Generation Interconnection

System Impact Study Report

For

Queue Request

AC2-184

“Cedar Creek 138 kV I”

June 2020

Contents

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer 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 system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The Interconnection Customer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

General

Freepoint Solar LLC, the Interconnection Customer (IC), has proposed AC2-184, a 20 MW MFO (7.6 MW Capacity) facility to be located near Smyrna, Kent County, Delaware. PJM studied the project in the Delmarva Power and Light Company (DPL) system at the Cedar 138 kV Substation and evaluated it for compliance with reliability criteria for summer peak conditions in 2020. The AC2-184 project will utilize the same Point of Interconnection as the Interconnection Customer's prior queue position AC1-091. The planned in-service date, as requested by the IC during the project kick-off call, was December 2018. This date is not attainable due to additional PJM studies and the Transmission Owner's construction schedule.

Point of Interconnection

The Interconnection Customer requested that queue projects AC2-184 utilize the same Point of Interconnection as their prior queue positions AC1-091, 092, 093, and 094 a new terminal position at the Delmarva Power and Light Cedar Creek 138 kV Substation (see Attachment 1).

Transmission Owner Scope of Work

No additional Transmission Owner work is required for AC2-184 over what has been previously identified for the AC1-091 thru 094 projects.

Required Relaying and Communications

Relaying and communications costs are the same as those included in the reports for AC1-091 thru 094.

Metering

Three phase 138 kV revenue metering points will need to be established. DPL will purchase and install all metering instrument transformers as well as construct a metering structure. The secondary wiring connections at the instrument transformers will be completed by DPL's metering technicians. The metering control cable and meter cabinets will be supplied and installed by DPL. DPL will install conduit for the control cable between the instrument transformers and the metering enclosure. The location of the metering enclosure will be determined in the construction phase. DPL will provide both the Primary and the Backup meters. DPL's meter technicians will program and install the Primary & Backup solid state multi-function meters for each new metering position. Each meter will be equipped with load profile, telemetry, and DNP outputs. The IC will be provided with one meter DNP output for each meter. DPL will own the metering equipment for the interconnection point, unless the IC asserts its right to install, own, and operate the metering system.

The Interconnection Customer will be required to make provisions for a voice quality phone line within approximately 3 feet of each Company metering position to facilitate remote interrogation and data collection.

It is the IC's responsibility to send the data that PJM and DPL requires directly to PJM. The IC will grant permission for PJM to send DPL the following telemetry that the IC sends to PJM: real time MW, MVAR, volts, amperes, generator status, and interval MWH and MVARH.
The estimate for DPL to design, purchase, and install metering as specified in the aforementioned scope for metering is included in the Substation Interconnection Estimate.

Interconnection Customer Scope of Work

The Interconnection Customer is responsible for all design and construction related to activities on their side of the Point of Interconnection. Site preparation, including grading and an access road, as necessary, is assumed to be by the IC. Route selection, line design, and right-of-way acquisition of the direct connect facilities is not included in this report, and is the responsibility of the IC. Protective relaying and metering design and installation must comply with DPL's applicable standards. The IC is also required to provide revenue metering and real-time telemetering data to PJM in conformance with the requirements contained in PJM Manuals M-01 and M-14 and the PJM Tariff.

DPL Interconnection Customer Scope of Direct Connection Work Requirements:

- DPL requires that an IC circuit breaker is located within 500 feet of the DPL substation to facilitate the relay protection scheme between DPL and the IC at the Point of Interconnection (POI).

Special Operating Requirements

1. DPL will require the capability to remotely disconnect the generator from the grid by communication from its System Operations facility. Such disconnection may be facilitated by a generator breaker, or other method depending upon the specific circumstances and the evaluation by DPL.

2. DPL reserves the right to charge the Interconnection Customer operation and maintenance expenses to maintain the Interconnection Customer attachment facilities, including metering and telecommunications facilities, owned by DPL.

Network Impacts

The Queue Project AC2-184 was evaluated as a 20.0 MW (Capacity 20.0 MW) injection at the Cedar Creek 138 kV substation in the DPL area. Project AC2-184 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC2-184 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

Generator Deliverability

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

None

Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None

Short Circuit

(Summary of impacted circuit breakers)

None

Stability and Reactive Power Requirement

(Results of the dynamic studies should be inserted here)

No issues identified. See Attachment 2 for full report.

Light Load Analysis - 2020

Light Load Studies to be conducted during the System Impact Study phase (as required by PJM Manual 14B).

Not required

Affected System Analysis & Mitigation

Not required

Delivery of Energy Portion of Interconnection Request

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

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 will study all overload conditions associated with the overloaded element(s) identified.

None

Summer Peak Load Flow Analysis Reinforcements

None

Light Load Load Flow Analysis Reinforcements

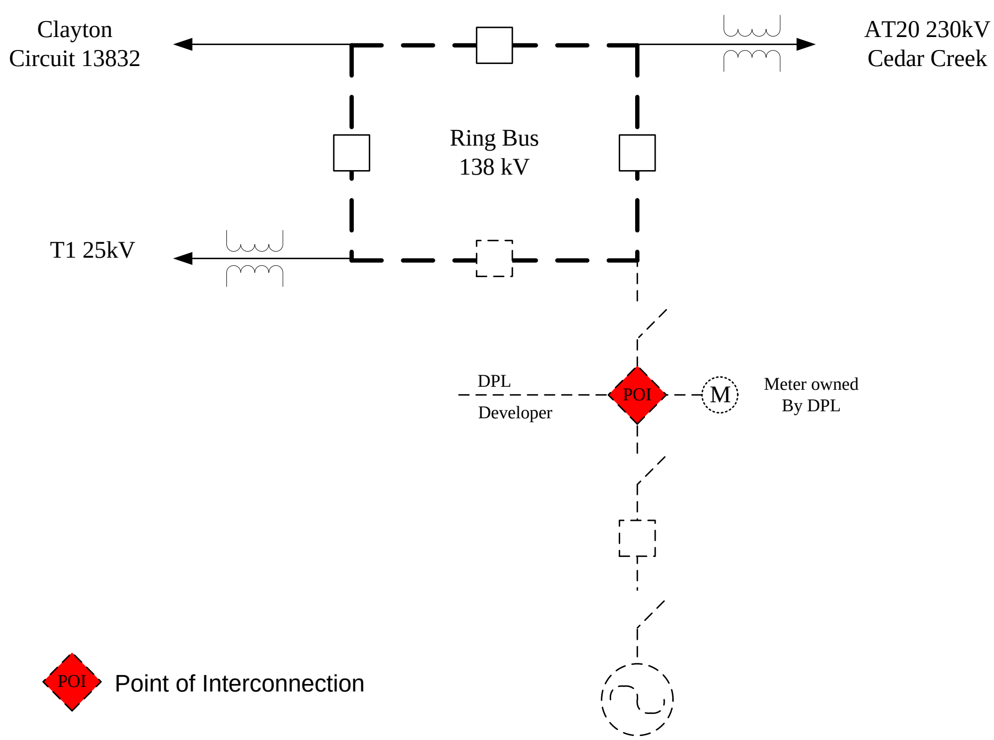
None

Delmarva Power and Light Costs

Cost estimates will further be refined as a part of the Facilities Study for this project. The Interconnection Customer will be responsible for all costs incurred by DPL in connection with the AC2-184 project. Such costs may include, but are not limited to, any transmission system assets currently in DPL's rate base that are prematurely retired due to the AC2-184 project. PJM shall work with DPL to identify these retirement costs and any additional expenses. DPL reserves the right to reassess issues presented in this document and, upon appropriate justification, submit additional costs related to the AC2-184 project.

Attachment 1 – Single Line Diagram

AC2-185 & AC2-184 Cedar Creek 138 kV



AC2-185 & AC2-184
AC1-091 thru AC1-094

If location of generator is greater than 500 feet from substation, additional developer circuit breaker will be required.

Attachment 2 – Dynamic Simulation Analysis

AC2-184/185

System Impact Study

Dynamic Simulation Analysis

Version 0

Executive Summary

Generator Interconnection Requests AC2-184/185 are for a combined 40 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) at the existing Cedar Creek 138 kV Substation in the Delmarva Power and Light transmission system, New Castle County, Delaware.

This report describes a dynamic simulation analysis of AC2-184/185 as part of the overall system impact study.

The load flow scenario for the analysis was based on the RTEP 2020 Summer Peak case, modified to include applicable queue projects. AC2-184/185 has been dispatched online at maximum power output, with POI voltage of (1.01 p.u.), consistent with the default generator reference voltage specified in PJM Manual 03 Transmission Operations Section 3.3.3 for generator connections to the PJM 138 kV system.

The AC2-184/185 queue project was tested for compliance with NERC, PJM and other applicable criteria. The range of contingencies evaluated was limited to that necessary to assess compliance and each was limited to a 20-second simulation time period.

Simulated NERC Standard TPL-001 faults include:

1. Three-phase (3ph) fault with normal clearing (Category P1)
2. Operating of a line section w/o a fault, Single-line-to-ground (slg) on Bus Section and Breaker. (Category P2)
3. Single-line-to-ground (slg) with delayed clearing as a result of breaker failure (Category P4)
4. Single-line-to-ground (slg) with delayed clearing as a result of protection failure (Category P5)
5. Single-line-to-ground (slg) with normal clearing for common structure (Category P7)

Note: For generator interconnection studies, Category P3 and P6 faults will be studied on an as needed basis. In this study, P2 contingencies are covered by P1 and P4 contingencies.

The system was tested for a system intact condition and the fault types listed above. Specific fault descriptions and breaker clearing times used for this study are provided in the result table.

No relevant High Speed Reclosing (HSR) contingencies were identified.

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

For the remaining fault contingencies tested on the 2020 Summer Peak case:

a) Post-contingency oscillations were positively damped with a damping margin of at least 3%.
b) The AC2-184/185 generator was able to ride through all faults (except for faults where protective action trips a generator(s)).
c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

No mitigations were found to be required.

1. Introduction

Generator Interconnection Requests AC2-184/185 are for a combined 40 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) at the existing Cedar Creek 138 kV Substation in the Delmarva Power and Light transmission system, New Castle County, Delaware.

This analysis is effectively a screening study to determine whether the addition of AC2-184/185 will meet the dynamic requirements of the NERC, PJM and Transmission Owner reliability standards.

In this report the AC2-184/185 project and how it is proposed to be connected to the grid are first described, followed by a description of how the project is modeled in this study. The fault cases are then described and analyzed, and lastly a discussion of the results is provided.

2. Description of Project

Generator Interconnection Requests AC2-184/185 are for a combined 40 MW Maximum Facility Output (MFO) solar powered generating facility with a Point of Interconnection (POI) at the existing Cedar Creek 138 kV Substation in the Delmarva Power and Light transmission system, New Castle County, Delaware.

Figure 1 shows the simplified one-line diagram of the AC2-184/185 load flow models. Table 1 through to Table 5 list the parameters given in the impact study data and the corresponding parameters of the AC2-184/185 load flow models.

The dynamic models for the AC2-184/185 plant are based on the SMASC_C131_33_IVF111 PSS/E version 33 user defined model supplied by the Developer in the attachments to the System Impact Study (SIS) Data Sheets.

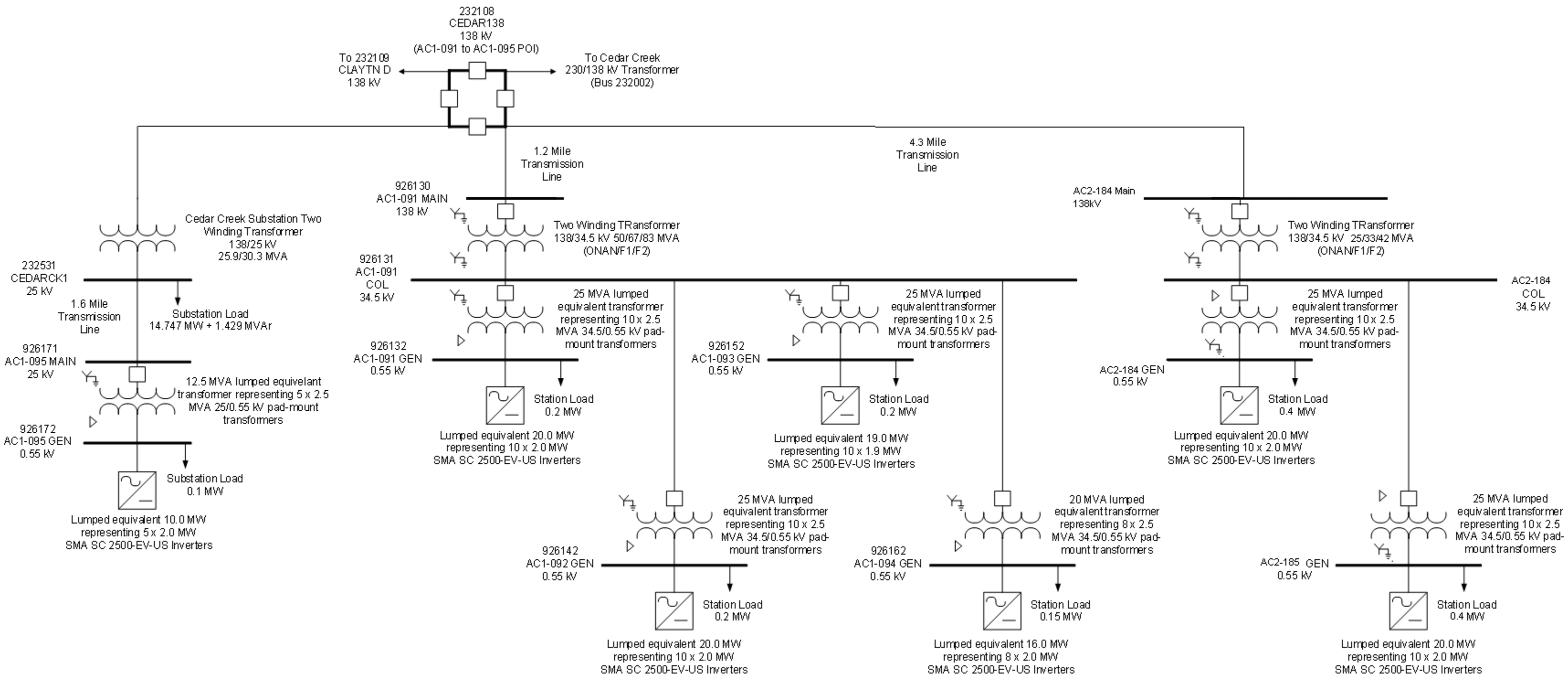


Figure 1: AC2-184/185 Plant Model

Table 1: AC2-184 Plant Model

	Impact Study Data	**Model**
Inverters	10 × 2.0 MW SC 2500-EV-US PV Inverters MVA base = 2.5 MVA Terminal voltage = 0.55 kV	Lumped equivalent representing 10 × 2.0 MW SC 2500-EV-US Inverters Pgen 20.0 MW Pmax 20.0 MW Pmin 0 MW Qmax 6.6 MVAr Qmin -6.6 MVAr Mbase 25.0 MVA Zsorce 0.0 + j10000 pu @Mbase
GSU transformer	10 x 34.5/0.55 kV two winding transformers Transformer MVA base = 2.5 MVA Rating = 2.5 MVA Impedance = 0.007 + j0.057 pu @ MVA base Number of taps = N/A Tap step size = N/A	Lumped equivalent representing 10 x 34.5/0.55 kV two winding transformers Transformer MVA base = 25.0 MVA Rating = 25.0 MVA Impedance = 0.007 + j0.057 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Collector step-up transformer (Share with AC2-185)	138/34.5 kV two winding transformer Rating = 25/33/42 MVA (OA/F1/F2) Transformer MVA base = 25 MVA Impedance = 0.0030 + j0.0899 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %	138/34.5 kV two winding transformer Rating = 25/33/42 MVA (OA/F1/F2) Transformer MVA base = 25 MVA Impedance = 0.0030 + j0.0899 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Auxiliary load	N/A	Not modeled
Station load	0.4 MW + 0.013 MVAr	0.4 MW + 0.013 MVAr modeled at the inverter bus
Collector System Equivalent(Share with AC2-185)	Impedance = 0.00502 + j0.00405 Suseptance = 0.00365	Impedance = 0.00502 + j0.00405 Suseptance = 0.00365
Transmission line	Length = 4.3 miles Impedance = 0.0021 + j0.0161 Suseptance = 0.00011	Length = 4.3 miles Impedance = 0.0021 + j0.0161 Suseptance = 0.00011

Table 2: AC2-185 Plant Model

	Impact Study Data	Model
Inverters	10 × 2.0 MW SC 2500-EV-US PV Inverters MVA base = 2.5 MVA Terminal voltage = 0.55 kV	Lumped equivalent representing 10 × 2.0 MW SC 2500-EV-US Inverters Pgen 20.0 MW Pmax 20.0 MW Pmin 0 MW Qmax 6.6 MVAr Qmin -6.6 MVAr Mbase 25.0 MVA Zsorce 0.0 + j10000 pu @Mbase
GSU transformer	10 x 34.5/0.55 kV two winding transformers Transformer MVA base = 2.5 MVA Rating = 2.5 MVA Impedance = 0.007 + j0.057 pu @ MVA base Number of taps = N/A Tap step size = N/A	Lumped equivalent representing 10 x 34.5/0.55 kV two winding transformers Transformer MVA base = 25.0 MVA Rating = 25.0 MVA Impedance = 0.007 + j0.057 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Collector step-up transformer (Share with AC2-184)	138/34.5 kV two winding transformer Rating = 25/33/42 MVA (OA/F1/F2) Transformer MVA base = 25 MVA Impedance = 0.0030 + j0.0899 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %	138/34.5 kV two winding transformer Rating = 25/33/42 MVA (OA/F1/F2) Transformer MVA base = 25 MVA Impedance = 0.0030 + j0.0899 pu @ MVA base Number of taps = 5 Tap step size = 2.5 %
Auxiliary load	N/A	Not modeled
Station load	0.4 MW + 0.013 MVAr	0.4 MW + 0.013 MVAr modeled at the inverter bus
Collector System Equivalent(Share with AC2-184)	Impedance = 0.00502 + j0.00405 Suseptance = 0.00365	Impedance = 0.00502 + j0.00405 Suseptance = 0.00365
Transmission line	Length = 4.3 miles Impedance = 0.0021 + j0.0161 Suseptance = 0.00011	Length = 4.3 miles Impedance = 0.0021 + j0.0161 Suseptance = 0.00011

3. Loadflow and Dynamics Case Setup

The dynamics simulation analysis was carried out using PSS/E Version 33.7.

The load flow scenario and fault cases for this study are based on PJM's Regional Transmission Planning Process[1].

The selected load flow scenario is the RTEP 2020 Summer Peak case with the following modifications:

a) Addition of all applicable queue projects prior to AC2-184/185.

b) Addition of AC2-184/185 queue project.

c) Removal of withdrawn and subsequent queue projects in the vicinity of AC2-184/185.

d) Dispatch of units in the PJM system to maintain slack generators within limits.

The AC2-184/185 initial conditions are listed in **Table 3**, indicating maximum power output, with AC2-184/185 regulating POI voltage of (1.01 p.u.), consistent with the default generator reference voltage specified in PJM Manual 03 Transmission Operations Section 3.3.3 for generator connections to the PJM 138 kV system.

Table 3: AC2-184/185 machine initial conditions

Bus	Name	Unit	PGEN (MW)	QGEN (MVAR)	ETERM (p.u.)	POI Voltage (p.u.)
932634	AC2-184 GEN 0.5500	1	20	0.7	0.99	1.01
932635	AC2-185 GEN 0.5500	1	20	0.7	0.99	1.01

Generation within the vicinity of AC2-184/185 has been dispatched online at maximum output (PMAX). The dispatch of generation in the vicinity of AC2-184/185 is given in Attachment 3.

[1] Manual 14B: PJM Region Transmission Planning Process, Rev 33, May 5 2016, Attachment G : PJM Stability, Short Circuit, and Special RTEP Practices and Procedures.

4. Fault Cases

Tables 3 listed the contingencies and results that were studied, with representative worst case total clearing times provided by PJM. Each contingency was studied over a 20 second simulation time interval.

Simulated NERC Standard TPL-001 faults include:

1. Three-phase (3ph) fault with normal clearing (Category P1)
2. Operating of a line section w/o a fault, Single-line-to-ground (slg) on Bus Section and Breaker. (Category P2)
3. Single-line-to-ground (slg) with delayed clearing as a result of breaker failure (Category P4)
4. Single-line-to-ground (slg) with delayed clearing as a result of protection failure (Category P5)
5. Single-line-to-ground (slg) with normal clearing for common structure (Category P7)

Note: For generator interconnection studies, Category P3 and P6 faults will be studied on an as needed basis. In this study, P2 contingencies are covered by P1 and P4 contingencies.

The system was tested for a system intact condition and the fault types listed above. No relevant High Speed Reclosing (HSR) contingencies were studied.

5. Evaluation Criteria

This study is focused on AC2-184/185, along with the rest of the PJM system, maintaining synchronism and having all states return to an acceptable new condition following the disturbance. The recovery criteria applicable to this study are as per PJM's Regional Transmission Planning Process and Transmission Owner criteria:

a) The system with AC2-184/185 included is transiently stable and post-contingency oscillations should be positively damped with a damping margin of at least 3%.

b) The AC2-184/185 is able to ride through faults (except for faults where protective action trips AC2-184/185).

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

6. Summary of Results

Plots from the dynamic simulations are provided in Attachment 4, with results summarized in Table 3.

The frequency protection was disabled due to the PSSE deficiency in calculating frequencies for 3ph fault at POIs.

For the fault contingencies tested in this study:

a) Post-contingency oscillations were positively damped with a damping margin of at least 3%.

b) The AC2-184/185 generator was able to withstand all contingencies.

c) Following fault clearing, all bus voltages recover to a minimum of 0.7 per unit after 2.5 seconds (except where protective action isolates that bus).

d) No transmission element trips, other than those either directly connected or designed to trip as a consequence of that fault.

7. Mitigations

No Mitigations were found to be required.

Table 4: Fault list

P0: Steady State

Fault ID	Duration
P0.00	Steady State 20 sec run

P1: Three Phase Faults with normal clearing

Fault ID	Fault description	Clearing Time Normal (Cycles)	Results
P1.00	3ph @ AC1-091 Main – Cedar Creek 138kV line, normal clear loss of AC1-091/092/093/094, AC2-184/185	9	Stable
P1.01	3ph @ Cedar Creek 138/25kV TF, normal clear loss of AC1-095	9	Stable
P1.02	3ph @ Cedar Creek 138/230kV TF	9	Stable
P1.03	3ph @ Cedar Creek – Clayton 138kV line	9	Stable
P1.04	3ph @ Cedar Creek – Red Lion 230kV line	7	Stable
P1.05	3ph @ Cedar Creek – Cedar Creek Reactor 230kV line, normal clear Reactors	7	Stable
P1.06	3ph @ Cedar Creek – Milford 230kV line	7	Stable
P1.07	3ph @ Clayton – Demecsmy 138kV line, normal clear loss of SMYRNA unit 1 and 2	9	Stable
P1.08	3ph @ Clayton – Jones – Cheswold 138kV line	9	Stable
P1.09	3ph @ Cheswold – Felton 138kV line	9	Stable
P1.10	3ph @ Cheswold 138/69kV TF	9	Stable
P1.11	3ph @ Cheswold 138kV capbanks, normal clear loss of all Cheswold 138kV capbanks	9	Stable

P4: SLG Stuck Breaker (SB) Faults at Backup Clearing

Fault ID	Fault description	Clearing Time Normal/Delayed (Cycles)	Results
P4.01	SLG @ Cedar Creek 138/25kV TF, normal clear loss of AC1-095. SB @ Cedar Creek 138kV, delayed clear loss of AC1-091 Main – Cedar Creek 138kV line, loss of AC1-091/092/093/094, AC2-184/185.	9/21	Stable
P4.02	SLG @ Cedar Creek 138/25kV TF, normal clear loss of AC1-095. SB @ Cedar Creek 138kV, delayed clear loss of Cedar Creek – Clayton 138kV line.	9/21	Stable
P4.03	SLG @ Cedar Creek – AC1-091 Main 138kV line, normal clear loss of AC1-091/092/093/094, AC2-184/185. SB @ Cedar Creek 138kV, delayed clear loss of Cedar Creek 138/230kV TF	9/21	Stable
P4.04	SLG @ Cedar Creek 138/230kV TF, SB @ Cedar Creek 138kV, delayed clear loss of Cedar Creek – Clayton 138kV line, loss of AC1-091 to AC1-095	9/21	Stable
P4.05	SLG @ Cedar Creek 230/138kV TF, SB @ Cedar Creek 230kV, delayed clear loss of Cedar Creek – Cedar Creek Reactor 230kV line, loss of Cedar Creek 230kV reactors	9/17.5	Stable
P4.06	SLG @ Cedar Creek 230/138kV TF, SB @ Cedar Creek 230kV, delayed clear loss of Cedar Creek – Milford 230kV line	9/17.5	Stable
P4.07	SLG @ Cedar Creek – Red Lion 230kV line, SB @ Cedar Creek 230kV, delayed clear loss of Creek – Milford 230kV line	7/17.5	Stable
P4.08	SLG @ Cedar Creek – Red Lion 230kV line, SB @ Cedar Creek 230kV, delayed clear loss of Cedar Creek – Cedar Creek Reactor 230kV line, loss of Cedar Creek 230kV reactors	7/17.5	Stable
P4.09	SLG @ Clayton 138/25kV TF1, SB @ Clayton 138kV, delayed clear loss of Clayton – Cedar Creek 138kV line	9/21	Stable
P4.10	SLG @ Clayton 138/25kV TF1, SB @ Clayton 138kV, delayed clear loss of Clayton – Jones – Cheswold 138kV line	9/21	Stable
P4.11	SLG @ Clayton 138/25kV TF2, SB @ Clayton 138kV, delayed clear loss of Clayton – Jones – Cheswold 138kV line	9/21	Stable
P4.12	SLG @ Clayton 138/25kV TF2, SB @ Clayton 138kV, delayed clear loss of Clayton – Demecsmy 138kV line, loss of SMYRNA unit 1 and 2	9/21	Stable

Fault ID	Fault description	Clearing Time Normal/Delayed (Cycles)	Results
P4.13	SLG @ Clayton – Cedar Creek 138kV line, SB @ Clayton 138kV, delayed clear loss of Clayton – Demecsmy 138kV line, loss of SMYRNA unit 1 and 2	9/21	Stable
P4.14	SLG @ Cheswold 138/25 TF3, SB @ Cheswold 138kV, delayed clear loss of Cheswold – Felton 138kV line	9/21	Stable
P4.15	SLG @ Cheswold 138/25 TF3, SB @ Cheswold 138kV, delayed clear loss of Clayton – Jones – Cheswold 138kV line	9/21	Stable
P4.16	SLG @ Cheswold 138/69kV TF AT1, SB @ Cheswold 138kV, delayed clear loss of Cheswold – Felton 138kV line	9/21	Stable
P4.17	SLG @ Cheswold 138/69kV TF AT1, SB @ Cheswold 138kV, delayed clear loss of Cheswold 138kV capbanks	9/21	Stable
P4.18	SLG @ Cheswold 138kV Capbanks, SB @ Cheswold 138kV, delayed clear loss of Clayton – Jones – Cheswold 138kV line	9/21	Stable

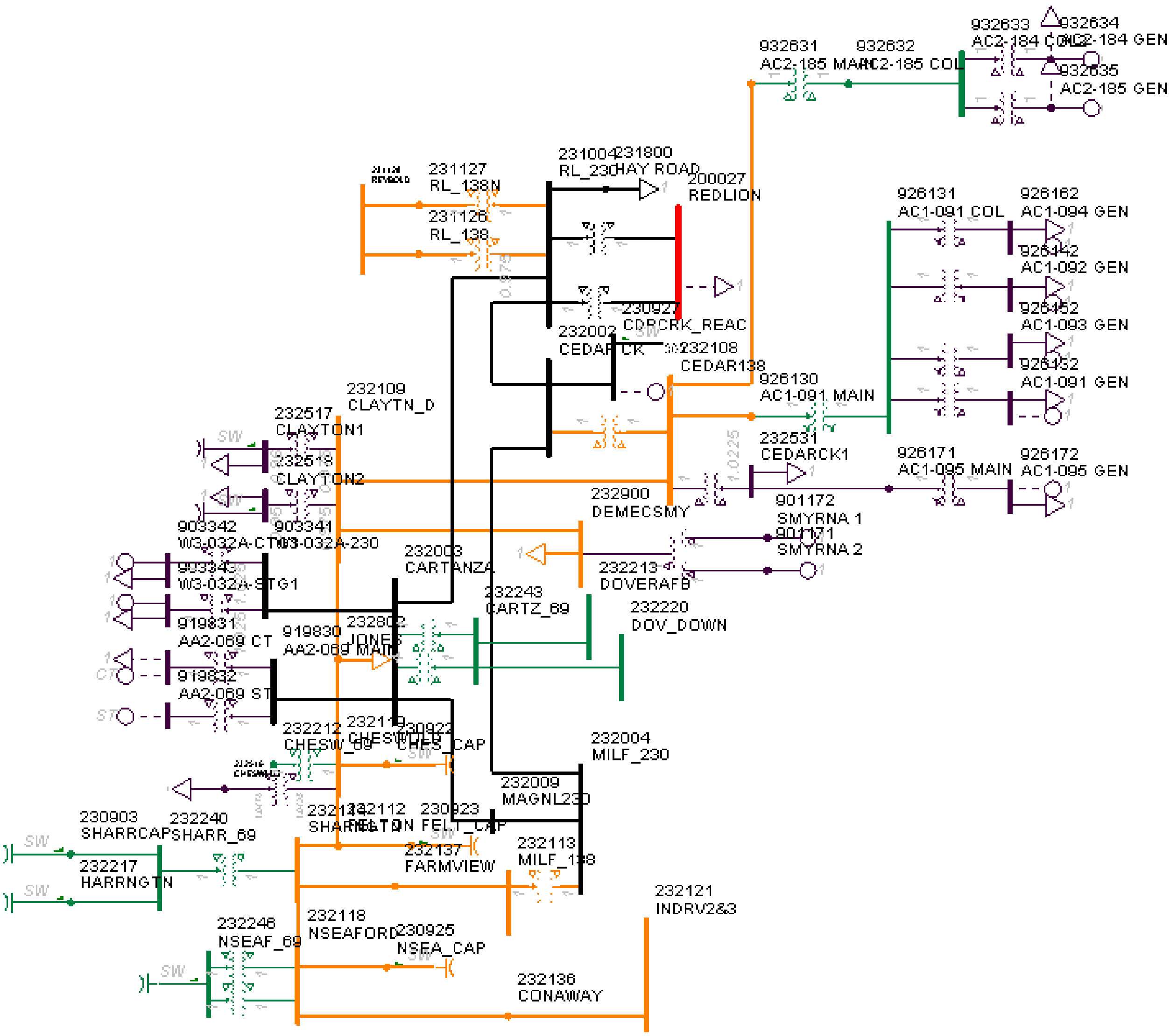
P5: SLG Fault with Delayed (Zone 2) Clearing

Fault ID	Fault description	Clearing Time Normal/Delayed (Cycles)	Results
P5.01	SLG @ 80% of Cedar Creek – Clayton 138kV line	9/37	Stable
P5.02	SLG @ 80% of Clayton – Cedar Creek 138kV line	9/37	Stable
P5.03	SLG @ 80% of Clayton – Jones – Cheswold 138kV line	9/37	Stable
P5.04	SLG @ 80% of Cheswold – Jones – Clayton 138kV line	9/37	Stable
P5.05	SLG @ 80% of Cheswold – Felton 138kV line	9/37	Stable
P5.06	SLG @ 80% of Felton – Cheswold 138kV line	9/37	Stable
P5.07	SLG @ Cedar Creek 138/230kV TF	/37	Stable
P5.08	SLG @ 80% of Cedar Creek – Red Lion 230kV line	7/25	Stable
P5.09	SLG @ 80% of Cedar Creek – Milford 230kV line	7/25	Stable

P7: Common Structure

Fault ID	Fault description	Clearing Time (Cycles)	Results
P7.01	CONTINGENCY 'DBL_4NC' /* RED LION-CEDAR CREEK 230;RED LION-CARTANZA 230 SLG @ Red Lion – Cedar Creek 230kV line, tower failure normal clear loss of Red Lion – Cartanza 230kV line	7	Stable
P7.02	CONTINGENCY 'DBL_4NC_2ND' /* RED LION-CEDAR CREEK 230;RED LION-REYBOLD 138 SLG @ Red Lion – Cedar Creek 230kV line, tower failure normal clear loss of Red Lion – Reybold 138kV line	9	Stable

Attachment 1. PSS/E Model One Line Diagram



Attachment 2. AC2-184/185 PSS/E Dynamic Model

932634 'USRMDL' 1 'SMAPPC18' 4 0 4 28 9 21 104 103 1 0
3 0.5 0.25 0.04 0.0 0.1 1.0 0.04 0
0 1 0 10 -0.001
0.1 1.0 0.04 0 1 0.2 0.2
0.8 0.91 0.915 1.060 1.055 0.3 1.0/
/ CtlMod KP_PF KI_PF PFXdcrTm PFDB KP_Vol KI_Vol VolXdcrTm VolDB
/ PFNomTot VolNomTot QNomTot VolDroop HybCtlTun
/ KP_P KI_P PXdcrTm PDB PNomTot QCommTm PCommTm
/ PFLim FRTThrhLo1 FRTThrhLo2 FRTThrhHi1 FRTThrhHi2 FRTHldTm Reserved
932634 'USRMDL' 1 'SMASC131' 1 1 0 76 15 193
1.0 1.0 0.0 0.8 1.0 0.0 1.0 1.0 0.35
1.0 0.0 5.0 0.5 2.0
0.0 0.9 0.5 1.0 0.9 0.9
0.0 0.2 0.05 0.4
0.35 0.35 1.0 2.0 2.0 2.0 0.1 0.098 0.1 0.098 0.2 0.2
0.01 1.0 20.0 0.5 0.61 0.62 0.0 0.125 0.1
1.2 0.1 1.18 1.0 1.15 2.0 0.88 12.0 0.6 5.0 0.5 3.0
65.0 0.1 64.0 1.0 61.5 3.0 59.3 5.0 57.0 3.0 50.0 0.1
30.0 0.0 10.0 30.0 0.0 1.0 1.0/
/ PPrim PWNom QVArNom PFLIM PFPF PFPFExt QVArMod QoDEna QoDQMax
/ VArCtlVol_Volref VArCtlVol_VolDB VArCtlVol_VArGra VArCtlVol_VArMax VArCtlVol_VArTm
/ PFPFExtStr PFPFStr PFWStr PFPFExtStop PFPFStop PFWStop
/ WCtlHzMod PHzStr PHzStop PWGra
/ WGra VArGra DGSMod DGSArGraNom DGSArGraNomHi DGSArGraNomLo DbVolNomMax DbVolNomMaxH DbVolNomMin DbVolNomMinH DGSqRcvrTm DGSNqRcvrTm
/ VArCmdFltTm FRTPreErrVEna FRTPreErrTm FRTSwOffTm FRTThrshld1 FRTThrshld2 VCtllCharEna VCtlllCharTm VCtlCorTm
/ VCtlMax VCtlMaxTm VCtlhhLim VCtlhhLimTm VCtlhLim VCtlhLimTm VCtllLim VCtllLimTm VCtlllLim VCtlllLimTm VCtlMin VCtlMinTm
/ HzCtlMax HzCtlMaxTm HzCtlhhLim HzCtlhhLimTm HzCtlhLim HzCtlhLimTm HzCtllLim HzCtllLimTm HzCtlllLim HzCtlllLimTm HzCtlMin HzCtlMinTm
/ KPLL1 PLLFlag KPPLL2 KIPLL2 Reserved Reserved GenTrpFlag

932635 'USRMDL' 1 'SMAPPC18' 4 0 4 28 9 21 104 103 1 0
3 0.5 0.25 0.04 0.0 0.1 1.0 0.04 0
0 1 0 10 -0.001
0.1 1.0 0.04 0 1 0.2 0.2
0.8 0.91 0.915 1.060 1.055 0.3 1.0/
/ CtlMod KP_PF KI_PF PFXdcrTm PFDB KP_Vol KI_Vol VolXdcrTm VolDB
/ PFNomTot VolNomTot QNomTot VolDroop HybCtlTun
/ KP_P KI_P PXdcrTm PDB PNomTot QCommTm PCommTm
/ PFLim FRTThrhLo1 FRTThrhLo2 FRTThrhHi1 FRTThrhHi2 FRTHldTm Reserved
932635 'USRMDL' 1 'SMASC131' 1 1 0 76 15 193
1.0 1.0 0.0 0.8 1.0 0.0 1.0 1.0 0.35

```
                        1.0 0.0 5.0 0.5 2.0
                        0.0 0.9 0.5 1.0 0.9 0.9
                        0.0 0.2 0.05 0.4
                        0.35 0.35 1.0 2.0 2.0 2.0 0.1 0.098 0.1 0.098 0.2 0.2
                        0.01 1.0 20.0 0.5 0.61 0.62 0.0 0.125 0.1
                        1.2 0.1 1.18 1.0 1.15 2.0 0.88 12.0 0.6 5.0 0.5 3.0
                        65.0 0.1 64.0 1.0 61.5 3.0 59.3 5.0 57.0 3.0 50.0 0.1
                        30.0 0.0 10.0 30.0 0.0 1.0 1.0/
/                       PPrim PWNom QVArNom PFLIM PFPF PFPFExt QVArMod QoDEna
QoDQMax
/                       VArCtlVol_Volref VArCtlVol_VolDB VArCtlVol_VArGra VArCtlVol_VArMax
VArCtlVol_VArTm
/                       PFPFExtStr PFPFStr PFWStr PFPFExtStop PFPFStop PFWStop
/                       WCtlHzMod PHzStr PHzStop PWGra
/                       WGra VArGra DGSMod DGSArGraNom DGSArGraNomHi DGSArGraNomLo
DbVolNomMax DbVolNomMaxH DbVolNomMin DbVolNomMinH DGSqRcvrTm DGSNqRcvrTm
/                       VArCmdFltTm FRTPreErrVEna FRTPreErrTm FRTSwOffTm FRTThrshld1
FRTThrshld2 VCtllCharEna VCtlllCharTm VCtlCorTm
/                       VCtlMax VCtlMaxTm VCtlhhLim VCtlhhLimTm VCtlhLim VCtlhLimTm VCtllLim
VCtllLimTm VCtlllLim VCtlllLimTm VCtlMin VCtlMinTm
/                       HzCtlMax HzCtlMaxTm HzCtlhhLim HzCtlhhLimTm HzCtlhLim HzCtlhLimTm
HzCtllLim HzCtllLimTm HzCtlllLim HzCtlllLimTm HzCtlMin HzCtlMinTm
/                       KPLL1 PLLFlag KPPLL2 KIPLL2 Reserved Reserved GenTrpFlag
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Attachment 3. AC2-184/185 PSS/E Case Dispatch

Bus Number	Bus Name	Id	In Service	PGen (MW)	PMax (MW)	PMin (MW)	QGen (Mvar)	QMax (Mvar)	QMin (Mvar)
200036	SALEM-G1 22.000	1	1	1253	1253	1018	376.6	535	100
200037	SALEM-G2 22.000	1	1	1245	1245	1008	376.6	542.9	100
200039	HOPE CG1 22.000	1	1	1320	1320	0	560	560	108
200052	ROCKSP 1 18.000	1	1	163.5	163.5	20	67.33	67.33	-50
200053	ROCKSP 2 18.000	1	1	163.5	163.5	20	67.33	67.33	-50
200054	ROCKSP 3 18.000	1	1	196	196	20	110.9	114	-55
200055	ROCKSP 4 18.000	1	1	196	196	20	110.9	114	-55
200062	SALEM G3 22.000	1	1	38.4	38.4	0	14	14	-14
230927	CDRCRK_REAC 230.00	1	1	0	0	0	-20	-20	-20
231118	NEWCASTL 138.00	1	1	0	0	0	-60	0	-60
231131	BLOOM ENRGY 138.00	1	1	27	27	0	0	0	0
231505	HR4 18.000	4	1	185	185	0	23.33	23.33	-23.3
231900	EM5 23.000	5	1	450	450	0	0	0	0
231902	DC CT7 13.800	1	1	62.1	62.1	0	-3.07	65.06	-3.07
231903	GEN4 13.800	4	1	72	72	0	0	0	0
231904	DC1 NUG 13.800	1	0	0	0	0	0	0	0
231905	DC2 NUG 13.800	1	0	0	0	0	0	0	0
231907	DC10 13.800	1	1	17.8	17.8	0	12.1	12.1	-5
231911	HR5 13.800	5	1	125	125	0	10	10	-10
231912	HR6 13.800	6	1	125	125	0	10	10	-10
231913	HR7 13.800	7	1	125	125	0	10	10	-10
231914	HR8 18.000	8	1	190	190	0	18.61	18.61	-9.3
231915	DC CT6 13.800	1	1	55	55	0	-17	15	-17
232227	EASTN_69 69.000	1	0	0	0	0	0	0	-30
232632	IR SVC 16.000	1	1	0	0	0	78.02	150	-150
232813	VAUGHN 69.000	1	1	3	3	0	0	0	0
232904	IR4 26.000	4	1	414.2	414.2	0	4.9	4.9	-2.93
232920	IR10 13.200	1	1	16.1	16.1	0	0	15	0
232925	NELSVC 16.000	1	1	0	0	0	4.651	150	-150
901171	SMYRNA 2 13.800	1	1	53	53	30	-4.44	28	-18
901172	SMYRNA 1 13.800	1	1	48	48	30	0.551	25	0
903342	W3-032A-CTG118.000	1	1	211	211	0	36.6	100	-60
903343	W3-032A-STG113.800	1	1	127	127	0	36.6	50	-40
907291	X1-074 CT 20.000	1	1	200.5	200.5	92	83.05	120	-85
907292	X1-074 ST 13.800	1	1	99.5	99.5	92	34	34	-34
913400	Y3-102-STG 23.500	1	1	499	499	0	110.9	499	-183
913401	Y3-102-CTG1 21.000	1	1	290	290	100	110.9	290	-114

913402	Y3-102-CTG2 21.000	1	1	290	290	100	110.9	290	-114
919831	AA2-069 CT 18.000	CT	1	245	245	0	36.6	130	-90
919832	AA2-069 ST 18.000	ST	1	217	217	0	36.6	170	-120
924881	AB2-142 C 24.900	1	1	5.1	5.1	0	0	0	0
926132	AC1-091 GEN 0.5500	1	1	20	20	0	6.29	6.6	-6.6
926142	AC1-092 GEN 0.5500	1	1	20	20	0	6.29	6.6	-6.6
926152	AC1-093 GEN 0.5500	1	1	19	19	0	6.29	6.3	-6.3
926162	AC1-094 GEN 0.5500	1	1	16	16	0	5.3	5.3	-5.3
926172	AC1-095 GEN 0.5500	1	1	10	10	0	3.3	3.3	-3.3
927321	AC1-229 C 138.00	1	1	3.8	3.8	0	1.254	1.254	-1.25
932634	AC2-184 GEN 0.5500	1	1	20	20	0	6.29	14.1	-14.1
932635	AC2-185 GEN 0.5500	1	1	20	20	0	6.29	14.1	-14.1

Attachment 4. Plots from Dynamic Simulations (See separated .PDF file)