PJM Generator Interconnection

X2-060 & Y1-068 East Mill 138 kV

0 MW Capacity / 50 MW Energy

Combined SIS &

Facilities Study Report

October 2012
DMS #693663v1A

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Introduction

This Combined System Impact and Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff, §205, as well as the System Impact Study Agreement between Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company.

Preface

The intent of this Combined System Impact and Facilities Study is to determine a plan, with preliminary cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by IC. As a requirement for interconnection, IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM and the underlying system. All facilities required for interconnection of a generation interconnection project must be designed to meet ITO technical specifications.

The Combined System Impact and Facilities Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. IC is responsible for its right of way, real estate, and construction permit issues.

General

Queue project X2-060 was studied as a 30 MW injection into ITO system at the East Mill 138 kV substation. Y1-068 added 20 MW additional. Project combined output was evaluated for compliance with reliability criteria for summer peak conditions in 2015.

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Network Impacts:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line Contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)

No problems identified.

Contribution to Previously Identified Overloads

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have % allocation of cost responsibility which will be calculated and reported for the Impact Study.)

None.

Short Circuit

(Report Overdutied breakers here)

No problems identified.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to result in operational restrictions to the project under study. The IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

No problems identified.

Stability Results

(The full stability study report can be found in Attachment A of this report. This section summarizes the requirements that were identified in the study.)

With the exception of the “d” type faults listed below, transient stability is maintained for all other cases studied, with all oscillations stabilized in less than 20 seconds. Fault descriptions are provided in Attachment A, Appendix A.3.

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For faults 01d, 02d, 03d, 04d, 05d1, 05d2, 06d1, 06d2, 07d1, 07d2, and 08d the rotor angle deviations for the X2-060 generator, the three existing generators at Westvaco are very large indicating they are pulling out of step and going unstable. To prevent the 'd' type faults from causing instability on the transmission system, it is the ITO practice to:

(a) Require that out of step protection be installed on the X2-060 generator by the IC to protect their equipment.
(b) Recommend that out of step protection be installed on the three existing generators at Westvaco (8G1, 6G2 & 12G3).

Maintenance outage: No maintenance outage conditions were evaluated.

Requirements:

Installation of out-of-step protection: IC shall install out-of-step protection on the X2-060 generator. This study was made using a certain set of operating conditions. There may be other operating conditions, although less probable, that can create stability problems. It is the IC responsibility to protect their own equipment from damage due to disturbances on the transmission system.

Recommendations:

1) PSS for X2-060 generator: The PSS model provided for the X2-060 generator was disabled in this study. It is recommended to install a properly tuned PSS for the X2-060 generator. If a PSS will be installed for the generator, the model and tuned parameters shall be provided to PJM for a re-study. Also, if future studies show a need for a PSS on X2-060, then the generator owner will be required to install and tune the PSS.

2) Installation of out-of-step protection on the existing Westvaco generators: It is highly recommended that out-of-step protection be installed on the existing generators (8G1, 6G2 & 12G3) at Westvaco substation.

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ITO Analysis

ITO requested an interconnection of one (1) 80 MW biomass generator, PJM queue X2-060. IC generator unit is located at Meadwestvaco Covington Mill Site, Covington, Virginia. IC desires to export a total of 50 MW to be injected into the Interconnection Transmission Owners distribution system. The remaining generation will be consumed Behind The Meter. The following are ITO Technical Requirements for IC interconnection.

ITO Attachment Facilities

New Attachment Facilities

Transfer trip equipment modifications for new generation. The cost of this equipment and modifications will be $220,409.

Existing Attachment Facilities

Existing facilities required to provide this interconnection include:

1. Metering
2. Generator out of sync protection
3. Telemetering Equipment

The existing facilities were installed under *Purchase of Electricity Agreements* in September 1975, September 1980, December 1983 and January, 2001 and are covered in the IC current *Agreement for Electric Service* dated September 1, 2004.

Listed below are costs that were not paid upfront and **must be paid before executing an ISA**. After payment is received the charges will be carried over to the new ISA as facility charges at 0.54%:

• September 1975	$ 3,000
• September 1980	$47,000
• January 2001	$11,210
Total	$61,210

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Listed below are charges that were paid upfront and will be carried over to the new ISA as facility charges at 0.54%:

- September 1980 $20,350
- December 1983 $26,107

  Total $46,457

The IC will also be responsible for providing and maintaining telephone lines to the ITO metering equipment at the Point of Interconnection and provide all communication lines necessary to transmit data from the metering to PJM.

The estimated time for engineering, material acquisition and construction of this interconnection is approximately three months. Detailed engineering, costs, material lead times and construction time requirements will be determined as part of the Combined System Impact & Facilities Study.

Modification to Existing Attachment Facilities

Modifications are required to existing Westvaco and East Mill Substations to accommodate proposed interconnection. Modifications inside the substations will include:

Metering Enclosure:

ITO will install the generator meter. The meter will be installed in a 36 inch wide metering enclosure, supplied by ITO at IC expense, and installed by IC. The enclosure will be installed and mounted indoors, inside the new 80 MVA generator switchgear room. Metering enclosure will be provided with a placard with the designation: *Dominion Virginia Power Metering Enclosure*. The center of the metering enclosure shall be mounted eye-level, with sufficient overhead clearance to allow lid to swing up and lock open. All secondary conductors between the metering PTs and CTs and generator meter cabinet will be #10 American Wire Gauge (AWG) and installed in National Electric Code (NEC)-approved conduit, provided and installed by IC. Meter enclosure will be bonded and grounded in accordance with NEC.

Note: The metering enclosure described above must be accessible to ITO personnel for purposes of periodic

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testing and maintenance of the metering equipment. Metering enclosure will be secured under ITO lock and key, with a small auxiliary hatch available for IC to view watt-hour meter register readings.

Auxiliary Power:

If a 120 Volt AC ground fault circuit interrupter outlet is not located within ten (10) feet of meter enclosure, a set of two (2) #10 AWG conductors must be installed for the purpose of providing 120 Volt AC auxiliary power in the metering cabinet, and must be installed within NEC-approved conduit between the IC breaker panel and the metering cabinet. All conduit and conductors for auxiliary power shall be provided and installed by IC.

Metering Instrument Transformers:

The 15 kV metering current transformers (CT's) and potential transformers (PT's) will be purchased by IC, at IC expense and approved by ITO. Metering CTs and PTs will be installed by IC in a compartment separate from the IC switchgear. The compartment containing the metering CT's and PT's will be secured under ITO lock and key and designated: *Dominion Virginia Power Metering TX's*. Note: H1 bushings of CT's should be turned to face generator, H2 bushings should be turned to face line-side.

Generator Watt-Hour Meter:

IC will install a standard, copper, dedicated telephone line at the ITO generator metering enclosure. IC will maintain the phone line for the sole purpose of allowing ITO to communicate with ITO metering equipment, and will not install any other telephone equipment (e.g. fax machine) on the phone line provided for the ITO metering equipment. IC will make available to ITO the phone number assigned to the dedicated phone line.

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Additional Watt-Hour Meters:

An additional six (6) watt-hour meters will be installed to meter the excess generation injected into the ITO system through the six (6) existing transformers located in Westvaco and East Mill substations. These six (6) watt-hour meters will include dial-up POTS modems for communication. A new metering panel will be built by the ITO, at IC expense, and installed in East Mill Substation to accommodate the additional three (3) watt-hour meters for transformers #4, #5 and #6.

The cost for this modification work is estimated to be $71,174.41 and be completed in three months.

IC site will be interfacing with the ITO source in the following manner:

- IC facility is fed by both Westvaco Substation transformers #1, #2, and #3 sourced from the 138 kilovolt (kV) Bus #6 and lines 109 (East Mill) and 155 (Fudge Hollow) and East Mill Substation Transformers #4, #5 and #6 sourced from the 138 kV Bus #1 and lines 109 (Westvaco) and 161 (Low Moor).

- The load data for the pertinent sectionalizing devices are as follows:

    - Line 109 has a typical "light" loading of 0.0 MVA
    - Line 155 has a typical "light" loading of 0.0 MVA
    - Line 161 has a typical "light" loading of 6.7 MVA

- IC parallel operation will not be limited to any particular time or ITO circuit-loading condition.

- IC will be contracted to export power into the ITO system.

Based on the minimum circuit loads given for the ITO sectionalizing devices, the following minimum "Local

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Load to IC Generation Capacity" ratios will apply for this installation:

ITO Transmission Line	Minimum Ratio
Line 109	0.00
Line 155	0.00
Line 161	0.22

These minimum ratios applicable for this installation will require the IC to have direct pilot wire tripping (or transfer trip) and an islanding scheme installed to ITO breakers L182, L282 and L382 in Westvaco Substation and to all three IC main breakers 7AUT4, 11AUT5 and 13AUT6 sourced from East Mill Substation. The islanding and direct trip control features are meant to ensure that a "prolonged" (or "permanent") islanding condition (with the IC generation supplying ITO load in the absence of the ITO source) will not be set-up. In addition, the direct tripping and islanding scheme function would aid in protecting the IC generation equipment from an out-of-step reclosure of the ITO source.

In its current design, the protection scheme at the Westvaco and East Mill substations is set up to initiate tripping of both the ITO breakers and IC breakers during a system disturbance through basic overcurrent or breaker failure scheme for disturbances at the local level. With the addition of the new generation in the East Mill, the existing islanding scheme will be expanded and reconfigured to ITO current design. These direct tripping functions and expanded islanding scheme should be sufficient to sectionalize the IC generation for the opening of the respective devices and prevent an islanding condition. In addition, the base protection package described below will also be required.

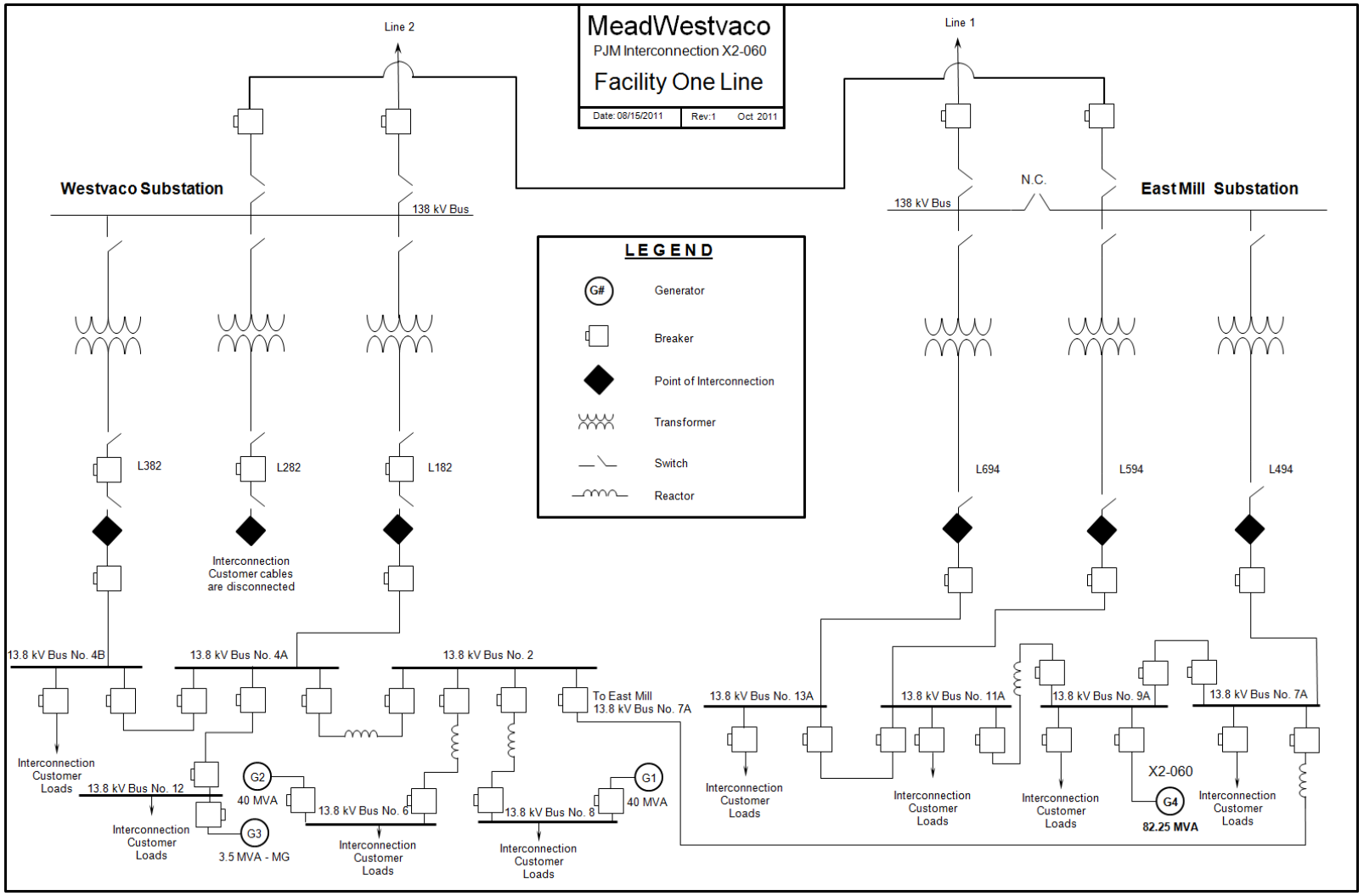
The required relay functions, each sectionalizing all of the IC's generation, and the corresponding setting ranges, applying for each of the designated ITO feeds, are listed in the following table:

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Function		Set Point	Duration To Disconnection (seconds)	
			Preferred	Maximum
27	Under voltage	90% of nominal operating voltage	Less than 2.0	2
59	Overvoltage	106% to 110% of nominal operating voltage	Less than 2.0	2
81U	Underfrequency	59.0 to 59.5 Hz	Less than 2.0	2
81O	Overfrequency	60.5 to 61.0 Hz	Less than 2.0	2
51	Phase Time-Delay Overcurrent	Set for minimum, with adequate load allowance	Maintain proper coordination	
51N	Ground Time-Delay Overcurrent	Set for minimum, with adequate imbalance allowance	Maintain proper coordination	

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Proposed One-Line:



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Attachment A – Stability Study Results

Introduction

This study evaluates the stability and dynamics for PJM queue project X2-060 and Y1-068 at East Mill 138 kV substation. The X2-060 project is for the installation of one generator with a maximum winter gross MW output of 80 MW. Along with the existing three generators at Westvaco substation, a total gross output of 30 MW injection into the ITO 138 kV transmission system was requested. The Y1-068 project increases the injection by 20 MW, for a total injection of 50 MW into the 138 kV transmission system.

The results of the stability study documented below include the X2-060 and Y1-068 requests (henceforth referred to as X2-060 in this report), for a total gross output of 50 MW injection into the ITO 138 kV transmission system.

Note: This study by PJM does not evaluate the stability and dynamics for the above mentioned queue project interconnection on neighboring FirstEnergy and/or AEP transmission facilities, as the Fudge Hollow – Greenbriar 138 kV tie line is "normally open" during normal operating conditions.

Analysis

The stability study for X2-060 was performed at 2015 light load conditions for normal operating conditions. The range of contingencies evaluated was limited to those necessary to assess compliance with the ITO criteria, which is derived from the NERC criteria. Simulation time was 20 seconds for all faults.

Four main fault types were considered, namely:

1) Three-phase fault (3-ph) with normal clearing (Category B from NERC standard TPL-001)
2) Single-line-to-ground (SLG) with delayed clearing as a result of breaker failure (Category C from NERC standard TPL-001)
3) SLG with delayed clearing as a result of protection failure (Category C from NERC standard TPL-001)
4) 3-ph with delayed clearing as a result of breaker failure (Category D from NERC standard TPL-001)

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Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A. Generation equipment data is shown in Appendix B. The PSSE model (load flow and dynamic data format) and single line diagram is provided in Appendix C. A table showing the maximum angle deviation is provided in Appendix D. The bus voltage summary is provided in Appendix A.

PSS/E Models for X2-060

Generator model:	GENROU
Excitation model:	IEESGO
Governor model:	UAC8B
PSS model:	UPSS2B (DISABLED FOR THIS STUDY – actual parameter values were not provided)

Parameter values for these models are provided in the Dynamic Data section in Appendix C.2.

The PSS model provided for the generator was disabled in this study. The results of this study do not include a PSS model for the X2-060 generator; prior to going in service, a PSS will be installed and a suitable model and properly tuned parameters need to be provided to PJM for a restudy. **If future studies show a need for a PSS on X2-060, then the generator owner will be required to install and tune the PSS.**

Results

PJM queue project X2-060 was modeled as an 80 MW 13.8 kV generator at East Mill substation as shown in Fig C-1. The three existing 13.8 kV generators at Westvaco (8G1, 6G2 and 12G3) were also modeled for this study.

An idev was provided by ITO to model the lower voltage network at this plant. There are reactors installed throughout the plant to control fault current, and due to this special configuration, it was not possible to dispatch the generators in the leading region and maintain an acceptable 13.8 kV voltage at the generator terminals. Specific dispatch conditions at the generator terminals for the X2-060 generator and the three existing generators at Westvaco are provided below:

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	X2-060 Unit #4	8G1 Unit #1	6G2 Unit #2	12G3 Unit #3
Gross power output (MW)	80	30	32.5	15
Reactive power output (MVARS)	+8.0	+8.0	+8.0	+4.83

Total Load (MW/MVARS) = 106.6 / 79.6

Net real power injection into the ITO Transmission system = 50.9 MW

Simulation Initialization

The X2-060 generator initialized successfully. No errors were reported.

20 second no fault test (Steady State evaluation):

The system successfully met the 20 second run test without any significant deviations in rotor angle and power.

Simulation Results

Transient Stability: Transient stability was tested using Siemens/PTI PSS/E Version 30.3, the 2015 case with a Light Load condition and the data supplied by the developer.

With the exception of the 'd' type faults listed below, transient stability is maintained for all other cases studied, with all oscillations stabilized in less than 20 seconds. Fault descriptions are provided in Appendix A.3

For faults 01d, 02d, 03d, 04d, 05d1, 05d2, 06d1, 06d2, 07d1, 07d2, and 08d the rotor angle deviations for the X2-060 generator, the three existing generators at Westvaco are very large indicating they are pulling out of step and going unstable. To prevent the 'd' type faults from causing instability on the transmission system, it is the ITO practice to:

(a) Require that out of step protection be installed on the X2-060 generator by the IC to protect their equipment.
(b) Recommend that out of step protection be installed on the three existing generators at Westvaco (8G1, 6G2 & 12G3).

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Maintenance outage: No maintenance outage conditions were evaluated.

Requirements:

Installation of out-of-step protection: Out-of-step protection is required to be installed by the IC on the X2-060 generator. This study was made using a certain set of operating conditions. There may be other operating conditions, although less probable, that can create stability problems. It is the IC's responsibility to protect their own equipment from damage due to disturbances on the transmission system.

Recommendations:

1) PSS for X2-060 generator: The PSS model provided for the X2-060 generator was disabled in this study. It is recommended to install a properly tuned PSS for the X2-060 generator. If a PSS will be installed for the generator, the model and tuned parameters shall be provided to PJM for a re-study. Also, if future studies show a need for a PSS on X2-060, then the generator owner will be required to install and tune the PSS.

2) Installation of out-of-step protection on the existing Westvaco generators: It is highly recommended that out-of-step protection be installed on the existing generators (8G1, 6G2 & 12G3) at Westvaco substation.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system load levels and operating conditions may disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in that or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and plant specific dynamic data for the plant and its controls are available, it must be forwarded to PJM. If it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall be performed to verify impact on the dynamic performance of the system. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

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Appendix A

A.1) Power Flow Conditions

2015 Light Load Base Case

A.2) Breaker Clearing Times

Table A-1: ITO Clearing Times (Cycles)

Voltage Level / Fault Type	A faults	B faults	C faults	D faults
	Primary (3-ph/SLG)	Stuck Breaker (Total)	Zone 2 (Total)	Re-closing (Total)
138 kV	5.5	26	41	26

A.3) Faults Considered (All facilities in service)

Note: For simplicity of fault type identification, PJM has adopted the following notation:

A faults: 3-ph faults with normal clearing time

B faults: SLG faults due to stuck breaker with delayed clearing time

C faults: SLG faults with delayed clearing time due to protection system failure

D faults: 3-ph fault due to stuck breaker with delayed clearing time

This notation is for internal purposes only, and does not necessarily correspond with the NERC category definition stated in TPL-001.

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Fault list

EAST MILL 138 kV BUS:

01a. 3-ph fault @ East Mill – Westvaco 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: East Mill – Westvaco 138 kV line

01b. SLG fault @ East Mill – Westvaco 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: East Mill – Westvaco 138 kV line
Breaker failure (10992) @ East Mill 138 kV bus
SLG fault @ East Mill – Westvaco 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: East Mill 138 kV bus

01c. SLG fault @ 80% of East Mill – Westvaco 138 kV line
Westvaco breaker tripped within 138 kV primary clearing time
East Mill breaker tripped within 138 kV Zone 2 clearing time
Loss of: East Mill – Westvaco 138 kV line

01d. 3-ph fault @ East Mill – Westvaco 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: East Mill – Westvaco 138 kV line
Breaker failure (10992) @ East Mill 138 kV bus
3-ph fault @ East Mill – Westvaco 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: East Mill 138 kV bus

02a. 3-ph fault @ East Mill – Lowmoor 138 kV line (through Covington2 138 kV bus)
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington2 138 kV bus

02b. SLG fault @ East Mill – Lowmoor 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington2 138 kV bus
Breaker failure (16192) @ East Mill 138 kV bus
SLG fault @ East Mill – Lowmoor 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: East Mill 138 kV bus

02c. SLG fault @ 80% of East Mill – Lowmoor 138 kV line
Lowmoor breakers tripped within 138 kV primary clearing time
East Mill breaker tripped within 138kV Zone 2 clearing time
Loss of: Covington2 138 kV bus

02d.3-ph fault @ East Mill – Lowmoor 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington2 138 kV bus
Breaker failure (16192) @ East Mill 138 kV bus
3-ph fault @ East Mill – Lowmoor 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: East Mill 138 kV bus

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WESTVACO 138 kV BUS:

03a. 3-ph fault @ Westvaco – Fudge Hollow 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Westvaco – Fudge Hollow 138 kV line

03b. SLG fault @ Westvaco – Fudge Hollow 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Westvaco – Fudge Hollow 138 kV line
Breaker failure (15582) @ Westvaco 138 kV bus
SLG fault @ Westvaco – Fudge Hollow 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Westvaco 138 kV bus

03c. SLG fault @ 80% of Westvaco – Fudge Hollow 138 kV line
Fudge Hollow breaker tripped within 138 kV breaker primary clearing time
Westvaco breaker tripped within 138 kV Zone 2 clearing time
Loss of: Westvaco – Fudge Hollow 138 kV line

03d. 3-ph fault @ Westvaco – Fudge Hollow 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Westvaco – Fudge Hollow 138 kV line
Breaker failure (15582) @ Westvaco 138 kV bus
3-ph fault @ Westvaco – Fudge Hollow 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Westvaco 138 kV bus

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FUDGE HOLLOW 138 kV BUS:

04a. 3-ph fault @ Fudge Hollow – Lowmoor 138 kV line (through Covington1 138 kV bus)
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington1 138 kV bus

04b. SLG fault @ Fudge Hollow – Lowmoor 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington1 138 kV bus
Breaker failure (112T155) @ Fudge Hollow 138 kV bus
SLG fault @ Fudge Hollow – Lowmoor 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Fudge Hollow 138 kV bus

04c. SLG fault @ 80% of Fudge Hollow – Lowmoor 138 kV line
Lowmoor breakers tripped within 138 kV primary clearing time
Fudge Hollow breaker tripped within 138kV Zone 2 clearing time
Loss of: Covington1 138 kV bus

04d. 3-ph fault @ Fudge Hollow – Lowmoor 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Covington1 138 kV bus
Breaker failure (112T155) @ Fudge Hollow 138 kV bus
3-ph fault @ Fudge Hollow – Lowmoor 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Fudge Hollow 138 kV bus

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LOWMOOR 138 kV BUS:

05a. 3-ph fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4 [A, B, C & D in PSSE case]
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors

05b1. SLG fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors
Breaker failure (H12T112) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington1 138 kV bus

05b2. SLG fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors
Breaker failure (H12T133) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker backup clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line

05c. SLG fault @ N/A

05d1. 3-ph fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors
Breaker failure (H12T112) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington1 138 kV bus

05d2. 3-ph fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors
Breaker failure (H12T133) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor 138 kV – Lowmoor 13.8 kV Units 1, 2, 3 & 4
Fault cleared within 138 kV breaker backup clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line

06a. 3-ph fault @ Lowmoor 230/138 kV transformer #1 [fault on 138 kV side]
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor 230 kV bus

06b1. SLG fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor 230 kV bus
Breaker failure (L34T112) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington1 138 kV bus

06b2. SLG fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor 230 kV bus
Breaker failure (L34T161) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington2 138 kV bus

06c. SLG fault @ N/A

06d1. 3-ph fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor 230 kV bus
Breaker failure (L34T112) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor 230/138 kV transformer #1

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Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington1 138 kV bus

06d2. 3-ph fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor 230 kV bus
Breaker failure (L34T161) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor 230/138 kV transformer #1
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington2 138 kV bus

07a. 3-ph fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line

07b1. SLG fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line
Breaker failure (133T161) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington2 138 kV bus

07b2. SLG fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line
Breaker failure (H12T133) @ Lowmoor 138 kV bus
SLG fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors

07c. SLG fault @ 80% of Lowmoor – Clifton Forge 138 kV line
Clifton Forge breaker tripped within 138 kV primary clearing time
Lowmoor breaker tripped within 138kV Zone 2 clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line

07d1. 3-ph fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line
Breaker failure (133T161) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Covington2 138 kV bus

07d2. 3-ph fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker primary clearing time
Loss of: Lowmoor – Clifton Forge 138 kV line
Breaker failure (H12T133) @ Lowmoor 138 kV bus
3-ph fault @ Lowmoor – Clifton Forge 138 kV line
Fault cleared within 138 kV breaker backup clearing time
Loss of: Lowmoor units A&B; Lowmoor units C&D; Lowmoor 138 kV capacitors

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CLIFTON FORGE 138 kV BUS:

08a. 3-ph fault @ Clifton Forge 230/138 kV transformer #1[fault on 138 kV side]
Fault cleared within 138 kV breaker primary clearing time
Loss of: Clifton Forge 230 kV bus

08b. SLG fault @ Clifton Forge 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Clifton Forge 230 kV bus
Breaker failure (L222) @ Clifton Forge 138 kV bus
SLG fault @ Clifton Forge 230/138 kV transformer #1
Fault cleared within 138 kV breaker backup clearing time
Loss of: Clifton Forge 138 kV bus

08c. SLG fault @ N/A

08d. 3-ph fault @ Clifton Forge 230/138 kV transformer #1
Fault cleared within 138 kV breaker primary clearing time
Loss of: Clifton Forge 230 kV bus
Breaker failure (L222) @ Clifton Forge 138 kV bus
3-ph fault @ Clifton Forge 230/138 kV transformer #1
Fault cleared within 138 kV breaker backup clearing time
Loss of: Clifton Forge 138 kV bus

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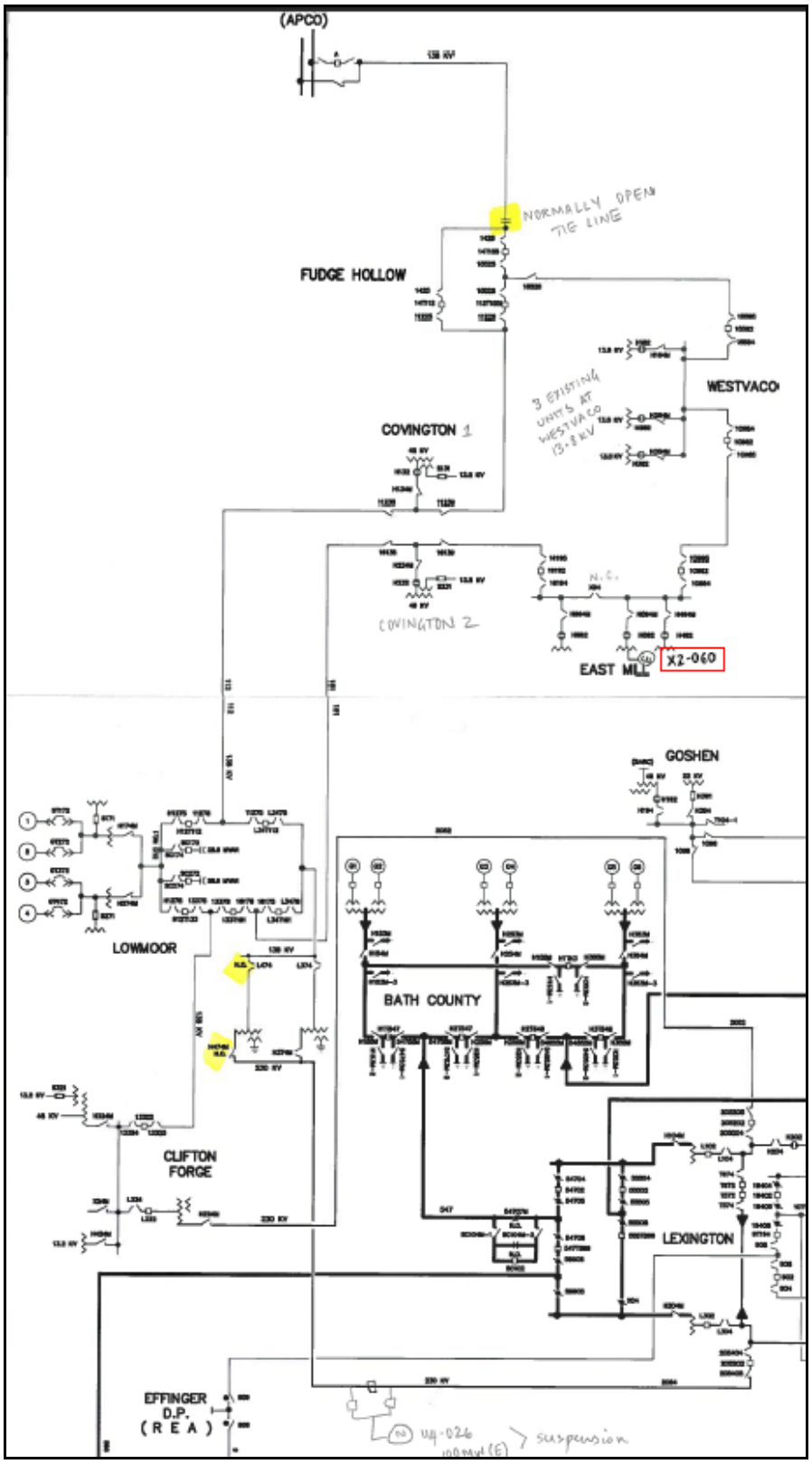


Figure A-1: ITO Single Line showing X2-060 POI at East Mill substation

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B.1) Data for X2-060 (&Y1-068) Generator

Queue Letter/Position/Unit ID: X2-060
Project Capability data
Primary Fuel Type: Biomass
Maximum Summer Net MW Output: 30
Maximum Summer Gross MW Output: 157.5
Minimum Summer Gross MW Output: 60
Maximum Winter Gross MW Output: 157.5 [1]
Minimum Winter Gross MW Output: 60
Gross Reactive Power Capability at Maximum Gross MW Output: [2]
Leading (MVAR) : -33.5
Lagging (MVAR) : 45
Station service Load (MW / MVAR) : 106.6 / 79.6 [3]
MVA Base (upon which all reactances, resistances and inertia are calculated): 87.6
Nominal Power Factor: 0.85
Terminal Voltage (kV) : 13.8
Unsaturated Reactances (on MVA Base)
Direct Axis Synchronous Reactance, $X_d(i)$: 2.18
Direct Axis Transient Reactance, $X'_d(i)$: 0.215
Direct Axis Sub-transient Reactance, $X''_d(i)$: 0.154
Quadrature Axis Synchronous Reactance, $X_q(i)$: 2.0
Quadrature Axis Transient Reactance, $X'_q(i)$: 0.26
Quadrature Axis Sub-transient Reactance, $X''_q(i)$: 0.19
Stator Leakage Reactance, X_1: 0.2
Negative Sequence Reactance, X_2: 0.196
Zero Sequence Reactance, X_0: 0.093
Time Constants (seconds)
Direct Axis Transient Open Circuit, T'_{do}: 9.3
Direct Axis Sub-transient Open Circuit, T''_{do}: 0.05
Quadrature Axis Transient Open Circuit, T'_{qo}: 2.8
Quadrature Axis Sub-transient Open Circuit, T''_{qo}: 0.05
Inertia, H (kW-sec/kVA, on kVA base): 1.8
Speed Damping, D: 0
Saturation Values at Per-unit Voltage [S(1.0), S(1.2)] 0.07, 0.4 [4]

Unit GSU data

X2-060 generator is connecting to an existing 13.8 kV network. The 138/13.8 kV transformer(s) data and existing topology at Westvaco and East Mill 138 kV substations was provided by ITO to model this generator.

[1] Calculated from "Maximum Export 4/27/12" Single line (includes MW for X2-060 and the three existing units)
[2] Calculated from Reactive Capability Curves provided for Generator
[3] Calculated from "Maximum Export 4/27/12" Single line (includes MW for X2-060 and the three existing units)
[4] Values provided in Impact Study Form for Generator

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Appendix C

C.1) Load Flow Model Data

```
/*********************************************************
/* Power flow idev for X2-060 stability study (2015 LL case)
/* Provided by ITO on 08-01-12;
/* FOR USE WITH WESTVACO PJM QUEUE X2-060
/* THIS ADDS WESTVACO & EAST MILL LOWSIDE SYSTEM TO THE LOADFLOW CASE
/*********************************************************

/*********************************************************************
/***DELETE LOADS AND GENERATION FROM WESTVACO AND EASTMILL 138 KV BUSSES***
/*********************************************************************
BAT_PURGMAC 314859 'A'
BAT_PURGLOAD 314860 '1'
BAT_PURGLOAD 314859 '1'

RDCH
1
   662,'4WESTUT3    ', 13.8000,1, 0.000, 14.400, 345, 365,1.00029, -17.0200, 312
   663,'4EASTUT4    ', 13.8000,1, 0.000, 14.400, 345, 365,0.99585, -15.2336, 312
   664,'4EASTUT5    ', 13.8000,1, 0.000, 14.400, 345, 365,0.99805, -16.6352, 312
   665,'4EASTUT6    ', 13.8000,1, 0.000, 14.400, 345, 365,0.99805, -16.6352, 312
   666,'4AUT1       ', 13.8000,1, 0.000, 0.000, 345, 365,0.99992, -17.0407, 312
   667,'4BUT3       ', 13.8000,1, 0.000, 0.000, 345, 365,1.00029, -17.0200, 312
   668,'7AUT4       ', 13.8000,1, 0.000, 0.000, 345, 365,0.99585, -15.2336, 312
   669,'11AUT5      ', 13.8000,1, 0.000, 0.000, 345, 365,0.99805, -16.6352, 312
   670,'13AUT6      ', 13.8000,1, 0.000, 0.000, 345, 365,0.99805, -16.6352, 312
   671,'BUS2        ', 13.8000,1, 0.000, 0.000, 345, 365,0.99067, -15.1224, 312
   672,'BUS4A       ', 13.8000,2, 0.000, 0.000, 345, 365,1.00000, -16.9383, 312
   673,'BUS4B       ', 13.8000,1, 0.000, 0.000, 345, 365,1.00000, -16.9383, 312
   674,'BUS7A       ', 13.8000,1, 0.000, 0.000, 345, 365,0.99585, -15.2336, 312
   675,'BUS11A      ', 13.8000,1, 0.000, 0.000, 345, 365,0.99805, -16.6352, 312
   676,'BUS9A       ', 13.8000,1, 0.000, 0.000, 345, 365,0.97951, -11.9951, 312
   677,'BUS13A      ', 13.8000,1, 0.000, 0.000, 345, 365,0.99805, -16.6352, 312
   678,'BUS8        ', 13.8000,2, 0.000, 0.000, 345, 365,0.98176, -14.3738, 312
   679,'BUS6        ', 13.8000,2, 0.000, 0.000, 345, 365,0.98309, -13.5232, 312
   680,'4WESTUT2    ', 13.8000,1, 0.000, 0.000, 345, 365,0.99571, -19.0892, 312
   681,'4WESTUT1    ', 13.8000,1, 0.000, 14.400, 345, 365,0.99992, -17.0407, 312
   909332,'X2-060_BUS15', 13.8000,2, 0.000, 0.000, 345, 365,0.97164, -3.1099, 312
0 / END OF BUS DATA, BEGIN LOAD DATA
   672,'1 ',1, 345, 365, 8.500, 7.000, 0.000, 0.000, 0.000, 0.000, 312
   673,'1 ',1, 345, 365, 13.000, 9.100, 0.000, 0.000, 0.000, 0.000, 312
   674,'1 ',1, 345, 365, 13.200, 11.600, 0.000, 0.000, 0.000, 0.000, 312
   675,'1 ',1, 345, 365, 7.000, 5.600, 0.000, 0.000, 0.000, 0.000, 312
   676,'1 ',1, 345, 365, 6.100, 4.900, 0.000, 0.000, 0.000, 0.000, 312
   677,'1 ',1, 345, 365, 11.500, 8.900, 0.000, 0.000, 0.000, 0.000, 312
   678,'1 ',1, 345, 365, 22.000, 13.600, 0.000, 0.000, 0.000, 0.000, 312
   679,'1 ',1, 345, 365, 15.300, 12.700, 0.000, 0.000, 0.000, 0.000, 312
909332,'1 ',1, 345, 365, 10.000, 6.200, 0.000, 0.000, 0.000, 0.000, 312
0 / END OF LOAD DATA, BEGIN GENERATOR DATA
   672,'3  ',  15.000,  4.837,  5.000,  -5.000,1.00000,  0,  26.000,  0.00000,  0.30860,  0.00000,
0.00000,1.00000,1, 100.0, 15.000, 0.000, 312,1.0000
   678,'1  ',  30.000,  8.000,  8.000,  -16.000,1.00000,  0,  40.000,  0.00000,  0.25600,  0.00000,
0.00000,1.00000,1, 100.0, 30.000, 0.000, 312,1.0000
   679,'2  ',  32.500,  8.000,  8.000,  -15.000,1.00000,  0,  40.000,  0.00000,  0.22800,  0.00000,
0.00000,1.00000,1, 100.0, 32.500, 0.000, 312,1.0000
909332,'4  ',  80.000,  8.000,  8.000,  -33.000,1.00000,  0,  87.600,  0.00000,  0.15400,  0.00000,
0.00000,1.00000,1, 100.0, 80.000, 0.000, 312,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
   662,  667,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   663,  668,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
```


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```
   664,  669,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   665,  670,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   666,  672,'1  ',  0.01070,  0.01170,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   666,  -681,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   667,  673,'1  ',  0.00670,  0.00730,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   668,  674,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   669,  675,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   670,  677,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   671,  -672,'1  ',  0.00210,  0.13130,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   671,  674,'1  ',  0.00210,  0.13130,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   671,  678,'1  ',  0.00190,  0.15750,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   671,  679,'1  ',  0.00190,  0.15750,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   672,  673,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   674,  676,'1  ',  0.00000,  0.21000,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   675,  676,'1  ',  0.00000,  0.21000,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   675,  677,'1  ',  0.00000,  0.00010,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 1,1.0000
   676,  909332,'1  ',  0.00000,  0.21000,  0.00000,  0.00,  0.00,  0.00,  0.00000,  0.00000,  0.00000,
0.00000,1, 0.00, 312,1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
   662,314859, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01590, 0.45300, 100.00
0.96213,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  662,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
   663,314860, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01620, 0.45600, 100.00
1.01331,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  663,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
   664,314860, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01570, 0.47600, 100.00
0.96213,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  664,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
   665,314860, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01570, 0.47200, 100.00
0.96213,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  665,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
   680,314859, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01640, 0.46500, 100.00
0.96844,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  680,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
   681,314859, 0,'1 ',1,1,1, 0.00000, 0.00000,2,'            ',1, 1,1.0000
   0.01630, 0.46400, 100.00
0.94319,  0.000,  0.000,  33.60,  33.60,  0.00,  1,  681,  1.10800,  0.90600,  1.00630,  0.99370,  33,  0,
0.00000,  0.00000
1.00000,  0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
Q
```


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C.2) Dynamic Data

```
/*****************************************************************
/* X2-060 Dynamic Data
/* Unit 4
/* Created 06-14-12
/* Power System Stabilizer UPSS2B values not provided, hence omitted
/*****************************************************************
909332 'GENROU' 4 9.3 0.05 2.8 0.05 1.8 0 2.18 2.0 0.215 0.26 0.154 0.2 0.07 0.4/
909332 'IEESGO' 4 0.12 0.37 0.29 0.04 0 0 25 0 0 0.9404 0/
909332 'USRMDL' 4 'UAC8B' 4 0 0 21 5 4 0 15 1.88 0 0.005 9999 -9999 9.15 0 20.32 -24.27 0.69 1.26
1.0 1.3 11.6 0 7.4 0.11 9.9 1.95/

/*****************************************************************
/* Dynamic Data for existing units at Westvaco
/* Unit 8G1 (ID=1), Unit 6G2(ID=2), Unit 12G3(ID=3)
/* Created 07-31-12
/* GOVERNOR models not provided, hence ignored.
/*****************************************************************

/* 8G1
678 'GENROU' 1 4.247 0.031 0.347 0.071 2.88 0 1.769 1.712 0.35 0.590 0.256 0.218 0.0394 0.0734/
678 'IEEET3' 1 0 120 0.15 1.2 -1.2 0.5 0.02 0.385 1.19 2.0 3.87 1.0/

/* 6G2
679 'GENROU' 2 3.855 0.033 0.325 0.075 1.80 0 1.758 1.686 0.326 0.575 0.228 0.188 0.1052 0.5777/
679 'IEEET3' 2 0 120 0.15 1.2 -1.2 0.5 0.02 0.4247 1.19 1.86 3.89 1.0/

/* 12G3
672 'GENSAL' 3 5.0868 0.0125 0.0311 1.492 0 0.9796 0.6811 0.4552 0.3086 0.2028 0.1887 0.3623/
672 'ESST4B' 3 0 20 20 2.63 -2.29 0.01 0 14.55 1.0 -0.87 1.0 4.32 2.90 9999 1.58 0 0/
```


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C.3) Single Line Diagram

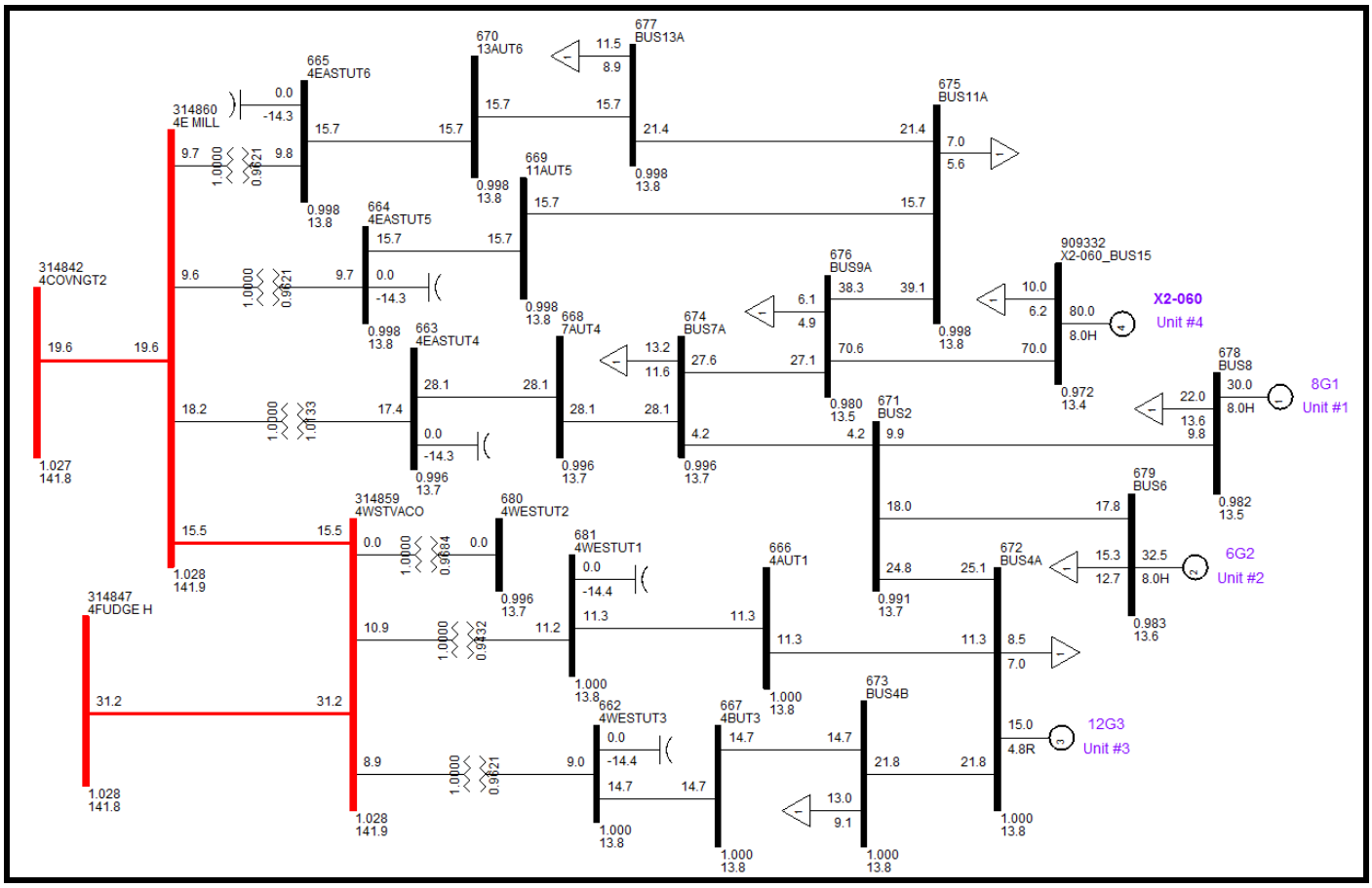


Figure C-1: Single-line diagram for X2-060 (LL case) (Breaker information not shown)

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Appendix D

Table D-1: Maximum Angle (absolute) Deviation
(Worst 6 channel deviations; Maximum angle limit set at 200)

Output File	Chan No.	Bus No.	Bus Name	ID	Type	Initial	Deviation	Time
01a	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	37.33	0.2834
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	28.2	0.6084
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	28.16	0.2792
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	-27.14	0.6751
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-25.57	0.7876
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-25.57	0.7876
01b	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	33	0.4292
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	26.4	0.9251
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-25.19	0.9626
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-25.19	0.9626
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-25.19	0.9626
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-25.19	0.9626
01c	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	29.99	0.4209
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	23.39	1.1376
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-22.52	1.1293
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-22.52	1.1293
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-22.52	1.1293
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-22.52	1.1293
01d	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	208.2	0.5667
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	181.2	0.55
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	180.4	0.5
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	157.5	0.6709
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	157.5	0.6709
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	157.5	0.6709
02a	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	37.73	0.2875
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	29.15	0.2834
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	28.96	0.2959
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	-28.05	0.6834
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-25.44	0.7959
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-25.44	0.7959
02b	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	41.47	0.5709
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	38.85	0.4792
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	38.11	0.5375
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	31.76	1.1001
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-24.94	0.9834
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-24.94	0.9834
02c	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	18.06	0.3667
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	15.51	1.1834
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-15.06	1.0001
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-15.06	1.0001
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-15.06	1.0001
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-15.06	1.0001
02d	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	211.3	0.4625
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	182.6	0.5
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	181.2	0.4459
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	158.3	0.6751
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	158.3	0.6751
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	158.3	0.6751
03a	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	37.14	0.2875
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	29.97	0.2834
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	29.29	0.2959
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	-28.03	0.6876
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-25.39	0.7917
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-25.39	0.7917
03b	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	39.5	0.5667
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	36.29	0.5334
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	35.94	0.4709
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	31.03	0.9334
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-24.85	0.9876
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-24.85	0.9876
03c	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	34.52	0.575
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	31.65	0.45
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	31.03	0.5209
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	26.96	1.0751
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-21.58	1.1418
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-21.58	1.1418
03d	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	208.1	0.4542
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	183.7	0.5
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	182.1	0.4459
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	156.7	0.7042
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	156.7	0.7042
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	156.7	0.7042
04a	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	35.3	0.2875
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	28.3	0.2875
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	27.65	0.2959

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Output File	Chan No.	Bus No.	Bus Name		ID	Type	Initial	Deviation	Time
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	-25.65	0.6876
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-24.39	0.7917
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-24.39	0.7917
04b	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	33.5	0.5459
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	31.23	0.4459
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	30.66	0.5167
	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	26.83	0.8209
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-24.15	0.9709
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-24.15	0.9709
04c	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	18.5	0.3667
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	16.38	0.4834
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	15.14	1.1043
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-14.6	0.9834
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-14.6	0.9834
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	-14.6	0.9834
04d	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	210.3	0.4792
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	183.5	0.5167
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	180	0.4625
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	158.9	0.7459
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	158.9	0.7459
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	158.9	0.7459
05a	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-51.45	0.1833
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-51.45	0.1833
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	-51.45	0.1833
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	-51.45	0.1833
	12	2919571[5]	U4026 WTG	0.6900	MACH '1 '	ANGL	-9.625	41.93	3.6086
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	33.47	0.275
05b1	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-51.45	0.1833
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-51.45	0.1833
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	-51.45	0.1833
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	-51.45	0.1833
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	-30.25	0.8751
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	29.36	0.4292
05b2	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-51.45	0.1833
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	-51.45	0.1833
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	-51.45	0.1833
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	-51.45	0.1833
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	-30.1	0.8792
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	29.36	0.4292
05d1	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	12	291957[5]	U4026 WTG	0.6900	MACH '1 '	ANGL	-9.625	187.4	1.1668
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	155.8	0.4209
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-51.45	0.1833
05d2	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	12	291957[5]	U4026 WTG	0.6900	MACH '1 '	ANGL	-9.625	187.4	1.1668
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	155.8	0.4209
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	-51.45	0.1833
06a	12	291957[5]	U4026 WTG	0.6900	MACH '1 '	ANGL	-9.625	41.92	1.0042
	242	909332	X2-060_BUS15	13.800	MACH '4 '	ANGL	54.04	39.5	0.3042
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	34	0.425
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	34	0.425
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	34	0.425
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	34	0.8792
06b1	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	60.46	0.6709
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	60.46	0.6709
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	60.46	0.6709
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	60.46	0.6709
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	50.75	0.6
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	47.61	0.5625
06b2	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	60.56	0.6709
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	60.56	0.6709
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	60.56	0.6709
	180	315188	1LOWMORC	13.200	MACH 'D '	ANGL	51.45	60.56	0.6709
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	50.62	0.9876
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	47.55	0.9626
06d1	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	157.9	0.5
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	157.9	0.5
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	157.9	0.5
06d2	2	672	BUS4A	13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	3	678	BUS8	13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6	13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	177	315186	1LOWMORA	13.200	MACH 'A '	ANGL	51.45	157.9	0.5
	178	315186	1LOWMORA	13.200	MACH 'B '	ANGL	51.45	157.9	0.5
	179	315188	1LOWMORC	13.200	MACH 'C '	ANGL	51.45	157.9	0.5

[5] wind turbine generator

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Output File	Chan No.	Bus No.	Bus Name	ID	Type	Initial	Deviation	Time
07a	12	291957[5]	U4026 WTG 0.6900	MACH '1 '	ANGL	-9.625	41.83	1.0042
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	37.85	0.2959
	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	30.95	0.3
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	30.75	0.4042
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	30.75	0.4042
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	30.75	0.4042
07b1	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	62.61	0.6626
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	62.61	0.6626
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	62.61	0.6626
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	62.61	0.6626
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	53.05	0.9626
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	50.04	0.9167
07b2	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	51.9	0.575
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-51.45	0.525
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-51.45	0.525
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-51.45	0.525
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-51.45	0.525
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	49.67	0.8709
07c	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-29.85	1.1876
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-29.85	1.1876
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-29.85	1.1876
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-29.85	1.1876
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	24.84	1.2043
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	23.29	0.4334
07d1	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	157.9	0.5
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	157.9	0.5
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	157.9	0.5
07d2	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	209.1	0.4625
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	180.7	0.5
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	180.5	0.45
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	157.9	0.5
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	157.9	0.5
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	157.9	0.5
08a	12	291957[5]	U4026 WTG 0.6900	MACH '1 '	ANGL	-9.625	32.53	1.0376
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	29	0.2917
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-25.36	0.8209
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-25.36	0.8209
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-25.36	0.8209
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-25.36	0.8209
08b	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	-28.45	1.0042
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	-28.45	1.0042
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	-28.45	1.0042
	180	315188	1LOWMORC 13.200	MACH 'D '	ANGL	51.45	-28.45	1.0042
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	23.53	0.5375
	242	909332	X2-060_BUS1513.800	MACH '4 '	ANGL	54.04	22.47	0.4292
08d	2	672	BUS4A 13.800	MACH '3 '	ANGL	2.288	208.2	0.5542
	3	678	BUS8 13.800	MACH '1 '	ANGL	29.32	180.6	0.5667
	4	679	BUS6 13.800	MACH '2 '	ANGL	29.86	180.6	0.5292
	177	315186	1LOWMORA 13.200	MACH 'A '	ANGL	51.45	159.9	0.5625
	178	315186	1LOWMORA 13.200	MACH 'B '	ANGL	51.45	159.9	0.5625
	179	315188	1LOWMORC 13.200	MACH 'C '	ANGL	51.45	159.9	0.5625
nf_20sec	113	315097	1CHESPK4 20.000	MACH '4 '	ANGL	31.1	0.00214	19.9181
	217	315294	1DOMTR10 13.800	MACH '10'	ANGL	53.82	0.00206	19.8681
	215	315292	1DOMTR78 13.800	MACH '8 '	ANGL	46.66	0.002033	20.0015
	214	315292	1DOMTR78 13.800	MACH '7 '	ANGL	47.6	0.002022	19.7806
	216	315293	1DOMTR9 13.800	MACH '9 '	ANGL	30.52	0.002016	19.8306
	102	315080	1HOPHCF4 13.800	MACH 'S '	ANGL	62.72	0.001995	19.7848

[5] wind turbine generator

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Appendix E

Table E-1: Bus Voltage Summary

Output file	Channel #	Bus Name	kV	Voltage at t=0 (pu)	Voltage at t=20 (pu)	Delta (pu)	% Voltage Change
nf_20sec	772	East Mill	138	1.028	1.028	0	0.00%
	771	Westvaco	138	1.0282	1.0282	0	0.00%
	769	Lowmoor	138	1.0258	1.0258	0	0.00%
	767	Lowmoor	230	0.9982	0.9982	0	0.00%
	753	Clifton Forge	230	0.99687	0.99687	0	0.00%
01a	772	East Mill	138	1.028	1.0266	0.0014	0.14%
	771	Westvaco	138	1.0282	1.029	-0.0008	-0.08%
	769	Lowmoor	138	1.0258	1.0257	1E-04	0.01%
	767	Lowmoor	230	0.9982	0.99816	4E-05	0.00%
	753	Clifton Forge	230	0.99687	0.99684	0.0000	0.00%
01b	772	East Mill	138	1.028	0	n/a	n/a
	771	Westvaco	138	1.0282	1.0312	-0.0030	-0.29%
	769	Lowmoor	138	1.0258	1.0268	-0.0010	-0.10%
	767	Lowmoor	230	0.9982	0.99877	-0.00057	-0.06%
	753	Clifton Forge	230	0.99687	0.99744	-0.0006	-0.06%
01c	772	East Mill	138	1.028	1.0266	0.0014	0.14%
	771	Westvaco	138	1.0282	1.029	-0.0008	-0.08%
	769	Lowmoor	138	1.0258	1.0258	0	0.00%
	767	Lowmoor	230	0.9982	0.99818	2E-05	0.00%
	753	Clifton Forge	230	0.99687	0.99686	0.0000	0.00%
01d	772	East Mill	138	1.028	0	n/a	n/a
	771	Westvaco	138	1.0282	0.97228	0.05592	5.44%
	769	Lowmoor	138	1.0258	0.99708	0.02872	2.80%
	767	Lowmoor	230	0.9982	0.97802	0.02018	2.02%
	753	Clifton Forge	230	0.99687	0.97943	0.0174	1.75%
02a	772	East Mill	138	1.028	1.0272	0.0008	0.08%
	771	Westvaco	138	1.0282	1.0272	0.0010	0.10%
	769	Lowmoor	138	1.0258	1.0234	0.0024	0.23%
	767	Lowmoor	230	0.9982	0.99677	0.0014	0.14%
	753	Clifton Forge	230	0.99687	0.99549	0.0014	0.14%
02b	772	East Mill	138	1.028	0	n/a	n/a
	771	Westvaco	138	1.0282	1.0294	-0.0012	-0.12%
	769	Lowmoor	138	1.0258	1.0247	0.0011	0.11%
	767	Lowmoor	230	0.9982	0.99758	0.0006	0.06%
	753	Clifton Forge	230	0.99687	0.99628	0.0006	0.06%
02c	772	East Mill	138	1.028	1.0272	0.0008	0.08%
	771	Westvaco	138	1.0282	1.0273	0.0009	0.09%
	769	Lowmoor	138	1.0258	1.0234	0.0024	0.23%
	767	Lowmoor	230	0.9982	0.99678	0.0014	0.14%
	753	Clifton Forge	230	0.99687	0.9955	0.0014	0.14%
02d	772	East Mill	138	1.028	0	n/a	n/a
	771	Westvaco	138	1.0282	0.96958	0.0586	5.70%
	769	Lowmoor	138	1.0258	0.99441	0.0314	3.06%
	767	Lowmoor	230	0.9982	0.97645	0.0217	2.18%
	753	Clifton Forge	230	0.99687	0.97791	0.0190	1.90%
03a	772	East Mill	138	1.028	1.0296	-0.0016	-0.16%
	771	Westvaco	138	1.0282	1.03	-0.0018	-0.18%
	769	Lowmoor	138	1.0258	1.0247	0.0011	0.11%
	767	Lowmoor	230	0.9982	0.99757	0.00063	0.06%
	753	Clifton Forge	230	0.99687	0.99627	0.0006	0.06%
03b	772	East Mill	138	1.028	1.022	0.006	0.58%
	771	Westvaco	138	1.0282	0	n/a	n/a
	769	Lowmoor	138	1.0258	1.0203	0.0055	0.54%
	767	Lowmoor	230	0.9982	0.99496	0.00324	0.32%
	753	Clifton Forge	230	0.99687	0.99375	0.0031	0.31%
03c	772	East Mill	138	1.028	1.0296	-0.0016	-0.16%
	771	Westvaco	138	1.0282	1.03	-0.0018	-0.18%
	769	Lowmoor	138	1.0258	1.0248	0.001	0.10%
	767	Lowmoor	230	0.9982	0.99759	0.00061	0.06%
	753	Clifton Forge	230	0.99687	0.99629	0.0006	0.06%
03d	772	East Mill	138	1.028	0.98168	0.04632	4.51%
	771	Westvaco	138	1.0282	0	n/a	n/a
	769	Lowmoor	138	1.0258	1.003	0.0228	2.22%
	767	Lowmoor	230	0.9982	0.98131	0.01689	1.69%
	753	Clifton Forge	230	0.99687	0.98268	0.0142	1.42%
04a	772	East Mill	138	1.028	1.0298	-0.0018	-0.18%
	771	Westvaco	138	1.0282	1.0302	-0.002	-0.19%
	769	Lowmoor	138	1.0258	1.025	0.0008	0.08%
	767	Lowmoor	230	0.9982	0.99785	0.00035	0.04%
	753	Clifton Forge	230	0.99687	0.99638	0.0005	0.05%
04b	772	East Mill	138	1.028	1.0298	-0.0018	-0.18%
	771	Westvaco	138	1.0282	1.0302	-0.002	-0.19%
	769	Lowmoor	138	1.0258	1.025	0.0008	0.08%
	767	Lowmoor	230	0.9982	0.99784	0.00036	0.04%
	753	Clifton Forge	230	0.99687	0.99636	0.0005	0.05%

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Output file	Channel #	Bus Name	kV	Voltage at t=0 (pu)	Voltage at t=20 (pu)	Delta (pu)	% Voltage Change
04c	772	East Mill	138	1.028	1.0299	-0.0019	-0.18%
	771	Westvaco	138	1.0282	1.0303	-0.0021	-0.20%
	769	Lowmoor	138	1.0258	1.0251	0.0007	0.07%
	767	Lowmoor	230	0.9982	0.99786	0.00034	0.03%
	753	Clifton Forge	230	0.99687	0.99639	0.0005	0.05%
04d	772	East Mill	138	1.028	0.99754	0.03046	2.96%
	771	Westvaco	138	1.0282	0.99708	0.03112	3.03%
	769	Lowmoor	138	1.0258	1.0133	0.0125	1.22%
	767	Lowmoor	230	0.9982	0.98763	0.01057	1.06%
	753	Clifton Forge	230	0.99687	0.98869	0.0082	0.82%
05a	772	East Mill	138	1.028	1.0348	-0.0068	-0.66%
	771	Westvaco	138	1.0282	1.0349	-0.0067	-0.65%
	769	Lowmoor	138	1.0258	1.0334	-0.0076	-0.74%
	767	Lowmoor	230	0.9982	1.002	-0.0038	-0.38%
	753	Clifton Forge	230	0.99687	1.0013	-0.0044	-0.44%
05b1	772	East Mill	138	1.028	1.0362	-0.0082	-0.80%
	771	Westvaco	138	1.0282	1.0365	-0.0083	-0.81%
	769	Lowmoor	138	1.0258	1.0332	-0.0074	-0.72%
	767	Lowmoor	230	0.9982	1.002	-0.0038	-0.38%
	753	Clifton Forge	230	0.99687	1.0012	-0.0043	-0.43%
05b2	772	East Mill	138	1.028	1.0368	-0.0088	-0.86%
	771	Westvaco	138	1.0282	1.037	-0.0088	-0.86%
	769	Lowmoor	138	1.0258	1.0357	-0.0099	-0.97%
	767	Lowmoor	230	0.9982	1.0036	-0.0054	-0.54%
	753	Clifton Forge	230	0.99687	0.99735	-0.0005	-0.05%
05d1	772	East Mill	138	1.028	0.99767	0.03033	2.95%
	771	Westvaco	138	1.0282	0.9972	0.031	3.01%
	769	Lowmoor	138	1.0258	1.0134	0.0124	1.21%
	767	Lowmoor	230	0.9982	0.98767	0.01053	1.05%
	753	Clifton Forge	230	0.99687	0.98873	0.0081	0.82%
05d2	772	East Mill	138	1.028	0.99547	0.03253	3.16%
	771	Westvaco	138	1.0282	0.99561	0.03259	3.17%
	769	Lowmoor	138	1.0258	1.0037	0.0221	2.15%
	767	Lowmoor	230	0.9982	0.98109	0.01711	1.71%
	753	Clifton Forge	230	0.99687	0.99327	0.0036	0.36%
06a	772	East Mill	138	1.028	1.0218	0.0062	0.60%
	771	Westvaco	138	1.0282	1.0219	0.0063	0.61%
	769	Lowmoor	138	1.0258	1.0188	0.007	0.68%
	767	Lowmoor	230	0.9982	0	n/a	n/a
	753	Clifton Forge	230	0.99687	0.99324	0.0036	0.36%
06b1	772	East Mill	138	1.028	1.0233	0.0047	0.46%
	771	Westvaco	138	1.0282	1.0238	0.0044	0.43%
	769	Lowmoor	138	1.0258	1.0167	0.0091	0.89%
	767	Lowmoor	230	0.9982	0	n/a	n/a
	753	Clifton Forge	230	0.99687	0.99186	0.0050	0.50%
06b2	772	East Mill	138	1.028	1.0203	0.0077	0.75%
	771	Westvaco	138	1.0282	1.0203	0.0079	0.77%
	769	Lowmoor	138	1.0258	1.0148	0.0110	1.07%
	767	Lowmoor	230	0.9982	0	n/a	n/a
	753	Clifton Forge	230	0.99687	0.99118	0.0057	0.57%
06d1	772	East Mill	138	1.028	0.96632	0.0617	6.00%
	771	Westvaco	138	1.0282	0.96585	0.0624	6.06%
	769	Lowmoor	138	1.0258	0.98215	0.0437	4.26%
	767	Lowmoor	230	0.9982	0	n/a	n/a
	753	Clifton Forge	230	0.99687	0.97028	0.0266	2.67%
06d2	772	East Mill	138	1.028	0.95327	0.0747	7.27%
	771	Westvaco	138	1.0282	0.95423	0.0740	7.19%
	769	Lowmoor	138	1.0258	0.9717	0.0541	5.27%
	767	Lowmoor	230	0.9982	0	n/a	n/a
	753	Clifton Forge	230	0.99687	0.96411	0.0328	3.29%
07a	772	East Mill	138	1.028	1.027	0.0010	0.10%
	771	Westvaco	138	1.0282	1.0271	0.0011	0.11%
	769	Lowmoor	138	1.0258	1.0246	0.0012	0.12%
	767	Lowmoor	230	0.9982	0.99818	0.0000	0.00%
	753	Clifton Forge	230	0.99687	0.99475	0.0021	0.21%
07b1	772	East Mill	138	1.028	1.0255	0.0025	0.24%
	771	Westvaco	138	1.0282	1.0255	0.0027	0.26%
	769	Lowmoor	138	1.0258	1.0212	0.0046	0.45%
	767	Lowmoor	230	0.9982	0.99631	0.0019	0.19%
	753	Clifton Forge	230	0.99687	0.99425	0.0026	0.26%
07b2	772	East Mill	138	1.028	1.0368	-0.0088	-0.86%
	771	Westvaco	138	1.0282	1.037	-0.0088	-0.86%
	769	Lowmoor	138	1.0258	1.0357	-0.0099	-0.97%
	767	Lowmoor	230	0.9982	1.0036	-0.0054	-0.54%
	753	Clifton Forge	230	0.99687	0.99735	-0.0005	-0.05%
07c	772	East Mill	138	1.028	1.0269	0.0011	0.11%
	771	Westvaco	138	1.0282	1.027	0.0012	0.12%
	769	Lowmoor	138	1.0258	1.0245	0.0013	0.13%
	767	Lowmoor	230	0.9982	0.99812	0.0001	0.01%
	753	Clifton Forge	230	0.99687	0.99472	0.0021	0.22%
07d1	772	East Mill	138	1.028	0.97937	0.0486	4.73%
	771	Westvaco	138	1.0282	0.98033	0.0479	4.66%
	769	Lowmoor	138	1.0258	0.99775	0.0281	2.73%
	767	Lowmoor	230	0.9982	0.97784	0.0204	2.04%

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Output file	Channel #	Bus Name	kV	Voltage at t=0 (pu)	Voltage at t=20 (pu)	Delta (pu)	% Voltage Change
	753	Clifton Forge	230	0.99687	0.99244	0.0044	0.44%
07d2	772	East Mill	138	1.028	0.99546	0.0325	3.17%
	771	Westvaco	138	1.0282	0.9956	0.0326	3.17%
	769	Lowmoor	138	1.0258	1.0037	0.0221	2.15%
	767	Lowmoor	230	0.9982	0.98109	0.0171	1.71%
	753	Clifton Forge	230	0.99687	0.99326	0.0036	0.36%
08a	772	East Mill	138	1.028	1.024	0.0040	0.39%
	771	Westvaco	138	1.0282	1.0241	0.0041	0.40%
	769	Lowmoor	138	1.0258	1.0212	0.0046	0.45%
	767	Lowmoor	230	0.9982	0.99616	0.0020	0.20%
	753	Clifton Forge	230	0.99687	0	n/a	n/a
08b	772	East Mill	138	1.028	1.0267	0.0013	0.13%
	771	Westvaco	138	1.0282	1.0269	0.0013	0.13%
	769	Lowmoor	138	1.0258	1.0243	0.0015	0.15%
	767	Lowmoor	230	0.9982	0.99792	0.0003	0.03%
	753	Clifton Forge	230	0.99687	0	n/a	n/a
08d	772	East Mill	138	1.028	0.99524	0.0328	3.19%
	771	Westvaco	138	1.0282	0.99538	0.0328	3.19%
	769	Lowmoor	138	1.0258	1.0035	0.0223	2.17%
	767	Lowmoor	230	0.9982	0.98088	0.0173	1.74%
	753	Clifton Forge	230	0.99687	0	n/a	n/a

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