each wind turbine.

The WTGs are to be grouped into three 34.5 kV collector systems F1, F2 and F3. Collector systems F1, F2 and F3 will contain thirteen, ten and fifteen WTGs, respectively.

Each collector system is to connect a 34.5 kV collector bus via a 1,200 A rated breaker. The collector bus is to connect to a 34.5/69 kV step-up transformer T3 which in turn is to connect to a 27 km, 69 kV transmission circuit via a 69 kV breaker rated at 1,200 A. The 34.5 kV collector bus, T3 transformer and associated equipment comprise the Ripley South substation.

The 69 kV transmission circuit is to connect to a 69 kV bus, which will connect to two 69/230 kV step-up transformers T1 and T2, near the existing B22D and B23D circuits. Transformer T1 will connect to B23D via a tap connection segment and transformer T2 will connect to B22D via a similar tap connection segment. High voltage (HV) and low voltage (LV) transformer breakers rated at 1,200 A each are to be provided for each transformer. The 69 kV bus, T1 and T2 transformers and associated equipment comprise the Ripley North substation.

Reactive power compensation devices are to be also installed at the Ripley North and South substations. Ripley North will have two 16 Mvar, 69 kV shunt capacitor banks. Ripley South will have a 14 MVA D-VAR inverter (3 units rated at 4 MVA each, 1 unit rated at 2 MVA) and one 11 Mvar, 34.5 kV shunt reactor. The D-VAR inverter will connect to 480 V/34.5 kV step-up transformers, which will connect to the collector bus via a 1,200 A rated breaker. The capacitor banks and reactor will connect to their respective buses via 1,200 A rated breakers.

The 69/240 kV step-up transformers T1 and T2 are to be rated at 25/33/42 MVA, connected HV - wye-grounded/LV – delta, and equipped with HV under-load tap changers (ULTCs) providing a ±10% voltage range in steps of 1%. In normal operation, the ULTCs will be manually operated and set at the +8 tap position (7% for 256.8 kV).

The 34.5/69 kV step-up transformer T3 is to be rated at 50/66.66/83.33 MVA, connected HV - wye-grounded/LV- wye-grounded tertiary winding, and equipped with HV under load tap changers (ULTCs) providing a ±10% voltage range in steps of 0.625%. In normal operation, the ULTCs will be set to hold the 34.5 kV collector bus voltage between 1.02 pu and 1.04 pu (35.19 kV to 35.88 kV).

The 400 V/34.5 kV generator step-up transformers are to be rated at 2.3 MVA and connected HV - delta/LV - wye-grounded. Fixed off-load HV taps at ±5%, ±2.5% and 0% are to be provided. The fixed off-load taps will be set at 0%.

Suncor has indicated that auto-reclosure facilities will not be installed for the Ripley 230 kV breakers.

Figure 1 (page 27) is a single line diagram of the proposed facility.

– End of Section –

3. General Requirements

Models & Data

1. Suncor must complete the IESO Facility Registration process in a timely manner before IESO final approval for connection is granted. Finalized models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted to the IESO at least seven months before first synchronization of any unit to allow the IESO to perform any additional reliability studies.

2. During commissioning, Suncor must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in the finalized models and data. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided, Suncor must accept any restrictions the IESO may impose upon their participation in IESO-administered market or connection to the IESO-controlled grid.

Generators

1. The Ripley WGS must satisfy the Generator Facility requirements in Appendix 4.2, References 1 to 11, Reference 13 and the voltage response time requirement in Reference 12 of the Market Rules.

In particular, references 1 and 2 require that a synchronous generator unit connecting to the IESO-controlled grid must have the minimum capability to perform the following:

- Supply reactive power continuously at all active power outputs in the range of 0.9 lagging to 0.95 leading power factor based on rated active power at its generator terminals for at least one constant 230 kV system voltage, and
- Supply full active power continuously while operating at a generator terminal voltage ranging from 0.95 pu to 1.05 pu of the generator's rated terminal voltage.

For a single generator connected to a generator step-up transformer which is in turn connected to the IESO-controlled grid, the above two requirements effectively limit the impedance between the generator terminals and HV side of the transformer to a maximum of 0.13 pu based on the MVA rating of the generator(s), which is normally based on the maximum continuous active power rating at a 0.9 power factor. However, if a generator is capable of supplying the full reactive power range at it terminals for at least one constant system voltage while operating at a terminal voltage range outside the range between 0.95 pu to 1.05 pu, the effective maximum impedance allowed between the generator terminals and the HV side of the generator step-up transformer could be higher than 0.13 pu.

For a facility employing induction WTGs or asynchronous WTGs, the facility must have the same capabilities to supply reactive power continuously as required of a synchronous generator with the same apparent power, as measured at the point of connection to the IESO-controlled grid.

Assuming the facility has a capability to operate from 0.95 pu to 1.05 pu of the generator's rated terminal voltage, the following maximum reactive power requirements, as measured at the connection point, must be supplied based on a maximum effective facility impedance of 0.13 pu:

- At all levels of active power output, the minimum reactive power required to be injected by the facility at the point of connection is +0.35 pu of rated active power, and
- At all levels of active power output, the minimum reactive power required to be absorbed by the facility at the point of connection is -0.33 pu of rated active power.

A facility deficient in the above reactive power requirements must install additional reactive compensation devices. Specifically, the IESO has identified the following requirements for compensation devices:

- For WTGs that have dynamic reactive power capabilities described in Appendix 4.2, Reference 1 of the Market Rules at all levels of active power output, shunt capacitors may be required to offset the reactive power losses within the facility in excess of the maximum allowable losses.
- For WTGs that do not have dynamic reactive power capabilities described in Appendix 4.2, Reference 1 of the Market Rules, dynamic reactive compensation devices must be installed to make up the deficient reactive power capabilities as required in Appendix 4.2, Reference 1. In addition, shunt capacitors may be required to offset the reactive power losses within the facility in excess of the maximum allowable losses.

2. The WTGs must be able to ride through recognized contingencies on the IESO-controlled grid that do not disconnect the facility by configuration. This will require adequate low and high voltage ride through capability.

3. The connection and disconnection of the WTGs must minimize any adverse effects on the IESO-controlled grid.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

1. High voltage 230 kV equipment connected to terminal stations must be capable of continuously operating in the range between 220 kV and 250 kV (Appendix 4.1, Reference 2 of the Market Rules).

Some recognized contingencies (e.g. load shedding, open line end) can cause a temporary voltage increase above the maximum continuous limit of 250 kV. For these conditions, connection equipment may be exposed to voltages slightly above its maximum continuous rating for the short period of time that it takes the IESO to direct operations to restore a normal voltage profile, and to prepare for the next contingency. This re-preparation period will be as short as possible, but it will not take longer than 30 minutes.

Therefore, the IESO requires that the 230 kV connection equipment have the following requirements:

- connection equipment must have a maximum continuous voltage rating of at least 250 kV in southern Ontario,
- equipment must be able to interrupt rated fault current for voltages up to the maximum continuous rating, and
- equipment must remain in service, and not automatically trip, for voltages up to 5% above the maximum continuous rating, for up to 30 minutes, to allow the system to be re-dispatched to return voltages within their normal range.

2. The Transmission System Code (TSC), Appendix 2 states that 230 kV connection equipment should have a rated 3-phase symmetrical short circuit capability of 63 kA and a rated single line to ground (SLG) symmetrical short circuit capability of 80 kA (usually limited to 63 kA). The TSC also requires that 230 kV breakers have a rated interrupting time of three cycles (50 ms) or less.

3. Connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated. This includes ensuring that all breakers fail in the open position.

   Connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions. This includes ensuring that SF6 breakers are equipped with heaters to prevent freezing.

Protection Systems

1. Faults within the facility must not trip 230 kV circuits B22D and/or B23D except for the failure of a Ripley 230 kV connection breaker. After the facility begins commercial operation, if the tripping of B22D and/or B23D occurs due to events within Ripley, the facility may be required to be disconnected until the problem is solved.

2. Protection systems must be designed to meet all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 (Version B) and any additional requirements identified by Hydro One. Where required by Hydro One, protection systems at Ripley must be coordinated with Hydro One protections systems.

3. The facility must be capable of operating at full active power for a limited period of time for frequencies as low as 58.8 Hz. The wind turbine generators (WTGs) must not trip for under-frequency system conditions that are below 60 Hz but above 57.0 Hz and above the curve shown in Figure 2.

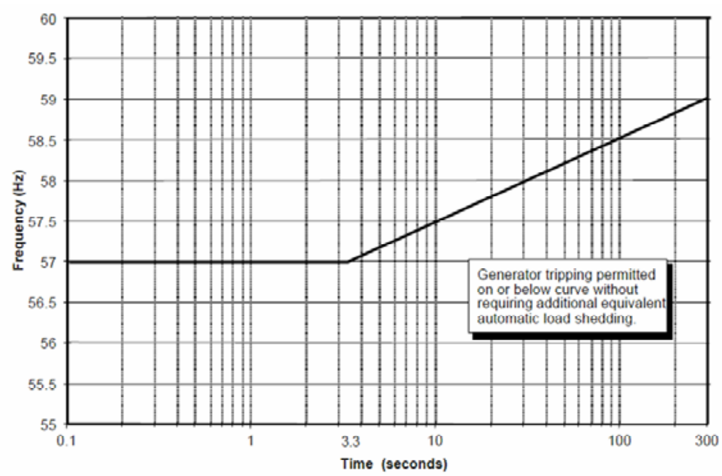


Figure 2: Standards for Setting Under-frequency Trip Protection for Generators

IESO Monitoring and Telemetry Data

1. The Market Rules (Appendix 4.15 and Appendix 4.19) list the requirements with respect to the telemetry data that must be provided to the IESO and to the performance standards that must be achieved on a continual basis by all generators.

   In accordance with the requirements for a *major generation facility*, Suncor must ensure that all the equipment needed to provide the telemetry data and meet the performance standards will be installed.

The IESO requires the following items at the minimum to be telemetered to the IESO from Ripley WGS:

- Bi-directional 230 kV active and reactive power flows at the B22D and B23D connection points,
- Bi-directional 34.5 kV active and reactive power flows of transformer T3,
- Reactive power flow of 34.5 kV D-VAR inverter,
- Voltages at the 230 kV connection points on B22D and B23D,
- Voltages on the Ripley North 69 kV bus,
- Voltages on the 34.5 kV collector bus,
- Status of 230 kV line disconnects 89-B22D and 89-B23D,
- Status of 230 kV breakers 52-T1 and 52-T2,
- Status of 69 kV breakers 52-MV1, 52-MV2 and 52-T3,
- Status of 34.5 kV breakers F1, F2 and F3, and
- Status of 69 kV capacitor bank breakers, and 34.5 kV D-VAR inverter and reactor breakers.

The IESO will finalize items to be telemetered during the IESO Market Entry Process.

Miscellaneous

1. The facility must be capable of operating continuously in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.1, Reference 3 of the Market Rules.

2. The facility must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable unless required by the IESO.

3. All plant auxiliaries must be capable of operating continuously within the 230 kV system voltage range of 220 kV to 250 kV.

4. Suncor is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 230 kV system in order to verify the dynamic response of D-VAR inverter and the WTGs. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One.

– End of Section –

4. General Assessment

4.1 Connection Arrangement

The proposed Ripley facility shown in Figure 1 (page 27) will not reduce the level of reliability of the IESO-controlled grid and is, therefore, acceptable to the IESO.

An outage to transformer T1 or T2 will limit the generation capability of the facility to 42 MVA based on the T1 and T2 ONAF ratings.

4.2 Connection Equipment

Suncor has provided the following 230 kV equipment specifications for Ripley:

Switches 89-B22D & 89-B23D

- Type – Disconnect
- Continuous maximum operating voltage – 250 kV
- Continuous current rating – 1,200 A
- Short circuit symmetrical duty – 63 kA

For switches 89-B22D and 89-B23D, the Market Rules and Transmission System Code requirements are met.

Breakers 52-T1 & 52-T2

- Type – SF6
- Continuous maximum operating voltage – 250 kV
- Rated interrupting time – 3 cycles (50ms)
- Continuous current rating – 1,200 A
- Short circuit symmetrical duty – 63 kA

For breakers 52-T1 and 52-T2, the Market Rules and Transmission System Code requirements are met.

4.3 Special Protection Systems

The Bruce Special Protection System (BSPS) is a collection of special protection systems installed at the Bruce B switching station (SS) and at other stations, which perform pre-defined control actions in response to recognized contingencies by monitoring the status of the electrical connection between nodes in southern Ontario. The primary purpose of the BSPS is to allow increased pre-contingency transfers on the existing transmission facilities emanating from the Bruce nuclear generation station (NGS).

The BSPS is classified as a "Type 1 Special Protection System", and conforms to criteria and guidelines specified in the Northeast Power Coordinating Council (NPCC) Special Protection System Criteria Document A-11.

The IESO has identified a requirement that wind generation stations connecting near the Bruce NGS must connect to and participate in the BSPS. As detailed in the SIA report and addendum for Hydro One BSPS modifications (CAA ID 2005-EX222), the incorporation of wind generation rejection (G/R) to the BSPS is considered a new BSPS control action. It is expected that this new control action will provide the IESO with increased operating flexibility during transmission outage conditions.

Special protection system facilities must be installed at Ripley to accept a single pair (A & B) of G/R signals from the BSPS, and disconnect from B22D and B23D via the Ripley North 230 kV breakers with no intentional time delay, when selected for pre-arming by the IESO. These special protection system facilities must also comply with the NPCC Criteria Document A-11 for Type 1 special protection systems. In particular, separate 'A' and 'B' component racks are required to be physically separated by at least one rack between racks, and dual trip coils are required on the 230 kV breakers. Suncor must provide two dedicated communication channels, separated physically and geographically diverse, between the Ripley North substation and the Bruce NGS.

4.4 Fault Levels

Fault level studies were completed by Hydro One to specifically examine the effect of the Kingsbridge II phase 1, Underwood (Projects A & B), Amaranth II (Melancthon II), Ripley and Port Alma wind generation projects on fault levels at existing facilities in southwestern Ontario, assuming a maximum contribution from each project. (Please note that the Kingsbridge II phase 1, Underwood, Amaranth II and Port Alma projects were also selected by the Ontario Government as part of the Renewables II RFP.)

In particular, the Hydro One studies assumed all existing generation facilities in service. This included:

- six Bruce units,
- six Pickering units,
- four Darlington units,
- eight Nanticoke units,
- four Lennox units,
- the TransAlta Sarnia generation station (GS),
- the Brighton Beach GS,
- Erie Shores WGS,
- Kingsbridge I WGS, and
- Amaranth WGS.

In addition, the studies assumed other expected RFP generation projects in service. This included:

- Blue Highlands WGS,
- Greenfield Energy Centre,
- St. Clair Energy Centre,
- Goreway GS, and
- Portlands Energy Centre.

Finally, the studies used two assumptions for the Lambton thermal generation station (TGS). As detailed in the SIA report and addendum for the Greenfield (CAA ID 2004-167) and St. Clair (CAA ID 2004-187) Energy Centres, the worst case fault levels at and away from the Lambton 230 kV bus depend on the operating mode of the bus and the number of Lambton units in service. Therefore, the fault level studies were completed using two different scenarios:

- Lambton SS 230 kV bus open and re-configured with four Lambton TGS units in service (worst case at Lambton), and
- Lambton SS 230 kV bus closed with one Lambton TGS unit in service (worst case away from Lambton).

However, the study results indicated that the fault levels were approximately the same at facilities that are at a significant distance from Lambton. As such, Table 1 summarizes the fault levels near the Ripley WGS for the first scenario only.

Table 1: Fault levels near Ripley WGS with the Lambton 230 kV bus open and re-configured, and four Lambton TGS units in service

Bus	**Symmetrical Fault (kA)***		**Asymmetrical Fault (kA)***		**Breaker Lowest Ratings (kA)****
	3-phase	**Single Line to Ground (SLG)**	**3-phase**	**SLG**	
Existing system					
Bruce 230 kV A	31.3	40.3	41.1	54.5	63 kA sym
Detweiler 230 kV	21.7	19.1	23.8	21.6	40 kA sym
Seaforth 115 kV	10.8	12.9	12.3	14.6	34 kA sym
System with Kingsbridge II phase 1, Underwood, Amaranth II, Ripley and Port Alma wind projects					
Bruce 230 kV A	32.6	41.9	42.6	56.1	63 kA sym
Detweiler 230 kV	21.9	19.2	24.1	21.4	40 kA sym
Seaforth 115 kV	10.8	12.9	12.3	14.7	34 kA sym

* Based on a pre-fault voltage level of 250 kV for the 230 kV system & a pre-fault level of 127 kV for the 115 kV system.

** Worst case rating.

The results in Table 1 generally show that there is a slight increase in fault currents with the addition of the five wind projects at Bruce A and Detweiler. However, the fault levels do not exceed the interrupting capabilities of the worst rated breakers.

– End of Section –

5. SIA Methodology

5.1 Study Assumptions

The following assumptions were made in the IESO studies:

- Base Case: A representative summer 2008 base case was used.
- Demand Data: A demand of approximately 27,450 MW with a load power factor of 0.897 was used.
- Transmission Facilities: All existing and proposed major transmission facilities with 2008 in-service dates or earlier were assumed in service.
- Generation Facilities: The following facilities were included:
  - 6 Bruce units
  - 5 Pickering units
  - 4 Darlington units
  - 5 Nanticoke units
  - 0 Lambton units
  - Connected RFP projects: Port Burwell (Lake Erie Shores), Kingsbridge I, Amaranth (Melancthon I) and GTAA.
  - Expected RFP projects: Blue Highlands, Amaranth II (Melancthon II), Underwood (Projects A & B), Kingsbridge II phase 1, Port Alma, Greenfield Energy Centre, St. Clair Energy Centre, Goreway and Portlands.
- Interface Flows: FABC – 4,993 MW, FETT – 4,713 MW, NBLIP – 1,002 MW, FS – 1,238 MW and QFW – 1,269 MW
- Imports: Michigan – 1,537 MW, Quebec – 0 MW, New York Niagara – 1,110 MW and New York St. Lawrence – 0 MW.
- Equipment Ratings: Continuous and short-term ratings as provided by the equipment owners.

5.2 Study Criteria

To assess the impact of the proposed Ripley WGS, the technical criteria identified in the IESO Transmission Assessment Criteria document were used in the IESO studies. This document can be found on the IESO web site at

http://www.ieso.ca/imoweb/pubs/marketAdmin/IMO_REQ_0041_TransmissionAssessmentCriteria.pdf.

In particular for voltage change limits, after a single or double-element contingency, with all facilities in service pre-contingency, system voltage declines (500 kV, 230 kV and 115 kV) are limited to a 10% voltage change before tap changer action (pre-ULTC) and after tap changer action (post-ULTC).

This voltage change criteria also applies to the loss of a generating facility due to a single element contingency involving any upstream element from the generator bus.

5.3 Study Tools, Data & Models

The Siemens PSS/E software program was used by the IESO to complete the load flow and dynamic response studies.

The Ripley WGS was modeled using data provided by Suncor. In particular for each collector system, all the WTGs were aggregated into a single generator connected to a representative circuit via a generator step-up transformer. Each generator and generator step-up transformer was appropriately sized to represent the total number of WTGs on the collector system.

The dynamic response studies (section 7.0) were completed using a 'confidential' PSS/E model of the ENERCON E-82 WTG released to the IESO by ENERCON, and a PSS/E model of the D-VAR provided to the IESO by American Superconductor.

The D-VAR model parameters are listed in Appendix B.

– End of Section –

6. Load Flow Assessment

Load flow studies were carried out to assess the impact of the Ripley 76 MW WGS on the performance of the IESO-controlled grid near the proposed connection point. In particular, the voltage performance of the power system and the thermal loading of transmission circuits for pre-contingency and post-contingency situations were examined.

In addition, the reactive power capability of the Ripley WGS is assessed and compared to the Market Rules requirements.

The study assumptions are detailed in Section 5.1.

Figure 3 (page 28) shows the pre-contingency voltage profiles and power flows on circuits B22D and B23D with Ripley out of service. The Ripley 230 kV connection points are labelled ‘RIPLJB22’ and ‘RIPLJB23’.

Figure 4 (page 29) shows the pre-contingency voltage profiles and power flows with Ripley in service at an active power output of 76 MW and a reactive power output of +6 Mvar as measured at the 230 kV connection point.

6.1 Voltage Performance

The voltage performance of the IESO-controlled grid due to the incorporation of Ripley was evaluated by:

- Examining if voltage declines remain within criteria at various facilities for certain recognized transmission contingencies with and without Ripley connected, and
- Examining if voltage declines remain within criteria at various facilities for the loss of Ripley only.

The following transmission contingencies were used in evaluations:

- Simultaneous loss of 500 kV double circuit line B560V and B561M,
- Loss of 230 kV circuit B23D,
- Loss of 230 kV circuit with a Bruce A L23T25 breaker failure, and
- Simultaneous loss of 230 kV circuits B4V and B5V.

The results of the voltage performance studies (pre- and post-ULTC) for the various contingencies are found in the Tables in Appendix A. Only the buses with voltages most affected by Ripley are provided.

Among all the contingencies considered, the loss of the 500 kV double circuit line B560V and B561M is the most severe contingency that results in the largest post-contingency voltage declines. In particular, for this contingency without Ripley connected, some of the declines are close to the maximum 10% voltage change criteria. With Ripley connected, the declines increase by up to 0.45%, but still do not exceed the 10% criteria. The IESO finds that the voltage change performance of the IESO-controlled grid due to the incorporation of the Ripley WGS is acceptable.

6.2 Thermal Loading

Table 2 summarizes the thermal loading of the 500 kV and 230 kV transmission circuits connected to the Bruce nuclear generation station ("Bruce") with and without Ripley WGS connected for all elements in service.

Table 2: Flows away from Bruce with and without Ripley – All elements in service

Circuit (flow away from Bruce)	Without Ripley connected			With Ripley connected 76.24 MVA (76 MW, +6 Mvar)			Change in S (%) based on Ripley
	P (MW)	Q (Mvar)	S (MVA)	P (MW)	Q (Mvar)	S (MVA)	
B562L	293	-136	323	304	-134	332	11.81
B563L	412	-117	428	422	-114	437	11.81
B560V	1480	123	1485	1495	129	1500	19.68
B561M	1712	222	1726	1729	230	1744	23.61
B22D	254	47	258	222	45	227	-40.66
B23D	254	48	258	222	46	227	-40.66
B4V	194	-18	195	198	-17	199	5.25
B5V	195	-17	195	199	-16	199	5.25

As expected, the results show that the flows from Bruce, as measured at Bruce, decrease on the 230 kV circuits B22D and B23D and increase on the remaining circuits when Ripley is connected. For the circuits with increased flows, the flows are well below the continuous thermal limitations of the circuits leaving Bruce.

Since Ripley is connected to B22D and B23D, the thermal loading on these two circuits will be the most affected by a recognized contingency. As in the voltage decline results detailed in the previous section, the loss of B560V and B561M is the most severe contingency that produces the largest post-contingency flows on circuits B22D and B23D among all recognized contingencies with Ripley connected.

Tables 3 and 4 summarize the pre- and post-contingency voltages and flows on the circuit sections of B22D and B23D, respectively, for the loss of circuits B560V and B561M.

Table 3: B22D circuit section flows with Ripley – Contingency: Loss of B560V & B561M

Circuit Section	Pre-contingency				% of Continuous	Continuous Rating (Amps)	Post-contingency (Post-ULTC)				15-Minute LTR (Amps)*
	Voltage (kV)	P (MW)	Q (MX)	Current (Amps)			Voltage (kV)	P (MW)	Q (MX)	Current (Amps)	
Bruce A TS ** x Ripley WGS	250.0	222	45	523	33.1	1579	245	385	156	977	2054
Ripley WGS x Wingham Jct	248.1	259	45	612	38.8	1579	240	421	151	1076	2054
Wingham Jct x Seaforth TS	241.4	218	4	521	33.0	1579	223	374	51	979	2054
Searforth TS x Stratford Jct	239.1	143	-42	360	26.4	1361	216	301	-41	812	1710
Stratford Jct x Detweiler TS	241.3	82	-51	230	19.9	1154	218	237	-88	670	1460

* LTR ratings are based on a 50% pre-load with a 35ºC ambient temperature and a 5 km/hr wind speed.

** TS = transformer station

Table 4: B23D circuit section flows with Ripley – Contingency: Loss of B560V & B561M

Circuit Section	Pre-contingency				% of Continuous	Continuous Rating (Amps)	Post-contingency (Post-ULTC)				15-Minute LTR (Amps)*
	Voltage (kV)	P (MW)	Q (MX)	Current (Amps)			Voltage (kV)	P (MW)	Q (MX)	Current (Amps)	
Bruce A TS ** x Ripley WGS	250.0	222	46	524	33.2	1579	245	385	158	979	2054
Ripley WGS x Wingham Jct	248.1	259	46	612	38.8	1579	240	420	152	1075	2054
Wingham Jct x Seaforth TS	241.2	218	6	522	33.0	1579	223	374	53	980	2054
Searforth TS x Stratford Jct	238.8	144	-36	359	26.4	1361	216	301	-35	812	1710
Stratford Jct x Detweiler TS	240.4	77	-63	239	17.6	1361	217	232	-101	673	1710

* LTR ratings are based on a 50% pre-load with a 35ºC ambient temperature and a 5 km/hr wind speed.

** TS = transformer station

It can be seen that the post-contingency flows on all the B22D and B23D circuit sections are well below the 15-Minute Limited Time Ratings (LTRs). Hence, the connection of Ripley will not introduce any new post-contingency thermal loading problems.

The 15-Minute LTRs used in Tables 3 and 4 are based on a 50% pre-load because the pre-contingency flows are lower than 50% of their continuous ratings. If the 15-Minute LTRs were based on a 75% pre-load, the thermal margins would be less.

However, it should be noted that WTGs generally need wind speeds in excess of 8 m/s (~ 30 km/hr) to produce approximately half of their rated active power output. The circuit ratings used in Tables 3 and 4 are conservative since they are based on 5 km/hr wind speeds. As wind speeds increase, the thermal ratings of the various circuit sections will also increase. Generally, if overloading problems are identified using the conservative ratings, the IESO will use a wind speed of 15 km/hr for calculating thermal ratings of transmission facilities that are situated within a radius of 50 km from the WGS connection point. This additional assessment for the Ripley WGS was not required.

6.3 Reactive Power Capability

6.3.1 Wind Turbine Generator

For a 76 MW synchronous generation unit to meet the Market Rules requirements, it must be capable of supplying continuously dynamic reactive power in the range of +37 Mvar (0.9 lagging power factor) to -25 Mvar (0.95 leading pf) at all active power outputs over a range of terminal voltages from 0.95 pu to 1.05 pu. As a minimum, the 76 MW Ripley WGS must provide the same dynamic reactive power capability.

On a per unit basis, the ENERCON WTG with a rated active power capability of 2.0 MW should be capable of supplying continuously, at all levels of active power output, dynamic reactive power in the range of +0.96 Mvar (0.9 lagging pf) to -0.66 Mvar (0.95 leading pf) over a similar range of terminal voltages.

Based on the power reactive capability curve provided by ENERCON, the ordered configuration of the E82 2.0 MW WTG to be installed at Ripley operates in a form of power factor control. At 2.0 MW, the reactive power capability of the WTG exceeds the required range. At low active power outputs near 0 MW, the reactive power capability of the WTG is proportionately low and therefore, does not meet the required range.

In particular, at active power outputs below approximately 1.6 MW (0.8 pu of rated active power), the WTG cannot inject the required +0.96 Mvar. At active power outputs below approximately 1.34 MW (0.67 pu of rated active power), the WTG cannot absorb the required -0.66 Mvar.

The ENERCON E-82 WTG in the configuration ordered for Ripley WGS cannot supply continuously the dynamic reactive power required by the Market Rules.

Therefore, dynamic reactive compensation devices need to be installed within the Ripley WGS.

It should also be noted the reactive power capability of the WTG is not dependent on its terminal voltage. The WTG can operate continuously at a terminal voltage in the range of 0.9 pu to 1.1 pu of rated terminal voltage (400 V).

6.3.2 Connection Point

The Ripley facility must also have the same capabilities to supply reactive power continuously as required of a synchronous generation facility with the same apparent power, as measured at the point of connection to the IESO-controlled grid. These capabilities are based on the assumption that the reactive losses within the facility are at a maximum of 13%, based on the maximum continuous active power rating of the facility at a 0.9 power factor.

At the B22D and B23D 230 kV connection point, the Ripley 76 MW facility must have a minimum capability of supplying approximately +26 Mvar (0.9 lagging pf equivalent – capacitive capability) to -25 Mvar (0.95 leading pf equivalent – inductive capability) for at least one constant 230 kV system voltage at all active power outputs.

To confirm the need for additional reactive compensation devices, three load flow studies were completed with none of the reactive compensation devices described in section 2.0 connected. In addition, the studies attempted to maintain voltages within the facility to between 0.9 pu and 1.1 pu.

In the first study, with the Ripley WTGs at 76 MW and 0 Mvar, the facility supplies a total of -41.8 Mvar at the 230 kV connection point for a 230 kV system voltage of 248 kV. Figure 5 (page 30) shows the reactive power flows within the Ripley facility. This study indicates that the reactive losses within the facility exceed 13%.

In the second study, with the Ripley WTGs at 76 MW and 37 Mvar (0.9 lagging power factor), the facility supplies a total of 1.8 Mvar at the 230 kV connection point. Figure 6 (page 31) shows the reactive power flows within the Ripley facility. This study is used for assessing the capacitive capability of the facility.

In the third study, with the Ripley WTGs at 0 MW and 0 Mvar, the facility supplies a total of 3.8 Mvar at the 230 kV connection point. Refer to Figure 7 (page 32) for the reactive power flows. This is the most onerous case for assessing the inductive capability of the facility.

Therefore, in addition to the dynamic reactive requirements identified in section 6.3.1, reactive compensation devices are also required to be installed at Ripley to meet the reactive power capabilities at the 230 kV connection point.

6.3.3 Reactive Compensation Devices – Normal Operation

As described in Section 2.0, Suncor will install reactive compensation devices at both the Ripley North and South substations to provide the required reactive power capabilities for the facility.

Specifically, the following devices are to be installed:

- 1 – 14 MVA D-VAR inverter consisting of 3 units rated at 4 MVA each and 1 unit rated at 2 MVA at Ripley South (connected to the 34.5 kV collector bus via 480 V/34.5 kV transformers rated at 14 MVA),

- 2 – 16 Mvar, 69 kV shunt capacitor banks with a discharge capability of five minutes at Ripley North, and
- 1 – 11 Mvar, 34.5 kV shunt reactor at Ripley South.

The D-VAR voltage controller in conjunction with the D-VAR inverter will control the operation of the two 69 kV capacitor banks and the 34.5 kV reactor. The D-VAR voltage controller will be normally set to regulate the 69 kV bus voltage at Ripley North to a target voltage of 0.97 pu (66.24 kV). The 0.97 pu voltage target was chosen so that the facility will not absorb reactive power from the IESO-controlled grid under normal operating conditions.

To regulate the 69 kV bus voltage, the controller will coordinate the on/off switching of the two capacitor banks and the reactor based on the output level of the D-VAR inverter. The basic principle is that the D-VAR inverter will try to keep its output at 0 Mvar by switching in and out the capacitor banks and reactor as appropriate.

To prevent the switching of the capacitor banks and the reactor for brief voltage fluctuations during a transient condition, the controller will delay the switching of those devices by a time delay. The time delay can be adjusted to allow the devices to be switched during the post-fault period of a contingency.

However, it should be noted that the IESO is concerned that any capacitor back switched in during the post-fault period may need to be switched out once the tripped equipment associated with the contingency is restored back to service. Since each capacitor bank has a five minute discharge, it will remain unavailable for use should the same contingency occur again during the discharge time period. Therefore, the capacitive reactive power available only from the D-VAR inverter may not be enough to support the voltage during the post-fault period.

The IESO also understands that under steady state conditions the D-VAR voltage controller will also be used to control, via the ENERCON SCADA power factor control, the reactive power output of ENERCON WTGs, by adjusting their power factor set point (±0.9).

The T3 under load tap changer (ULTC) will also be used to control the 34.5 kV bus voltage at Ripley South between 1.02 pu to 1.04 pu (35.19 kV to 35.88 kV).

D-VAR Voltage Controller – Fast Regulation

The 14 MVA D-VAR inverter has a 2.67 overload capability for a period of time up to two seconds that will provide a ±37 Mvar dynamic reactive power output capability based on based on a nominal voltage of 1.00 pu (480 V). The overload capability enables when the 69 kV bus voltage at Ripley North exceeds the target voltage by ±0.1 pu. This mode of operation is referred to as ‘fast regulation’ and is determined by PSS/E parameters 28 to 395 (refer to Appendix B for further details). It is expected that the D-VAR inverter will operate in fast regulation under transient conditions.

When the two capacitor banks (+32 Mvar) and the reactor (-11 Mvar) are considered with the overload capability of the D-VAR inverter, the total reactive power capability of the various compensation devices will be +69 Mvar (capacitive) to -48 Mvar (inductive) based on the nominal rated voltages.

The ±37 Mvar reactive power output capability of the D-VAR inverter is adequate to provide the dynamic reactive power capability not provided by the ENERCON E-82 WTGs at low active power outputs, addressing the requirement identified in Section 6.3.1.

D-VAR Voltage Controller – Slow Regulation

When the Ripley North 69 kV bus voltage is maintained between 0.9 pu and 1.1 pu, the 14 MVA D-VAR inverter will provide nominally a continuous ±14 Mvar capability. This mode of operation is referred to as 'slow regulation' and is determined by PSS/E parameters 429 to 451 (refer to Appendix B for further details). It is expected that the D-VAR inverter will operate in slow regulation under steady-state conditions.

When only the reactive power compensation devices (D-VAR inverter, capacitors and reactor) are considered under steady-state conditions, the total continuous reactive power capability will be +46 Mvar (capacitive) to -35 Mvar (inductive) based on the nominal rated voltages.

6.3.4 Reactive Compensation Devices – Operation to meet Requirements at Connection Point

To meet the Market Rules requirements outlined in Section 6.3.2 (capacitive capability: +26 Mvar; inductive capability: -25 Mvar), the normal 69 kV bus target voltage for the D-VAR voltage controller may need to change depending on the voltage conditions of the 230 kV system. In addition, it may also be necessary to manually regulate the tap positions of transformers T1, T2 and T3 to maintain voltage limits within the facility.

To determine whether the specified reactive compensation devices satisfy the Market Rules requirements, load flow studies were completed to examine the inductive capability of Ripley at an active power output at 0 MW and the capacitive capability at the maximum rated active power output of 76 MW. These two cases are considered worst case for determining if the requirements will be met.

The IESO understands that to achieve the capacitive capability at the 230 kV connection point with the installed reactive compensation devices, the WTGs will be controlled by the D-VAR voltage controller to about 97.5% power factor lagging.

In the load flow studies, the 230 kV system voltage at the Ripley connection point was chosen to be approximately 248 kV and the Ripley facility voltages were maintained between 0.9 pu and 1.1 pu.

As shown in Figure 8 (page 33), the Ripley facility is capable of providing the Market Rules requirement for capacitive reactive power. With the WTGs at 97.5% power factor lagging, the D-VAR inverter at 10 Mvar and both 69 kV capacitor banks in service, the facility provides a total of +27.5 Mvar at the 230 kV connection point by increasing the Ripley North 69 kV bus voltage to 1.03 pu.

Figure 9 (page 34) shows that the Ripley facility is also capable of providing the Market Rules requirement for inductive reactive power. With the D-VAR inverter at -14 Mvar and the 34.5 kV reactor in service, the facility provides a total of -25 Mvar at the 230 kV connection point by changing the normal tap position of transformers T1 and T2 from +8 to nominal, increasing the Ripley North 69 kV bus voltage to 0.99 pu and decreasing the Ripley South 34.5 kV bus voltage to 0.91 pu.

The load flow results show that if the Ripley North 69 kV bus voltage can be controlled between 0.99 pu and 1.03 pu without exceeding voltage limits at Ripley South, the Ripley WGS meets the Market Rules requirements for reactive power capability at the 230 kV connection point.

– End of Section –

7. Dynamic Response Assessment

For the dynamic response assessment, the Ripley WGS had the following pre-contingency operation conditions:

- The Ripley WGS is absorbing a total of 2 Mvar at the 230 kV connection,
- The D-VAR voltage controller is regulating the Ripley North 69 kV bus to 0.97 pu,
- One 69 kV capacitor bank is in service,
- Transformer T3 is regulating the Ripley South 34.5 kV bus to between 1.02 pu and 1.04 pu,
- The WTGs are operating at 76 MW with a capacitive power factor of 97.5%, and
- Transformers T1 and T2 are at the +8 (7%) tap position.

In all the simulations completed for this assessment, the switching in of capacitor banks or reactors during the post-fault period was not examined due to limitations associated with the PSS/E D-VAR model. Refer to section 7.3 for further details.

7.1 Voltage Ride Through (VRT) Capability

The IESO requires that the wind turbine generators and associated equipment within the facility be able to withstand transient voltages and remain connected to the IESO-controlled grid following a recognized contingency unless the generators are removed from service by configuration. This requirement is commonly referred to as the ‘voltage ride through’ (VRT) capability.

Depending on the type of contingency, system voltages can be greatly depressed or elevated during the transient condition. To determine the VRT requirements for Ripley, contingencies expected to be most onerous on ride-through are examined. The results are used to determine the voltage surge or sag seen at the WTG terminals.

The IESO understands that the ENERCON E-82 WTGs will be equipped with over-voltage and under-voltage protection for each phase. For each WTG, the settings associated with these protections allow for the VRT performance as shown in Figure 10 below, where U_r is rated voltage (400 V) and T is an adjustable time period less than or equal to 5 seconds.

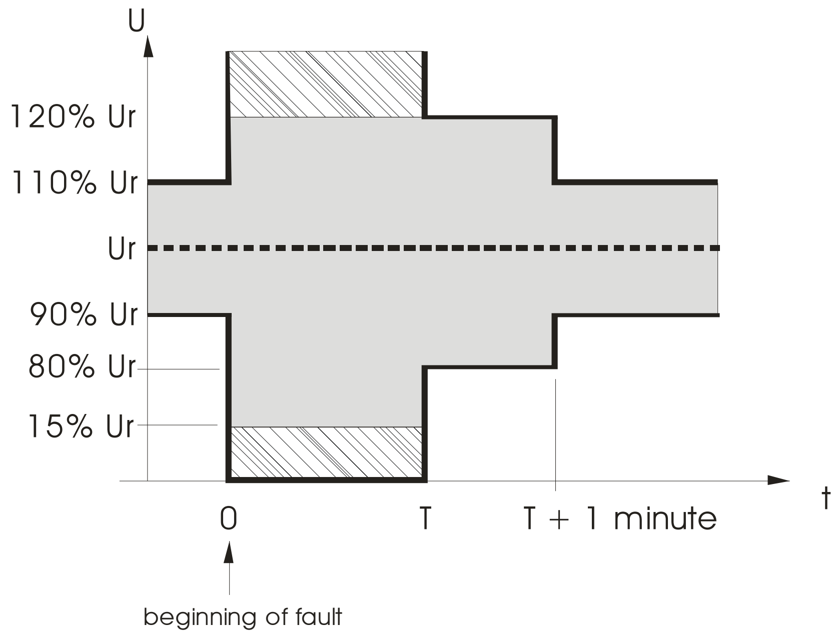


Figure 10: ENERCON E-82 WTG – Voltage Ride Through Performance Curve

The curve shows that each WTG will remain in operation, connected and feeds in the maximum possible active power if the voltage at the WTG terminals during and after the fault remains within the grey area.

If the voltage at the WTG terminals moves to the hatched areas (below 15% Ur or above 120% Ur), the appropriate controls will stop the WTG to feed in current and disconnect the WTG. However, the disconnected WTG will remain in operation for a time period defined by T. If during this period the voltage returns between 80% U_r and 120% U_r, the WTG will resynchronize and reconnect within 400 ms and continue to feed in the available active power. Otherwise, after this period, the WTG will switch off.

In the unmarked areas, the appropriate protection algorithms will disconnect the WTG. In turn, the WTG will immediately switch off.

In particular, the curve shows the ENERCON E-82 WTG has a low VRT capability of 15% U_r for a maximum time period of 5 seconds, and a high VRT capability of 120% U_r for a maximum time period of 5 seconds plus one minute without the need to reduce active and reactive power output.

The most severe high voltage condition at the Ripley 230 kV connection will occur with the inadvertent tripping of the Bruce reactors. The high VRT capability of the WTGs is expected to be sufficient to ride through this disturbance.

To access the low VRT capability of the WTGs, three contingencies considered worst-case for low VRT were simulated:

- a 3-phase fault on 230 kV circuit B22D at the Ripley 230 kV connection point,
- a line to line to ground (LLG) fault on 230 kV circuits B4V and B5V near Bruce A TS, and

- a single line to ground (SLG) fault on 230 kV circuit B23D at the Ripley 230 kV connection point with a Bruce A L23T25 breaker failure.

Results of the simulations in Figures 11, 12 and 13 (pages 35-37) show that the terminal voltage of the WTGs does not drop below 0.5 pu and recovers quickly to 0.9 pu or above once the fault is cleared. The low VRT capability of the WTGs is therefore adequate.

To assess the effect of the D-VAR inverter on the WTG terminal voltage, the simulation of a 3-phase fault at the Ripley 230 kV B22D connection point was repeated with the D-VAR inverter disabled. As shown in Figure 14 (page 38), the terminal voltage drops to about 0.5 pu and recovers back to 0.8 pu approximately 150 ms after the fault is cleared. It takes another 200 ms to return the terminal voltage to 0.9 pu or above. The total time elapsed during the transient period where the terminal voltage stays below 0.8 pu is about 225 ms. This simulation suggests the value of T in Figure 10 should be set to 225 ms or higher to cover for situations where the D-VAR inverter may be unavailable.

A comparison of the results for the B22D contingencies with and without D-VAR inverter connected shows that the D-VAR inverter quickly injects reactive power to improve the recovery time of the WTG terminal voltage.

The VRT capability of the ENERCON E-82 WTGs shown in Figure 10 is expected to be sufficient to allow Ripley to remain connected to the IESO-controlled grid for recognized system contingencies that do not remove the facility by configuration.

When the facility is incorporated into the IESO-controlled grid, if the WTGs trip for contingencies for which they are not removed by configuration, the IESO will require more enhanced low VRT to be installed by Suncor to prevent such tripping.

7.2 Transient Stability Performance

Transient stability simulations were completed to determine if the interconnected power system and the generating facilities including Ripley WGS remain stable and well damped for recognized contingencies having the greatest system-wide impact. In particular for Ripley, the simulations focused on the dynamic performance of the D-VAR inverter and the ENERCON E-82 WTGs.

In addition to the three contingencies described in section 7.1, the following two contingencies were simulated and examined:

- a LLG fault on the 500 kV double circuit line B561V & B560M (Bruce by Claireville and Milton) at Willow Creek Junction, and
- a LLG fault on the 500 kV double circuit line B562L & B563L (Bruce by Longwood) at Willow Creek Junction.

The three contingencies in section 7.1 are most impactive to the Ripley WGS but less impactive to the overall system than the above two contingencies.

For the B560M and B561V contingency, the results are plotted in Figures 15, 16 and 17 (pages 39 - 41). As shown in Figure 15, the power system remains stable and well damped as demonstrated by the machine performance of Bruce A unit G3 and the voltage response of the Bruce A 230 kV bus voltage. Similarly as shown in Figures 16 and 17, the performance of the D-VAR inverter and the WTGs are acceptable. The post-fault clipping of the D-VAR inverter output in Figure 16 occurs because the voltage variations are not large enough to cause it to put out its overload capability. In real time operation, it is expected the D-VAR voltage controller will switch in a capacitor bank before it reaches its rated steady state output capability.

For the B562L and B563L contingency, the results are plotted in Figures 18, 19 and 20 (pages 42 - 44). Like the simulation for the B560M and B561M contingency, the power system response and the dynamic responses of the Ripley D-VAR inverter and WTGs are stable and well damped. For this contingency, it is observed that the D-VAR inverter is absorbing reactive power during the post-fault period due to higher post-fault 230 kV voltages resulting from Bruce reactor switching.

In addition, the dynamic reactive power range of the D-VAR inverter for the B562L and B563L contingency is sufficient to recover the post-contingency voltage at the Ripley North bus back to a level close to the pre-contingency voltage.

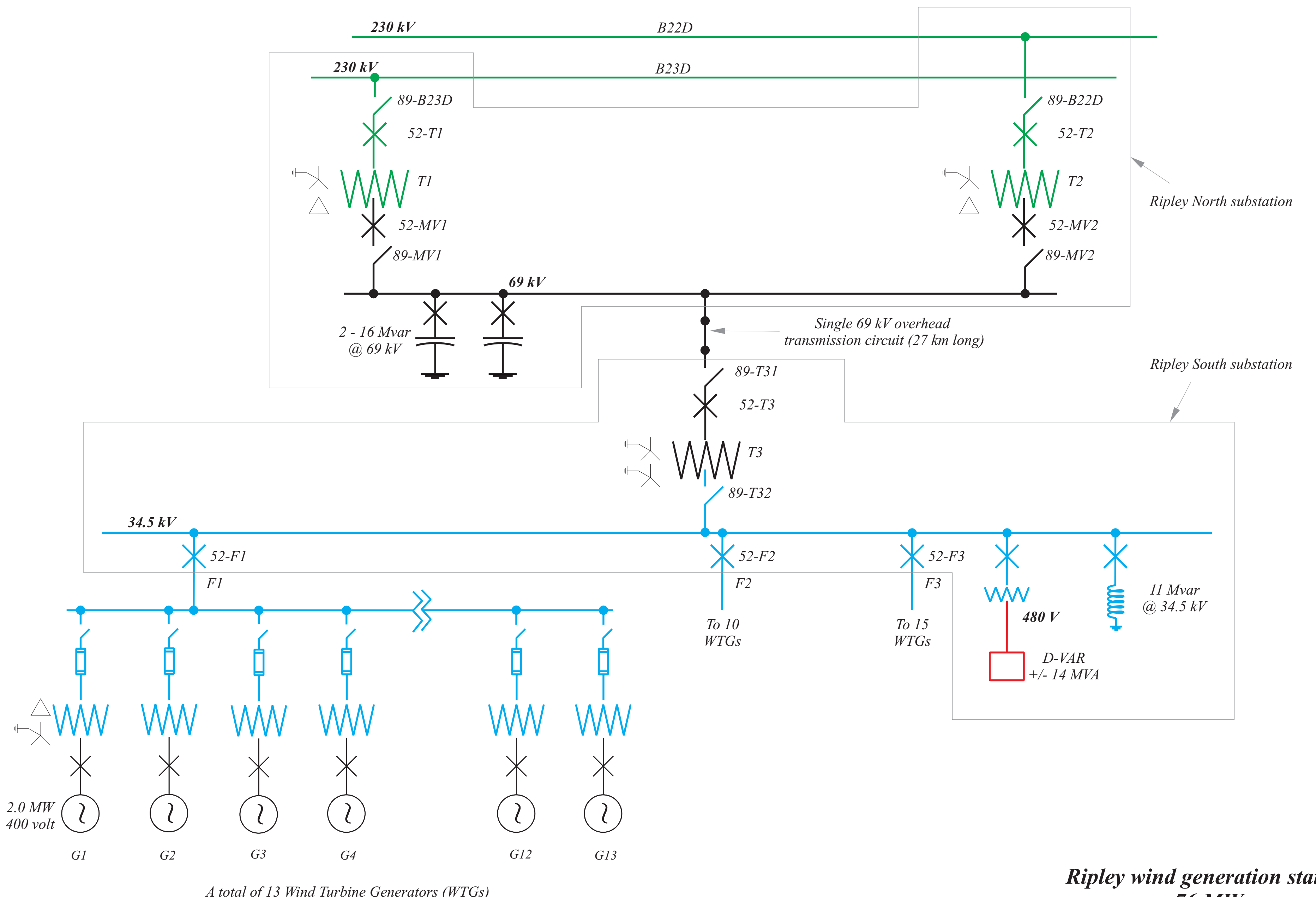
7.3 PSS/E Models – Wind Turbine Generator & D-VAR

The PSS/E ENERCON E-82 wind turbine generator model provided by ENERCON for this assessment is a ‘confidential’ model. Based on confirmation letters signed by the IESO and ENERCON in early 2006, ENERCON is obligated to provide to the IESO a ‘public’ model by December 31, 2006. Otherwise, the IESO is released of its obligation to treat the provided model as ‘confidential’ and may disclose the model with other parties as required.

The PSS/E D-VAR model provided by American Superconductor for this assessment consisted of several working files requiring manual initialization of the D-VAR inverter output to zero before the start of a simulation for proper operation. In addition, the model did not simulate operation of the D-VAR voltage controller where capacitors and/or reactors (static reactive compensation devices) are switched in or out depending on the output of the D-VAR inverter.

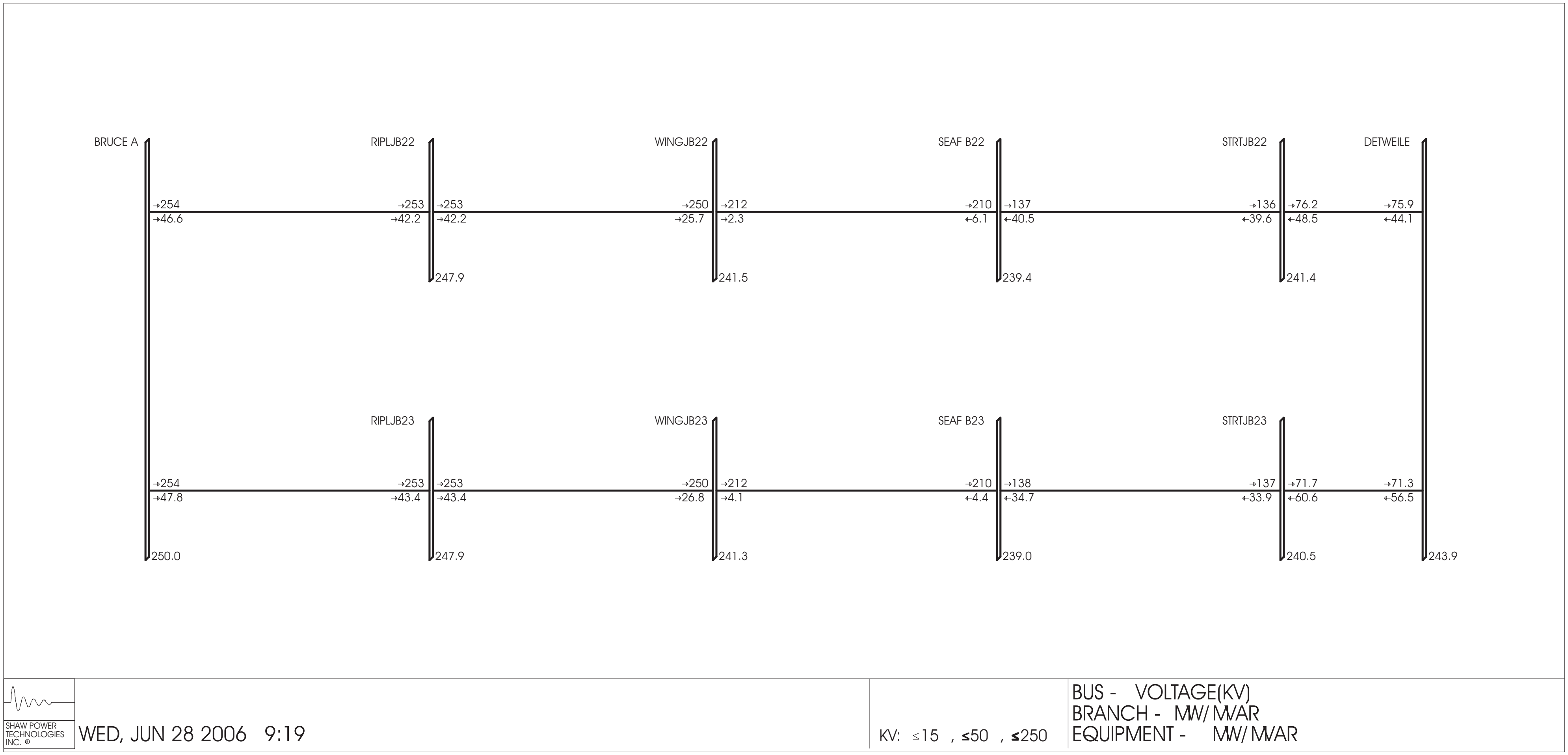
For general power system studies, the IESO requires a more conventional PSS/E model. The D-VAR model should be a self-contained user model with one single FLECS file (not several files that have to be placed in the working directory) and have states whose derivatives initialize correctly to zero at the start of the simulation. The model should also simulate the complete operation of the overall system involving the D-VAR inverter and any switching of static reactive compensation devices. The IESO understands that American Superconductor has plans to improve the model in 2007.

– End of Section –



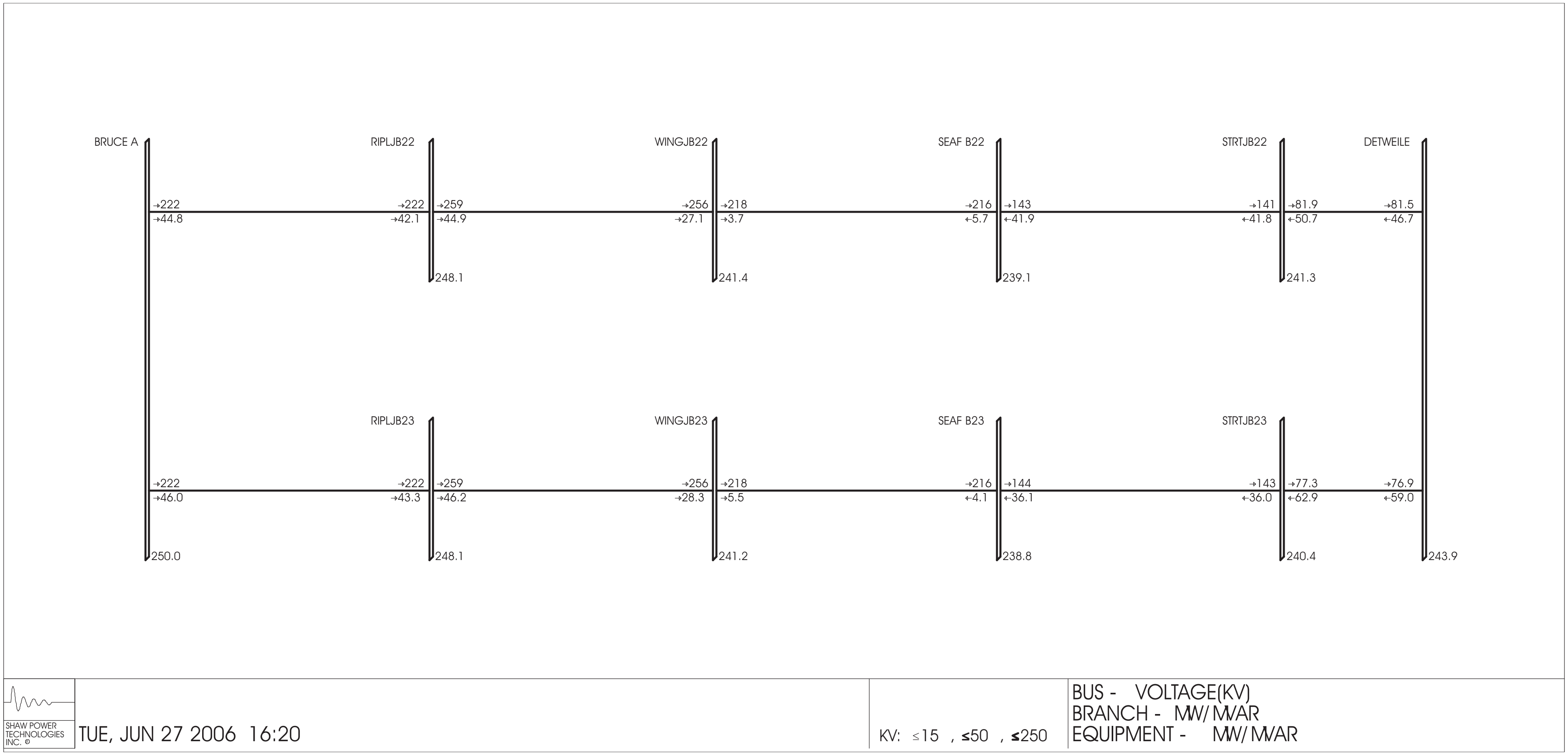
Ripley wind generation station
76 MW

Figure 1



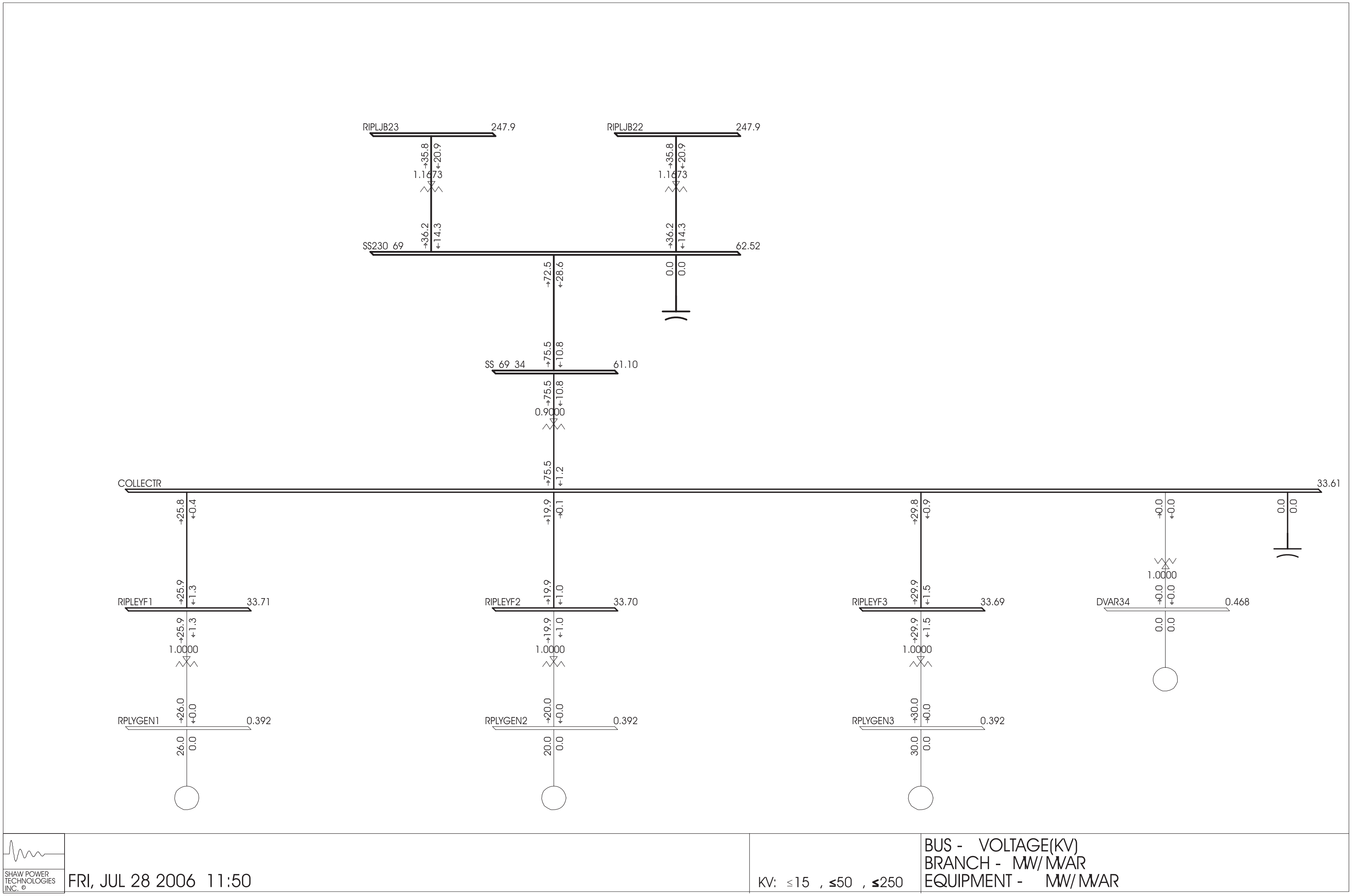
Pre-contingency flows on B22D & B23D without Ripley connected

Figure 3



Pre-contingency flows on B22D & B23D with Ripley connected

Figure 4


RIPLJB23 247.9
RIPLJB22 247.9
35.8 20.9
1.1673
36.2 14.3
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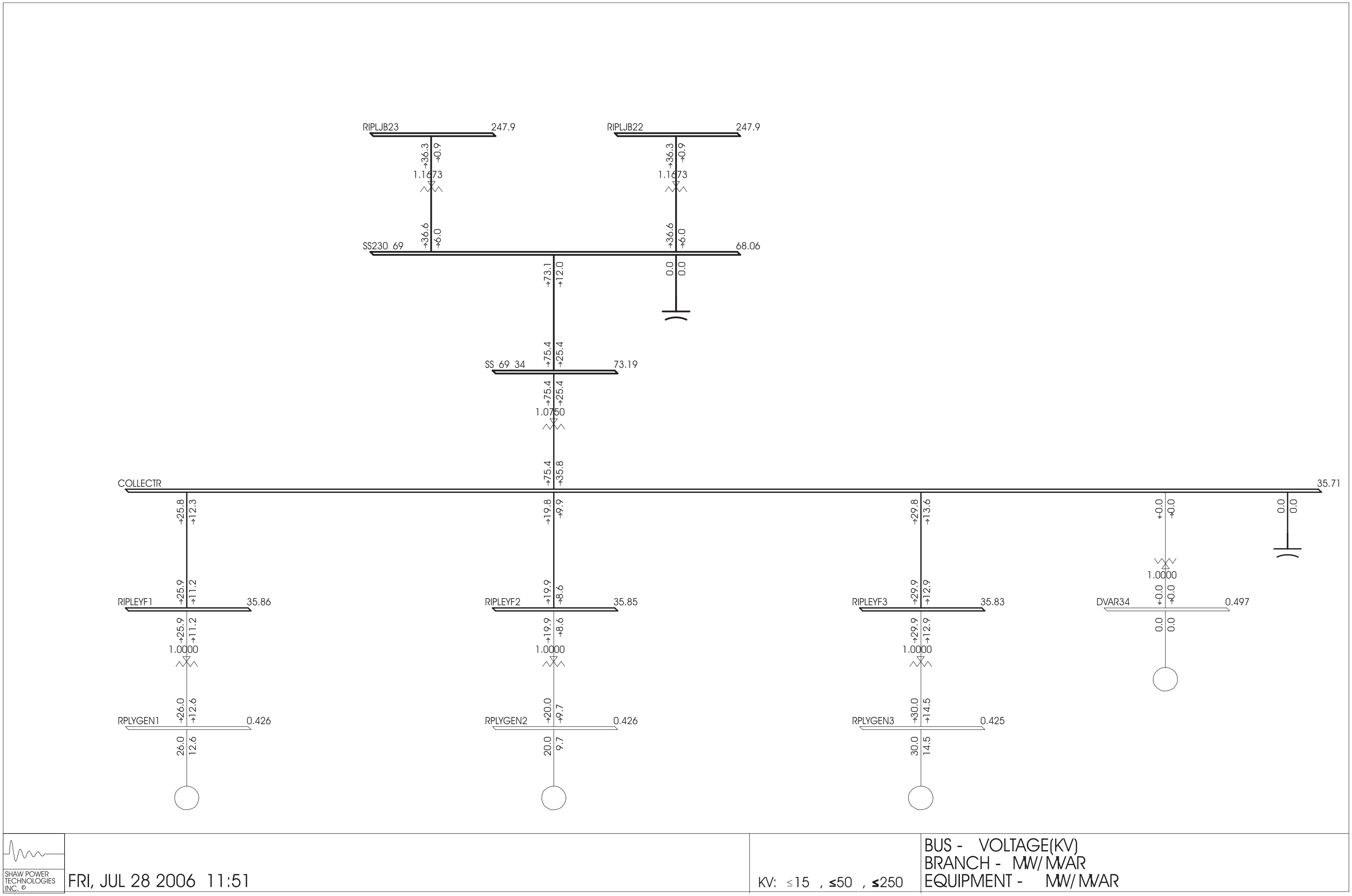
72.5 28.6
0.0 0.0
SS_69_34 61.10
75.5 10.8
0.9000
75.5 1.2
COLLECTR 33.61
25.8 0.4
19.9 0.1
29.8 0.9
25.9 1.3
19.9 1.0
29.9 1.5
RIPLEYF1 33.71
RIPLEYF2 33.70
RIPLEYF3 33.69
DVAR34 0.468
1.0000
26.0 0.0
20.0 0.0
30.0 0.0
RPLYGEN1 0.392
RPLYGEN2 0.392
RPLYGEN3 0.392
SHAW POWER TECHNOLOGIES INC. ©
FRI, JUL 28 2006 11:50
KV: ≤15 , ≤50 , ≤250
BUS - VOLTAGE(KV)
BRANCH - MW/ MVAR
EQUIPMENT - MW/ MVAR

Figure 5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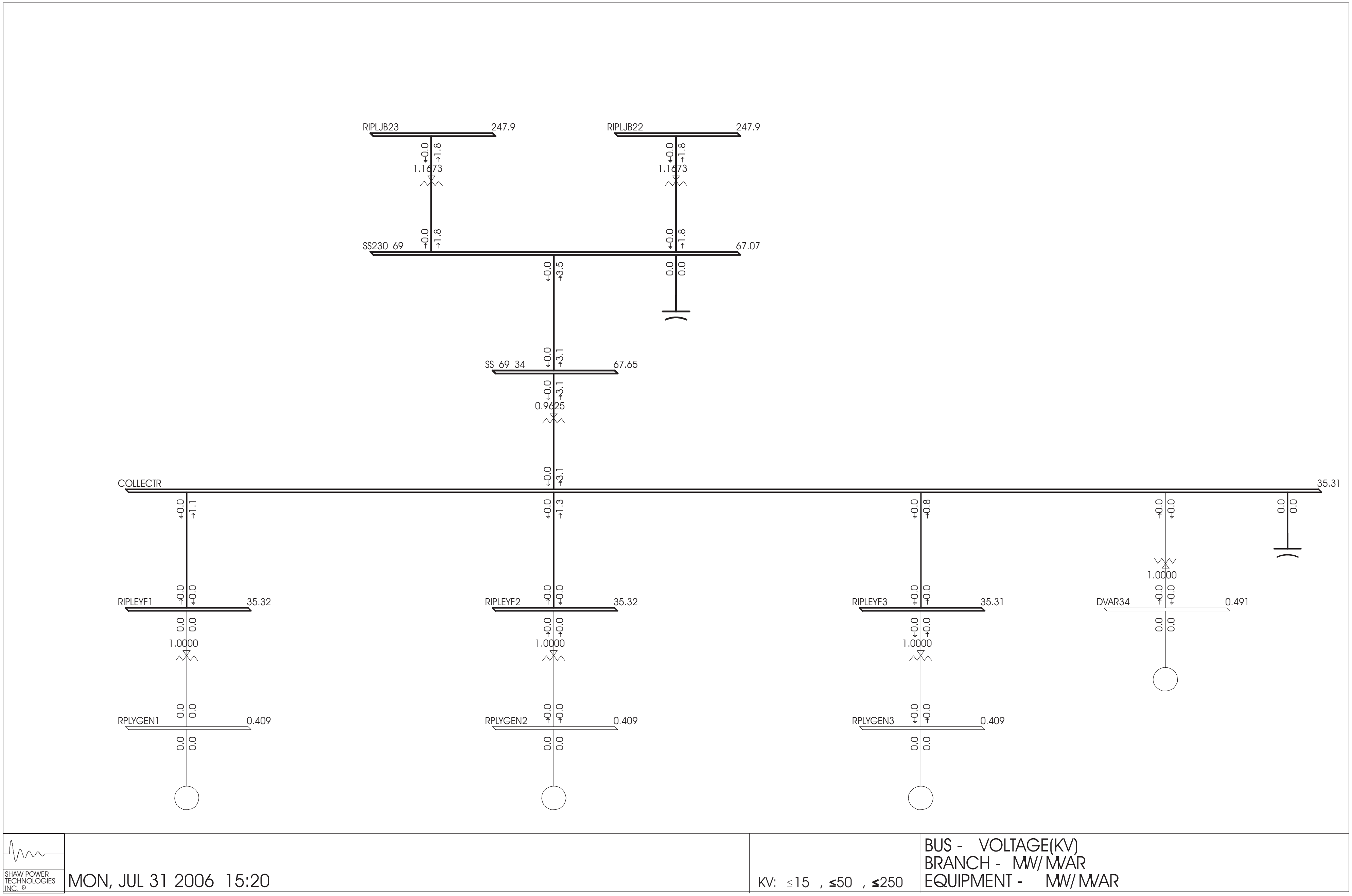
1.0750
COLLECTR 35.71
RIPLEYF1 35.86
RIPLEYF2 35.85
RIPLEYF3 35.83
DVAR34 0.497
1.0000
RPLYGEN1 0.426
RPLYGEN2 0.426
RPLYGEN3 0.425
SHAW POWER TECHNOLOGIES INC. ©
FRI, JUL 28 2006 11:51
KV: ≤15 , ≤50 , ≤250
BUS - VOLTAGE(KV)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

Figure 6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1.1673
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COLLECTR 35.31
RIPLEYF1 35.32
RIPLEYF2 35.32
RIPLEYF3 35.31
DVAR34 0.491
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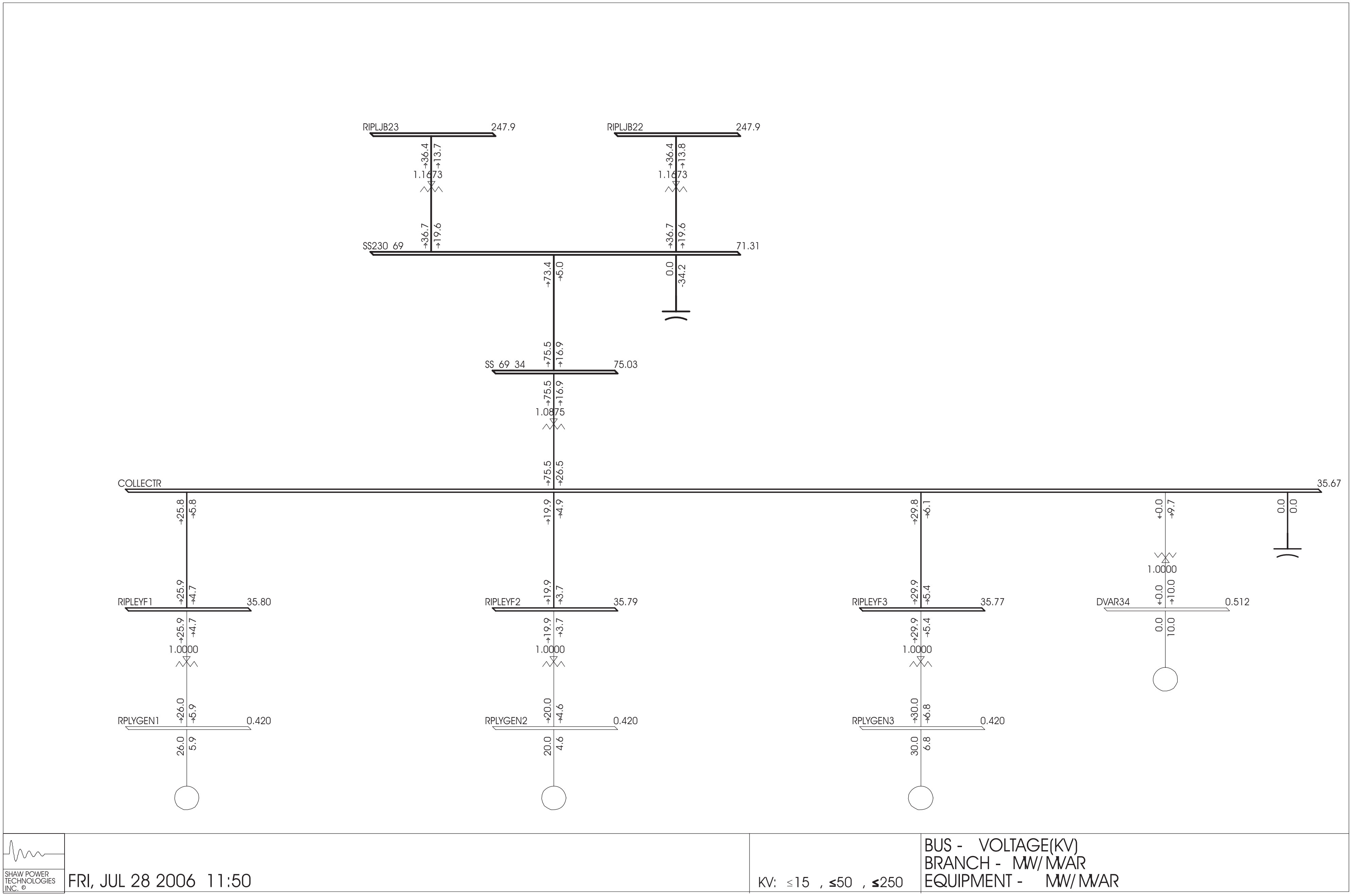
RPLYGEN1 0.409
RPLYGEN2 0.409
RPLYGEN3 0.409
SHAW POWER TECHNOLOGIES INC. ©
MON, JUL 31 2006 15:20
KV: ≤15 , ≤50 , ≤250
BUS - VOLTAGE(KV)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

Figure 7



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RIPLJB22 247.9
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36.4 13.8
1.1673
1.1673
36.7 19.6
36.7 19.6
SS230_69 71.31
73.4 5.0
0.0 -34.2
75.5 16.9
SS_69_34 75.03
75.5 16.9
1.0875
75.5 26.5
COLLECTR 35.67
25.8 5.8
19.9 4.9
29.8 6.1
0.0 9.7
0.0 0.0
1.0000
0.0 10.0
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RIPLEYF2 35.79
RIPLEYF3 35.77
DVAR34 0.512
25.9 4.7
19.9 3.7
29.9 5.4
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20.0 4.6
30.0 6.8
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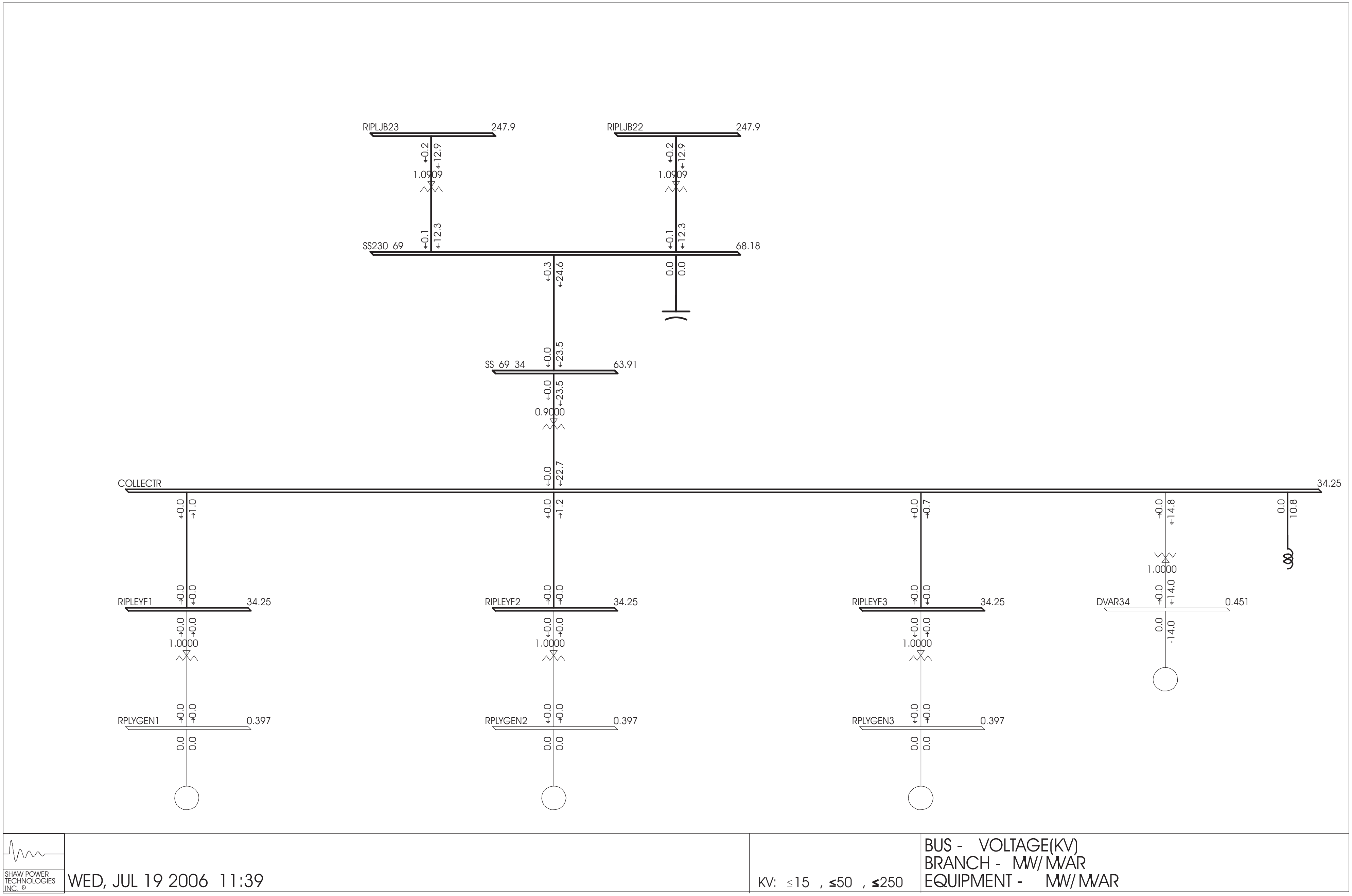
RPLYGEN2 0.420
RPLYGEN3 0.420
26.0 5.9
20.0 4.6
30.0 6.8
SHAW POWER TECHNOLOGIES INC. ©
FRI, JUL 28 2006 11:50
KV: ≤15 , ≤50 , ≤250
BUS - VOLTAGE(KV)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

Figure 8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1.0909
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SS_69_34
63.91
0.9000
COLLECTR
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RIPLEYF1
34.25
RIPLEYF2
34.25
RIPLEYF3
34.25
DVAR34
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1.0000
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0.397
RPLYGEN2
0.397
RPLYGEN3
0.397
SHAW POWER TECHNOLOGIES INC. ©
WED, JUL 19 2006 11:39
KV: ≤15 , ≤50 , ≤250
BUS - VOLTAGE(KV)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

Figure 9

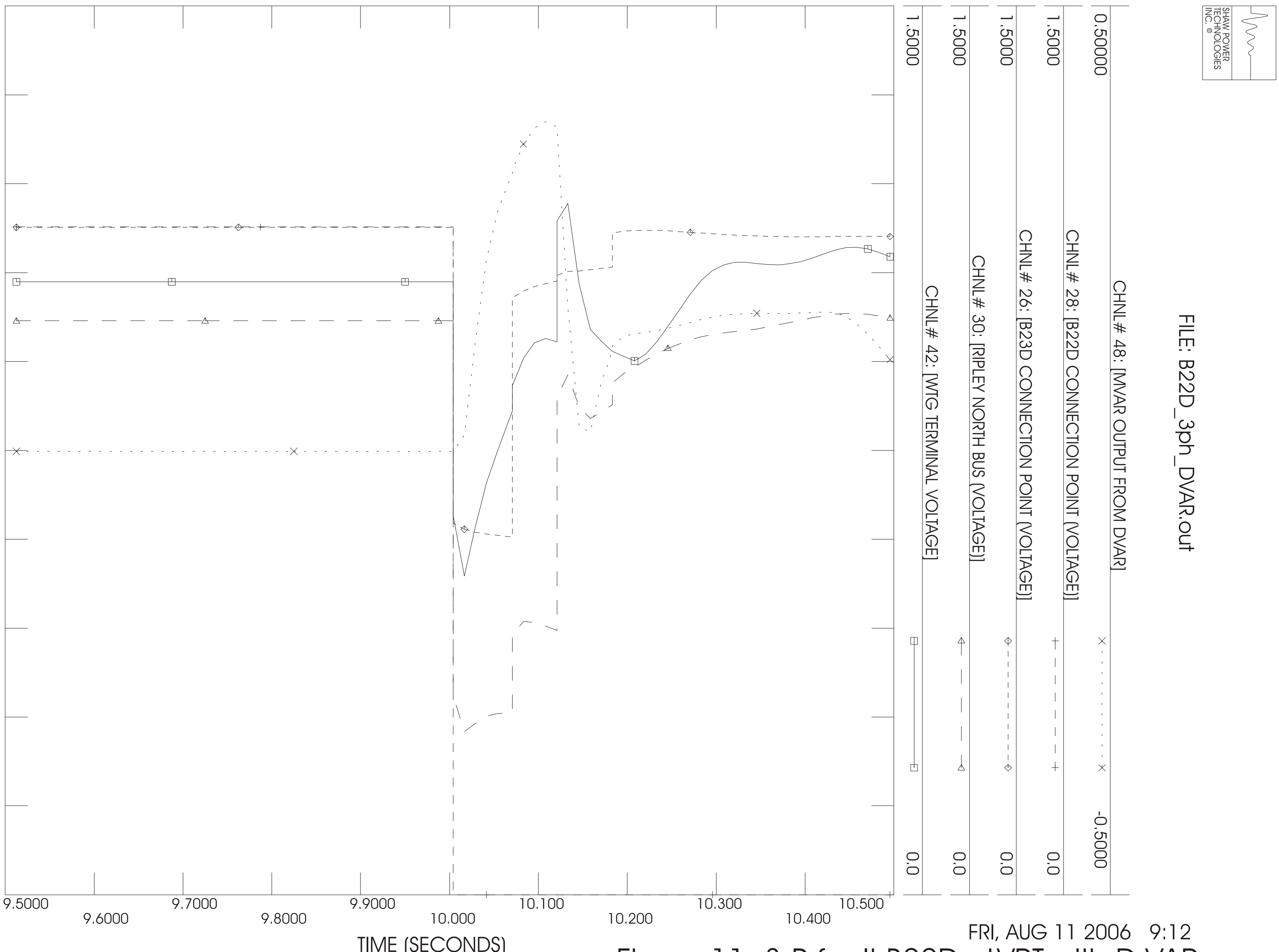


Figure 11: 3-P fault B22D - LVRT with D-VAR

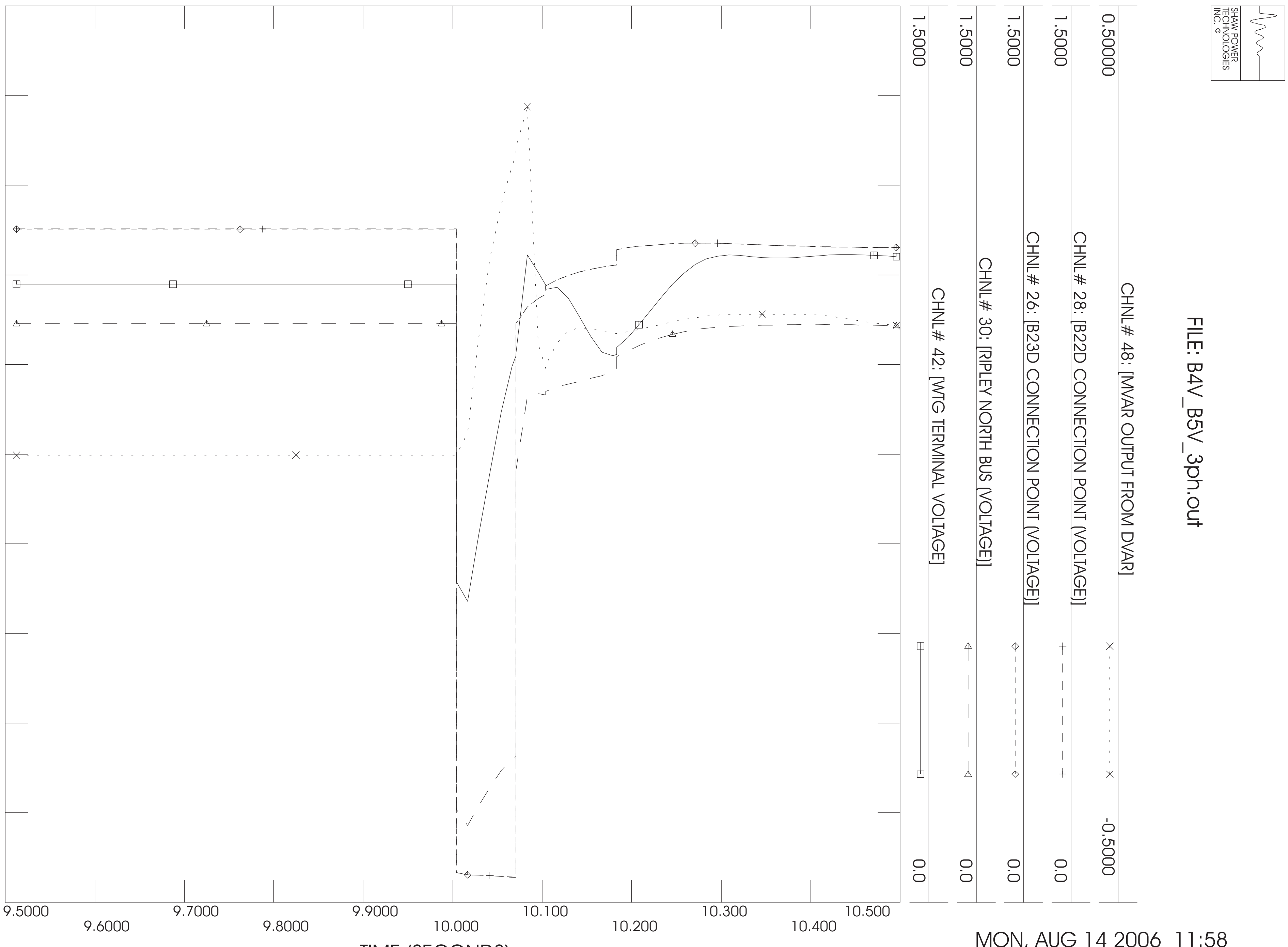


Figure 12: LLG fault B4V & B5V - LVRT with D-VAR

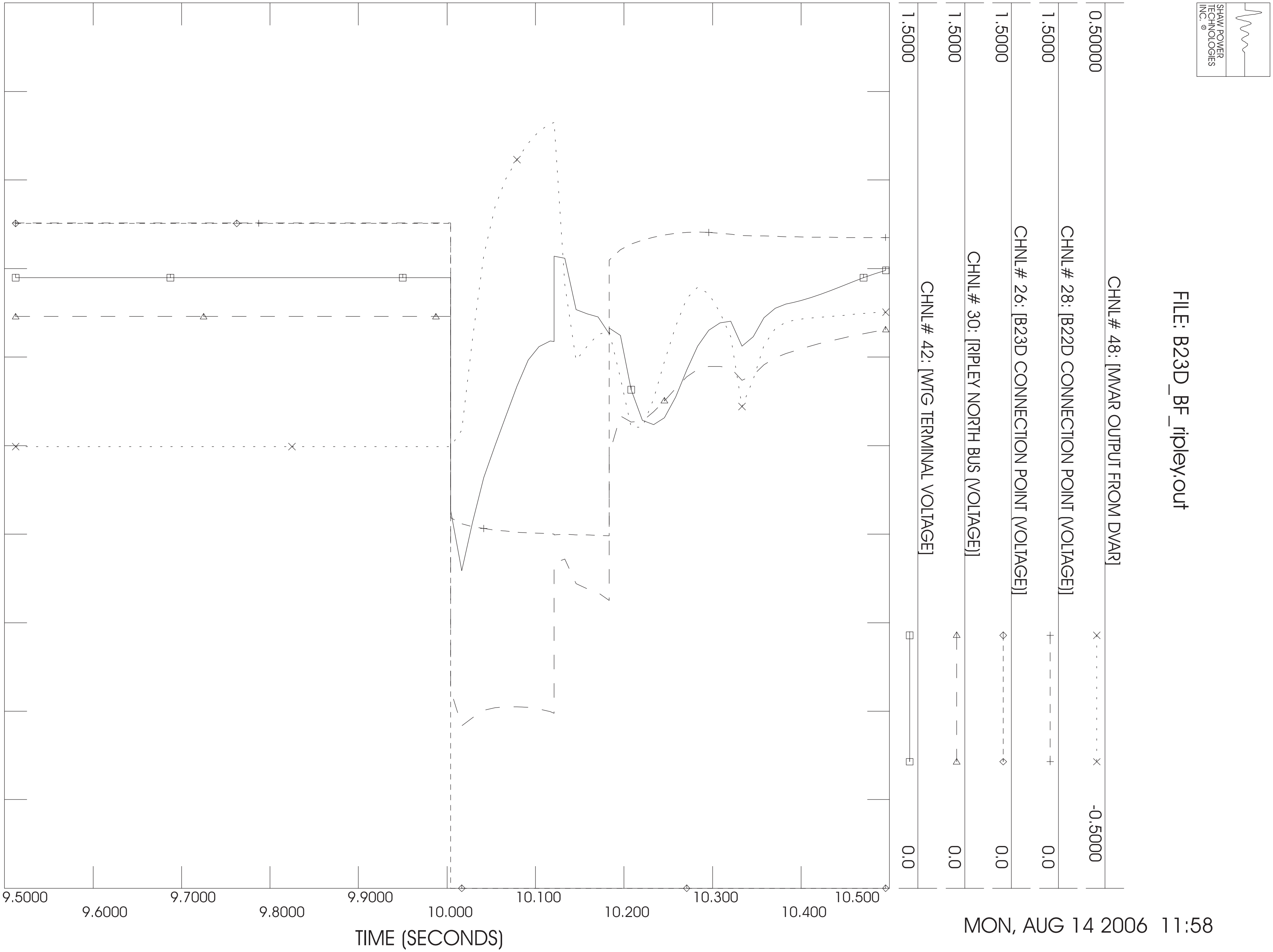


Figure 13: SLG fault B23D with Bruce A L23T25 BF - LVRT with D-VAR

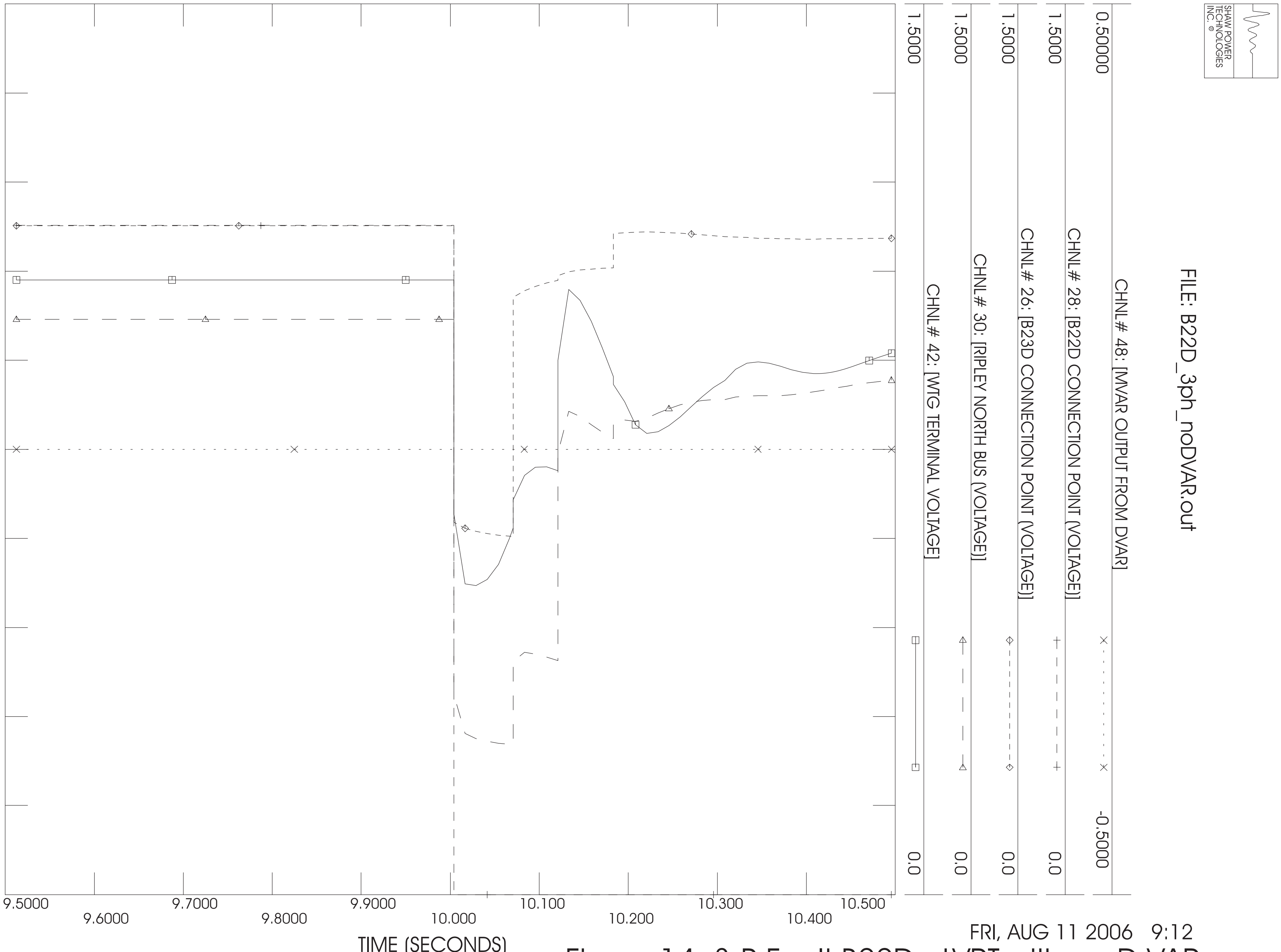


Figure 14: 3-P Fault B22D - LVRT with no D-VAR

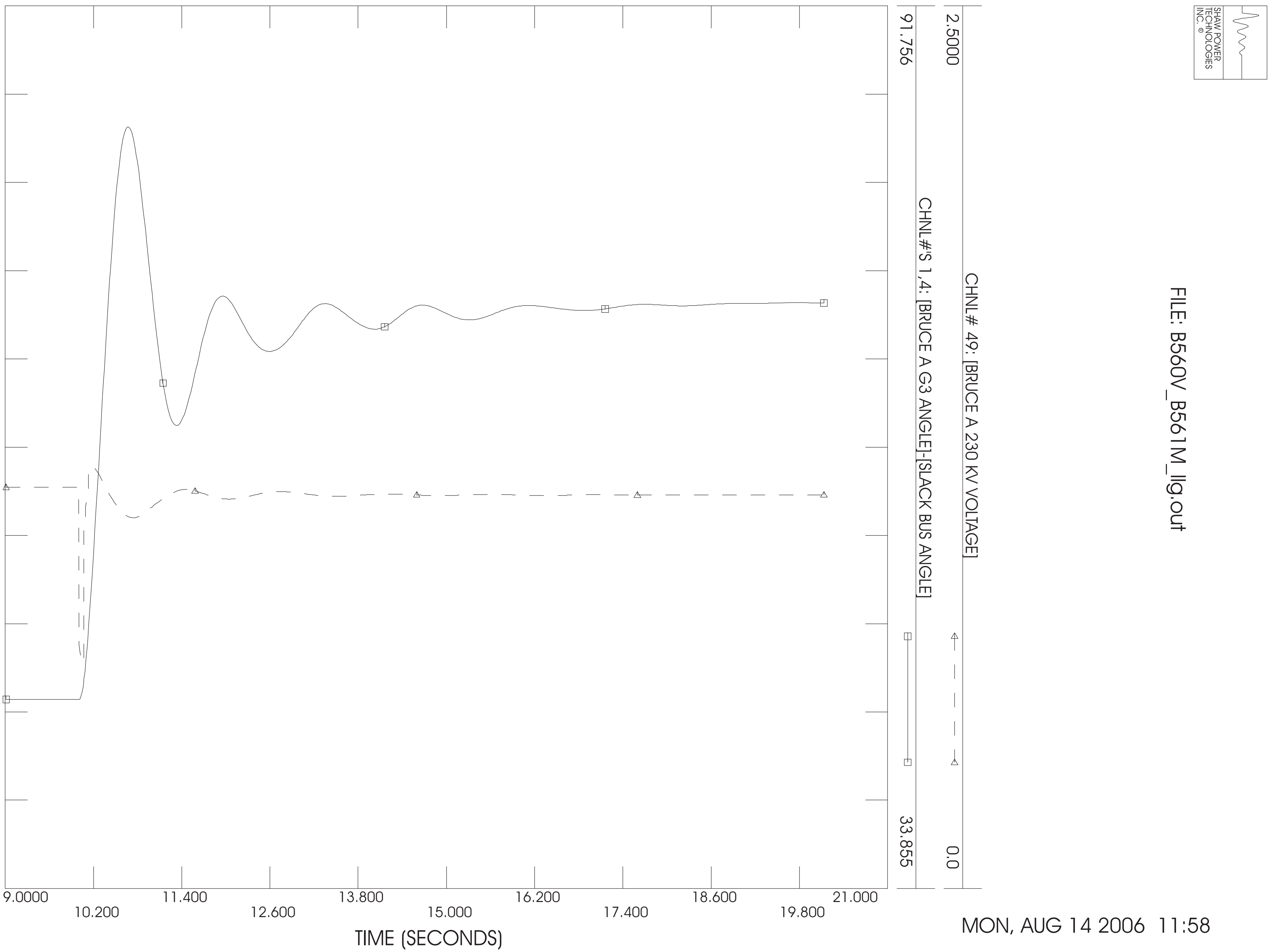


Figure 15: LLG fault B560V & B561M - Bruce A G3 angle & voltage

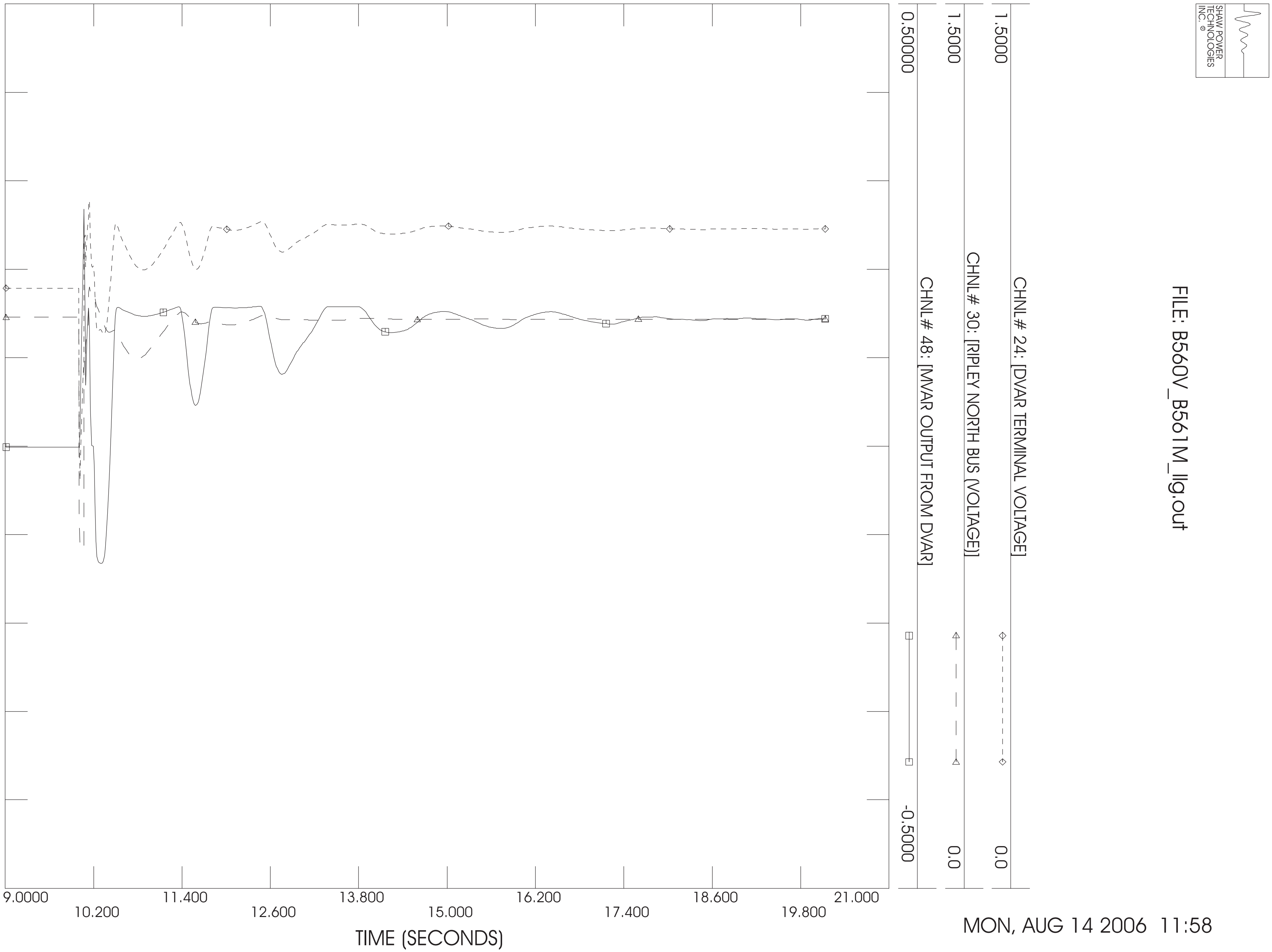
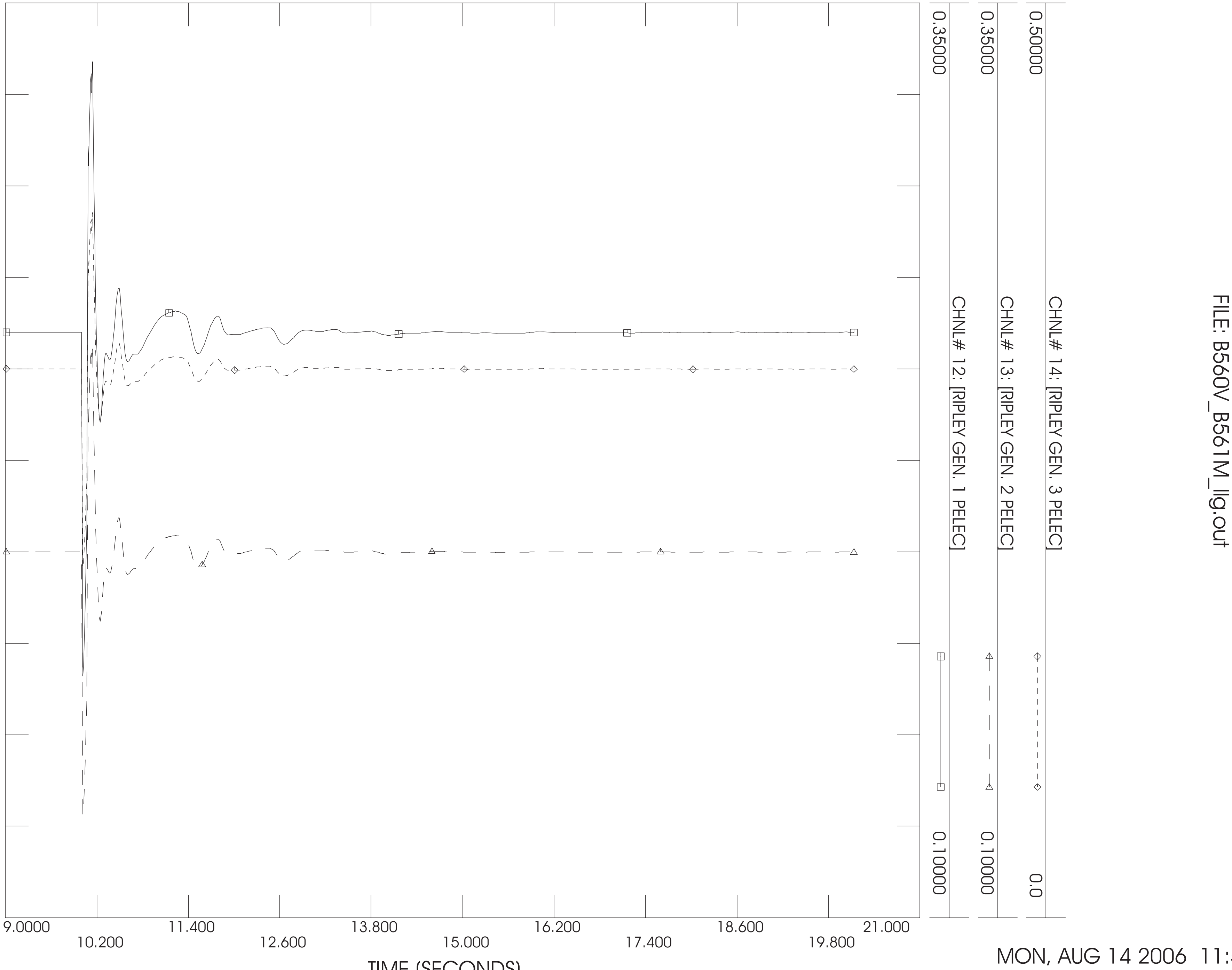


Figure 16: LLG fault B560V & B561M - D-VAR performance



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MON, AUG 14 2006 11:58

Figure 17: LLG fault B560V & B561M - WTGs performance

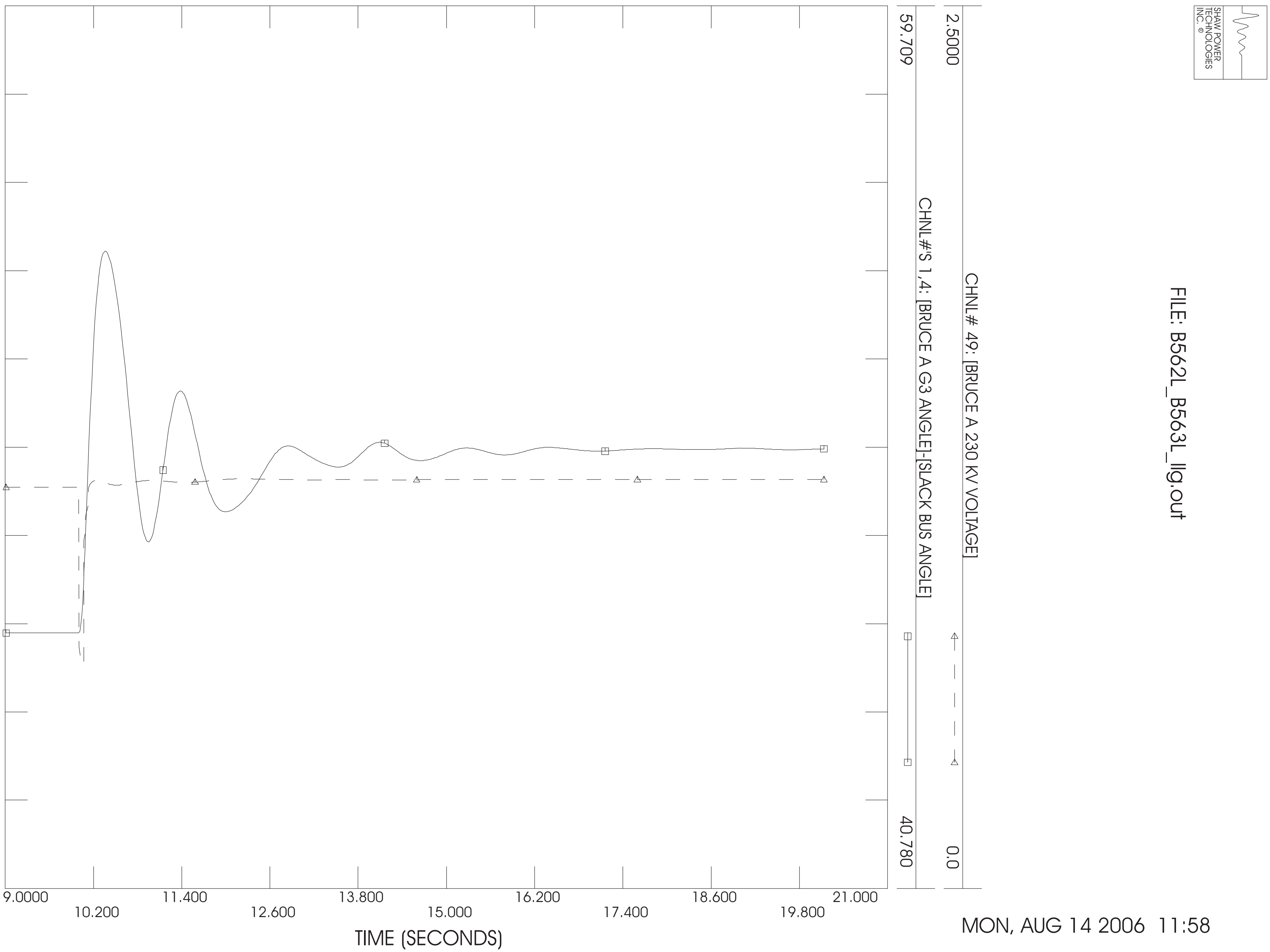

Figure 18: LLG fault B562L & B563L - Bruce A G3 angle & voltage

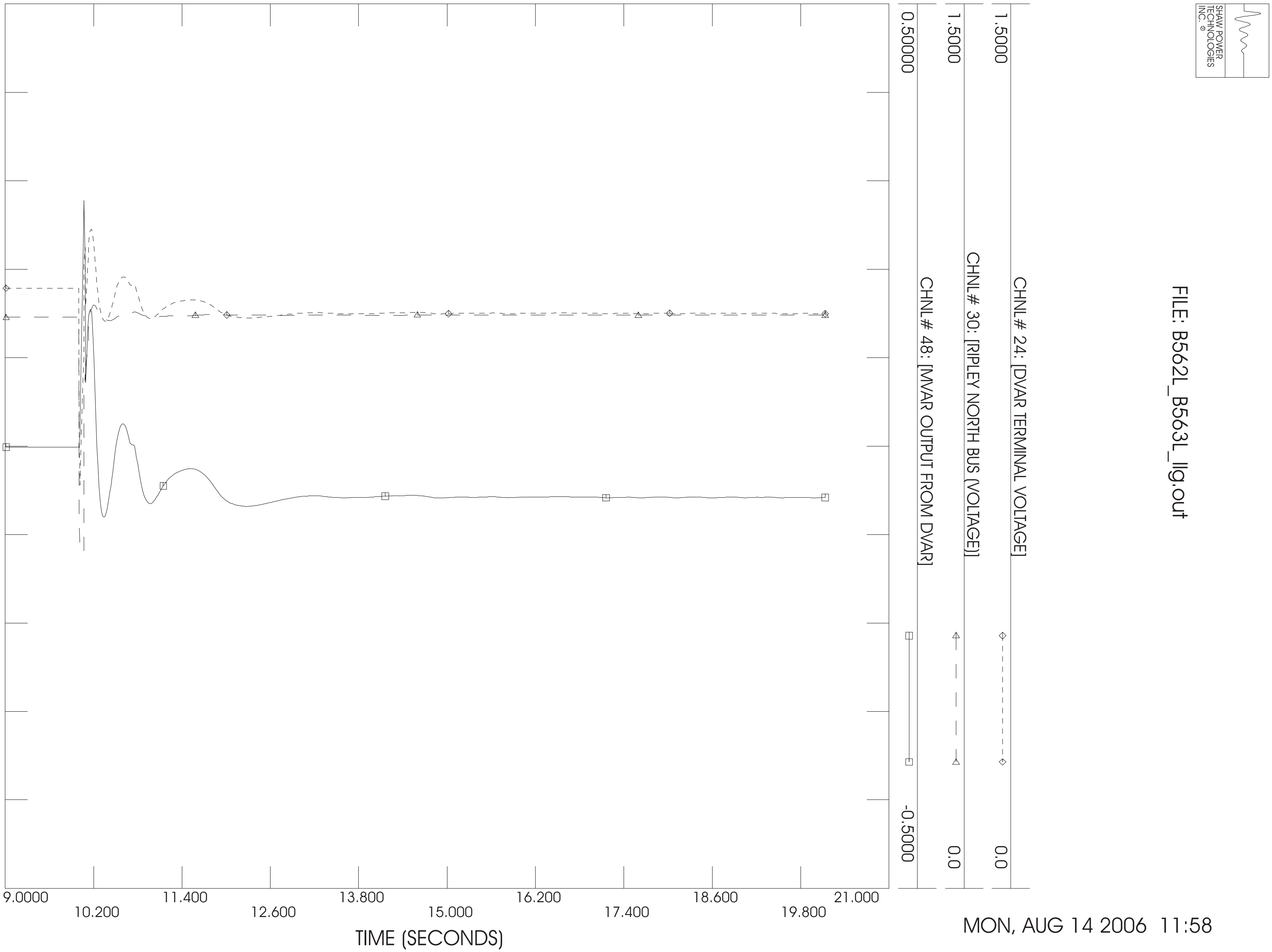

Figure 19: LLG fault B562L & B563L - D-VAR performance

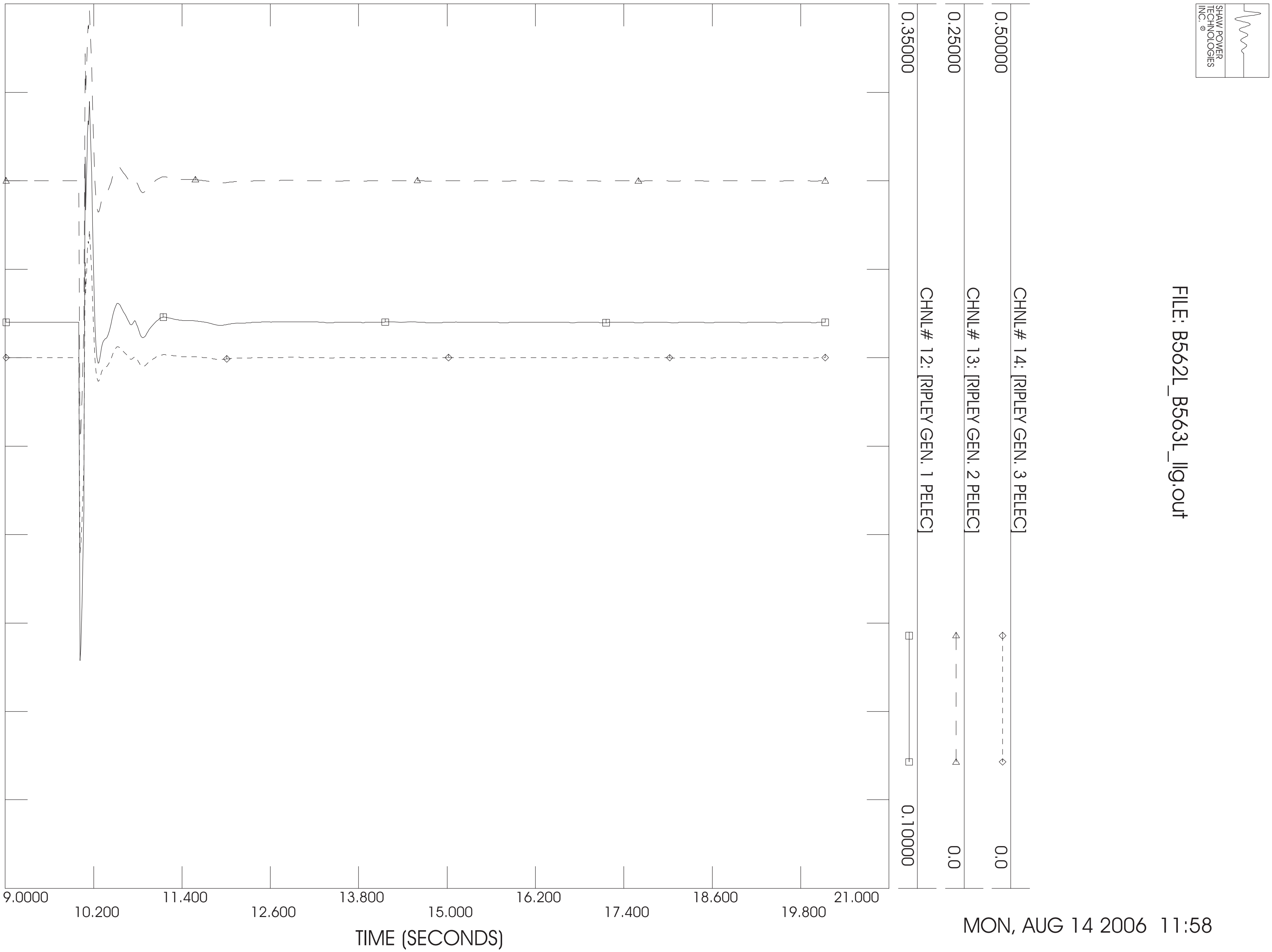

Figure 20: LLG fault B562L & B563L - WTGs performance

Appendix A: Results of Voltage Performance Studies

1 – Simultaneous loss of 500 kV circuits B560V and B561M without Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	249.96	247.64	-0.93	245.58	-1.75
Ripley 230 kV (B22D)	247.93	242.48	-2.20	239.90	-3.24
Ripley 230 kV (B23D)	247.89	242.44	-2.20	239.86	-3.24
Wingham 230 kV (B22D)	241.51	227.70	-5.72	223.48	-7.46
Wingham 230 kV (B23D)	241.34	227.53	-5.72	223.28	-7.48
Seaforth 230 kV (B22D)	239.37	222.28	-7.14	217.16	-9.28
Seaforth 230 kV (B23D)	239.05	221.97	-7.15	216.78	-9.31
Seaforth 115 kV	123.73	114.68	-7.31	111.97	-9.50
Stratford 230 kV (B22D)	241.42	224.83	-6.87	219.26	-9.18
Stratford 230 kV (B23D)	240.51	223.98	-6.88	218.22	-9.27
Detweiler 230 kV	243.91	229.75	-5.81	224.02	-8.16

1A – Simultaneous loss of 500 kV circuits B560V and B561M with Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	250.01	247.60	-0.96	245.39	-1.85
Ripley 230 kV (B22D)	248.10	242.65	-2.20	239.95	-3.29
Ripley 230 kV (B23D)	248.06	242.61	-2.20	239.91	-3.29
Wingham 230 kV (B22D)	241.40	227.29	-5.84	222.73	-7.73
Wingham 230 kV (B23D)	241.23	227.13	-5.85	222.53	-7.75
Seaforth 230 kV (B22D)	239.12	221.61	-7.32	215.97	-9.68
Seaforth 230 kV (B23D)	238.79	221.30	-7.32	215.59	-9.72
Seaforth 115 kV	123.51	114.33	-7.43	111.29	-9.89
Stratford 230 kV (B22D)	241.26	224.16	-7.09	218.02	-9.63
Stratford 230 kV (B23D)	240.35	223.31	-7.09	216.99	-9.72
Detweiler 230 kV	243.87	229.22	-6.01	222.93	-8.58

2 – Loss of 230 kV B23D without Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	249.96	249.64	-0.13	249.51	-0.18
Ripley 230 kV (B22D)	247.93	245.67	-0.91	245.26	-1.07
Ripley 230 kV (B23D)	247.89	0	n/a	0	n/a
Wingham 230 kV (B22D)	241.51	233.20	-3.44	231.97	-3.95
Wingham 230 kV (B23D)	241.34	0	n/a	0	n/a
Seaforth 230 kV (B22D)	239.37	229.39	-4.17	228.18	-4.68
Seaforth 230 kV (B23D)	239.05	0	n/a	0	n/a
Seaforth 115 kV	123.73	116.83	-5.57	116.22	-6.07
Stratford 230 kV (B22D)	241.42	234.56	-2.84	233.50	-3.28
Stratford 230 kV (B23D)	240.51	0	n/a	0	n/a
Detweiler 230 kV	243.91	242.60	-0.54	242.23	-0.69

2A – Loss of 230 kV B23D with Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	250.01	249.61	-0.16	249.47	-0.21
Ripley 230 kV (B22D)	248.10	245.71	-0.96	245.31	-1.12-
Ripley 230 kV (B23D)	248.06	0	n/a	0	n/a
Wingham 230 kV (B22D)	241.40	233.00	-3.48	231.76	-3.99
Wingham 230 kV (B23D)	241.23	0	n/a	0	n/a
Seaforth 230 kV (B22D)	239.12	229.18	-4.16	227.94	-4.68
Seaforth 230 kV (B23D)	238.79	0	n/a	0	n/a
Seaforth 115 kV	123.51	116.72	-5.50	116.06	-6.03
Stratford 230 kV (B22D)	241.26	234.47	-2.82	233.40	-3.26
Stratford 230 kV (B23D)	240.35	0	n/a	0	n/a
Detweiler 230 kV	243.87	242.63	-0.51	242.26	-0.66

3 – Loss of 230 kV B23D with a Bruce L23T25 breaker failure and without Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	249.96	249.52	-0.18	249.36	-0.24
Ripley 230 kV (B22D)	247.93	245.67	-0.91	245.26	-1.08
Ripley 230 kV (B23D)	247.89	0	n/a	0	n/a
Wingham 230 kV (B22D)	241.51	233.48	-3.33	232.30	-3.81
Wingham 230 kV (B23D)	241.34	0	n/a	0	n/a
Seaforth 230 kV (B22D)	239.37	229.72	-4.03	228.58	-4.51
Seaforth 230 kV (B23D)	239.05	0	n/a	0	n/a
Seaforth 115 kV	123.73	117.01	-5.43	116.46	-5.87
Stratford 230 kV (B22D)	241.42	234.81	-2.74	233.79	-3.16
Stratford 230 kV (B23D)	240.51	0	n/a	0	n/a
Detweiler 230 kV	243.91	242.76	-0.47	242.40	-0.62

3A – Loss of 230 kV B23D with a Bruce L23T25 breaker failure and with Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	250.01	249.50	-0.20	249.34	-0.27
Ripley 230 kV (B22D)	248.10	245.72	-0.96	245.30	-1.13
Ripley 230 kV (B23D)	248.06	0	n/a	0	n/a
Wingham 230 kV (B22D)	241.40	233.29	-3.36	232.07	-3.87
Wingham 230 kV (B23D)	241.23	0	n/a	0	n/a
Seaforth 230 kV (B22D)	239.12	229.51	-4.02	228.31	-4.52
Seaforth 230 kV (B23D)	238.79	0	n/a	0	n/a
Seaforth 115 kV	123.51	116.89	-5.36	116.28	-5.85
Stratford 230 kV (B22D)	241.26	234.73	-2.71	233.67	-3.15
Stratford 230 kV (B23D)	240.35	0	n/a	0	n/a
Detweiler 230 kV	243.87	242.80	-0.44	242.43	-0.59

4 – Simultaneous loss of 230 kV B4V and B5V without Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	249.96	248.07	-0.76	247.86	-0.84
Ripley 230 kV (B22D)	247.93	245.61	-0.94	245.43	-1.01
Ripley 230 kV (B23D)	247.89	245.57	-0.94	245.40	-1.01
Wingham 230 kV (B22D)	241.51	238.17	-1.38	238.09	-1.41
Wingham 230 kV (B23D)	241.34	238.01	-1.38	237.93	-1.41
Seaforth 230 kV (B22D)	239.37	235.81	-1.49	235.81	-1.49
Seaforth 230 kV (B23D)	239.05	235.49	-1.49	235.49	-1.49
Seaforth 115 kV	123.73	121.82	-1.54	121.86	-1.51
Stratford 230 kV (B22D)	241.42	238.23	-1.32	238.21	-1.33
Stratford 230 kV (B23D)	240.51	237.33	-1.32	237.31	-1.33
Detweiler 230 kV	243.91	241.25	-1.09	241.21	-1.11

4A – Simultaneous loss of 230 kV B4V and B5V with Ripley WGS connected

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	250.01	248.22	-0.72	248.02	-0.80
Ripley 230 kV (B22D)	248.10	245.95	-0.87	245.79	-0.93
Ripley 230 kV (B23D)	248.06	245.92	-0.87	245.75	-0.93
Wingham 230 kV (B22D)	241.40	238.26	-1.30	238.20	-1.33
Wingham 230 kV (B23D)	241.23	238.10	-1.30	238.03	-1.33
Seaforth 230 kV (B22D)	239.12	235.81	-1.38	235.82	-1.38
Seaforth 230 kV (B23D)	238.79	235.48	-1.39	235.50	-1.38
Seaforth 115 kV	123.51	121.81	-1.38	121.87	-1.33
Stratford 230 kV (B22D)	241.26	238.23	-1.26	238.23	-1.26
Stratford 230 kV (B23D)	240.35	237.34	-1.26	237.33	-1.26
Detweiler 230 kV	243.87	241.32	-1.05	241.28	-1.06

5 – Loss of Ripley WGS only

Bus	Pre-contingency voltage (kV)	Voltage (kV)			
		Pre-ULTC	% Change	Post-ULTC	% Change
Bruce A 230 kV	250.01	249.96	-0.02	249.96	-0.02
Ripley 230 kV (B22D)	248.10	247.92	-0.07	247.92	-0.07
Ripley 230 kV (B23D)	248.06	247.88	-0.07	247.88	-0.07
Wingham 230 kV (B22D)	241.40	241.51	0.04	241.51	0.04
Wingham 230 kV (B23D)	241.23	241.34	0.04	241.34	0.04
Seaforth 230 kV (B22D)	239.12	239.39	0.11	239.39	0.11
Seaforth 230 kV (B23D)	238.79	239.06	0.11	239.06	0.11
Seaforth 115 kV	123.51	123.74	0.18	123.74	0.18
Stratford 230 kV (B22D)	241.26	241.44	0.07	241.45	0.08
Stratford 230 kV (B23D)	240.35	240.53	0.07	240.54	0.08
Detweiler 230 kV	243.87	243.94	0.03	243.94	0.03

– End of Section –

Appendix B: PSS/E D-VAR Model Parameters

	ID	Value	Name
::	28	0.90	Low Reg Level (pu)
::	29	1.10	High Reg Level (pu)
::	34	0.5	Near Fault Level (pu)
::	37	1.15	Over Voltage Limit (pu)
::	42	5	Inverter Current Ref Minimum (A)
::	44	600	Inverter I Rated (A)
::	47	120	OverLoad Cycles
::	48	2.67	OverLoad Multiplier
::	49	30	Ramp Down (Line Cycles)
::	50	300	Thermal Recovery Time (s)
::	66	0	Sag Over Hyst (pu)
::	69	480	Inverter Terminal Voltage (V)
::	102	60	Operating Frequency (Hz)
::	117	0.2	No Reaction Level (pu)
::	119	8	Stacks
::	123	0.967	Voltage Comp Level (pu)
::	143	0	Trailer Has Magnet Subsystem (1=true)
::	184	1.5	High AC Peak Fault Limit (pu)
::	185	10	Trailer Configuration Type
::	187	0	External Cap Control Type
::	189	3	Use Inv Dynamic KpKi
::	250	12.12	V Comp Slope (pu A/pu V)
::	251	2	V Comp Type
::	252	0.125	V Comp Scale
::	259	0.05	Max 3-Phs Imbalance (Neg Seq) (pu)
::	284	1	Alt A2d is Ac input
::	290	1	Dc Bus is Disconnected
::	295	60	Undervoltage Inhibit T1 (cycles)
::	296	300	Undervoltage Inhibit T2 (cycles)
::	297	240	Max UnderVolt Inhibit delay (cycles)
::	298	1	Alt Protection Level (pu)
::	299	0	Alt Protection Slope (pu A/pu V)
::	328	0.025	Upper Nominal Neg Seq Limit (pu)
::	333	16	Min Throttled Inv Count
::	334	300	Pos Seq Avg Block cycles

::	335	300	Neg Seq Avg Block cycles
::	336	1.1	PLL cutoff freq (Hz)
::	337	0.1	PLL Damping Const
::	339	0.707	Seq Notch Damping Const
::	340	90	Seq Low Pass Cutoff Freq (Hz)
::	342	0	Correct Neg Seq Events
::	343	0	Enable Stack Throttling
::	344	0.005	Slow Threshold Err (pu)
::	345	0.03	Fast Threshold Err (pu)
::	346	0.01	Alt Slow Threshold Err (pu)
::	347	0.03	Alt Fast Threshold Err (pu)
::	348	10	Slow Filt Cutoff Freq (Hz)
::	349	400	Fast Filt Cutoff Freq (Hz)
::	350	0.1	Boost On Err (pu)
::	351	0.1	Buck On Err (pu)
::	352	0.04	Neg Seq On Err (pu)
::	353	5	Pos Seq Kp
::	354	0.5	Pos Seq Ki
::	355	3	Neg Seq Kp
::	356	0	Neg Seq Ki
::	357	0.25	Pos Droop Filt K
::	358	0.25	Neg Droop Filt K
::	359	0.02	Pos Seq Boost Droop
::	360	0.02	Pos Seq Buck Droop
::	361	0.02	Neg Seq Droop
::	362	1.15	Max Drooped Upper Lvl (pu)
::	363	0.85	Max Drooped Lower Lvl (pu)
::	364	0.04	Hard Shutoff delta (pu)
::	365	0	Target is Floating
::	366	0.1	Relative Delta Sag Target (pu)
::	367	0.1	Relative Delta Surge Target (pu)
::	368	1	Fixed Target Ref (pu)
::	370	1	Slow Avg Cutoff Freq (Hz)
::	371	1	Bandlimited Cutoff Freq (Hz)
::	372	0	Bumpless Turn On Time (cycles)
::	373	0	Require Alt Input above NoReact
::	374	1	Phase Lock to Primary PT
::	377	0.99	Pos Seq Longterm Limit (pu)
::	378	1.1	Fixed Upper Limitor (pu)
::	379	0.9	Fixed Lower Limitor (pu)
::	380	0.03	Limitor Hysterisis (pu)
::	381	5	Max Neg Seq Run time (s)

::	382	20	Max Pos Seq Run time (s)
::	383	0.15	Rel Pos Seq Limitor (pu)
::	384	0	Boost Delay Turn on (cticks)
::	385	0	Buck Delay Turn on (cticks)
::	386	0	Same Off->On Delay (cticks)
::	387	2	Opposite Off->On Delay (cticks)
::	389	0.03	Delta Neg Seq Err For Faster On
::	390	4	Neg Seq On delay (cticks)
::	395	0.04	Max Zero Seq Limit (pu)
::	429	0.00	Slow Relative Delta Sag Target (pu)
::	430	0.00	Slow Relative Delta Surge Target (pu)
::	431	0.9704	Slow Target V (pu)
::	432	0.033	Slow BandBlocking (s)
::	433	0.0	Slow Boost On Err (pu)
::	434	0.0	Slow Buck On Err (pu)
::	435	6	Slow Kp
::	436	1.5	Slow Ki
::	437	0.005	Slow Boost Droop - (m)
::	438	0.005	Slow Buck Droop - (n)
::	439	2	Regulation and Cap Trans Src
::	440	0.005	Slow Hysterisis Lvl (pu)
::	441	0.00	Slow Reg Low V Thresh (pu)
::	442	999	Slow Reg High V Thresh (pu)
::	443	0.5	Slow Max Cap Wait time (s)
::	444	0.01	Slow Cap Trans Thresh (pu)
::	445	1.1	Slow Max Drooped Upper (pu)
::	446	0.9	Slow Max Drooped Lower {pu)
::	447	0	Slow Bumpless Turnon (cycles)
::	448	0.45	Slow Reg Cap Size (pu)
::	449	1	Slow LTC Setpoint
::	450	0.01	Post Vbu Rel Surge (pu)
::	451	0.02	Post Vbu Buck Error On (pu)
::	10001	0.35	PSS-E: V-compliance speed factor

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