Q. Provide any studies that have been performed to verify that there will be no adverse interactions harmonic, dynamic or transient between the Labrador Island Link and the Maritime Link.

A. To date, a dynamic system analysis was undertaken to study the performance of the interconnected transmission in response to power system disturbances such as faults. Please see attached PUB-NLH-264 Attachment 1, entitled *Maritime Link Preliminary Interconnection Study* dated July 2014.

Harmonic and transient studies of the interconnected transmission system will be completed in the detailed design phase of the project. These studies will require detailed vendor information specific to their Line Commutated Converter technology and design and vendor specific computer models.

Approved for Release	August 13, 2014 Date

MARITIME LINK
PRELIMINARY INTERCONNECTION STUDY

Newfoundland and Labrador Hydro

July 2014

newfoundland labrador hydro
a nalcor energy company

Table of Contents

1. INTRODUCTION

On November 29, 2013, the Nova Scotia Utility and Review Board approved the Maritime Link Project. The Maritime Link (ML) requires the construction of a ± 200 kV, 500 MW HVdc transmission link between Bottom Brook Terminal Station (BBK) in western Newfoundland and Woodbine Substation in Cape Breton, Nova Scotia. In addition, Emera Newfoundland Limited (ENL), the owner of ML, will be constructing a new 230 kV transmission line between Granite Canal Terminal Station (GCL) and BBK to provide sufficient transfer capacity for the ML.

This report provides the results of a preliminary system planning study undertaken by Newfoundland and Labrador Hydro (Hydro). The objective of the study is to assess the interconnection of the ML to the Island-Interconnected Transmission System and to determine high-level system reinforcements and/or control schemes to ensure that the Island Interconnected System remains stable following disturbances.

The scope of the study includes the modeling and analysis of the transmission systems in both Newfoundland and Labrador with equivalent system representations in Nova Scotia and Quebec. The study includes an analysis of system stability during transient events with consideration of reactive power requirements for the ML.

The study builds on the steady-state and load flow analysis completed by Hydro's System Planning Department: "Bottom Brook VSC Export Limits – Maritime Link Runback Summary", completed in 2013.

The transient stability analysis was completed using Version 32 of PSS®E software from Siemens PTI.

2. ASSUMPTIONS

The analysis was performed using the following assumptions:

1. The Labrador-Island Link (LIL) is in service, along with all prerequisite upgrades to the Island Interconnected Transmission System, including:
    - A new 230 kV transmission line between Bay d'Espoir Terminal Station (BDE) and Western Avalon Terminal Station (WAV).
    - A new 230 kV transmission line between GCL and BBK.
    - A new 60 MW gas turbine is available at Holyrood (HRD) and is in service as a synchronous condenser. The generator is equivalent to a Brush BDAX 8-445ER.
    - Three 175 MW high-inertia synchronous condensers (HISCs) are in service at Soldiers Pond (SOP). For the purposes of this investigation, it is assumed that one of the three units is offline for maintenance[1].

2. Reserve for the Island Interconnected Transmission System is available either on the Island or in Labrador. The full capacity of the LIL available in response to transient events. When operating as a bipole, each pole can be adjusted to provide a power flow in the range between 45 MW and 450 MW. When operating as a monopole, power flow over the pole can be adjusted to anywhere in the range between 45 MW and 900 MW.

3. During transient events, the ML may be tripped to avoid instability or underfrequency load shedding within the Island Interconnected Transmission System.

4. There shall be no underfrequency load shedding for loss of a pole on the LIL while operating as a bipole. Underfrequency load shedding within the Island System is acceptable for loss of a monopole. As specified in "Hydro Operating Instruction T-068 - Guideline for Unit Maximum Loading", the loss of supply should not result in the loss of load set to trip at 58.0 Hz.

[1] It is assumed that all three HISCs are in service when the LIL is in monopole operation or in "future peak" cases.

5. Following a temporary pole fault on the LIL, full power on that pole can be restored within 300 ms.

6. The ML has a specified reactive power limit of 125 MVAR per pole. At Bottom Brook.

3. SYSTEM PLANNING CRITERIA

The following list is provided as summary of Hydro's Transmission Planning Practices as accepted by the Public Utilities Board:

- Hydro's bulk transmission system[2] is planned to be capable of sustaining the single contingency loss of any transmission element without loss of system stability;

- In the event a transmission element is out of service, power flow in all other elements of the power system should be at or below normal rating;

- The Hydro system is planned to be able to sustain a successful single pole reclose for a line to ground fault based on the premise that all system generation is available;

- Transformer additions at all major terminal stations (i.e. two or more transformers per voltage class) are planned on the basis of being able to withstand the loss of the largest unit;

- For single transformer stations there is a back-up plan in place which utilizes NLH's and/or Newfoundland Power's mobile equipment to restore service;

- For normal operations, the system is planned on the basis that all voltages be maintained between 95% and 105%;

- For contingency or emergency situations voltages between 90% and 110% is considered acceptable; and

- For new terminal stations connected to the bulk system, Hydro's preferred bus arrangement is a breaker-and-one-half scheme. Where there are a limited number of elements, a ring bus arrangement is acceptable.

[2] Hydro's bulk transmission system on the Island of Newfoundland is generally considered to be the 230 kV transmission system and the underlying 138 kV transmission loops between connection points on the 230 kV system including Western Avalon to Holyrood and Deer Lake-Stony Brook-Sunnyside.

For analysis of the Island Interconnected Transmission System with the HVdc connection to Labrador included, the following criteria are used to assess the need for system reinforcements:

3.1. STEADY STATE ANALYSIS CRITERIA

- With a transmission element (line, transformer, synchronous condenser, shunt or series compensation device) is out of service, power flow in all other elements of the power system should be at or below normal rating;

- Transformer additions at all major terminal stations (i.e. two or more transformers per voltage class) are planned on the basis of being able to withstand the loss of the largest unit;

- For normal operations all voltages be maintained between 95% and 105%;

- For contingency or emergency situations all voltages be maintained between 90% and 110%; and

- Analysis will be conducted with one high inertia synchronous condenser out of service at Soldiers Pond.

3.2. TRANSIENT ANALYSIS CRITERIA

- System response shall be stable and well damped following a disturbance;

- System disturbances include:
    - Successful single pole reclosing on line to ground faults;
    - Unsuccessful single pole reclosing on line to ground faults;
    - Three phase faults except a three phase fault on the Bay d'Espoir 230 kV bus with tripping of a 230 kV transmission line;

  - Loss of the largest generator on line on the Island System with and without fault;
  - Line to ground or three phase fault with tripping of a synchronous condenser;
  - Temporary pole fault;
  - Permanent pole fault; and
  - Temporary bipole fault.

- Post fault recovery voltages on the ac system shall be as follows:
  - Transient under voltages following fault clearing should not drop below 70%;
  - The duration of the voltage below 80% following fault clearing should not exceed 20 cycles;

- Post fault system frequencies shall not drop below 58 Hz;

- Under frequency load shedding:
  - shall not occur for loss of island generation with the HVdc link in service;
  - shall not occur for permanent loss of HVdc pole;
  - shall not occur for a temporary bipole outage; and
  - shall be controlled for a permanent bipole outage.

- There shall be no commutation failures of the HVdc link during post fault recovery.

4. BASE CASES

Analysis was performed using system models that were developed for LIL integration studies. These models reflect system conditions where the Island Transmission System is interconnected to Labrador via the LIL and to Nova Scotia via the ML.

In the base cases, the LIL was modeled using the PSS®E CDC4T Line-Commutated Converter (LCC) model with a PAU1XT frequency controller. The ML was modeled as a Voltage Source Converter (VSC) system using Version 1.1.10 of the HVdc Light Open Model from ABB.

Eleven base cases were considered for this analysis. The base cases were developed to assess the impacts of the following system variations:

1. System loading conditions (i.e. heavy, intermediate, light, and extreme light)
2. Island dispatch (i.e. maximum generation, economic dispatch, or minimum generation)
3. Import to the Island Transmission System over the LIL (i.e. 0 MW to 830 MW)
4. Export over the ML (i.e. 0 MW to 500 MW)

The base cases are listed in Table 1. Load flow plots for the base cases are provided in Appendix A.

Table 2 provides the Hydro's Island Interconnected System generation capacities used in preparing the base cases.

Table 1 – Base Case Scenarios

Case	System Condition	Island Load (MW)	LIL Mode	LIL Power (MW)	Island Generation	ML Mode	ML Power (MW)
BC1	Heavy Load	1757	Bipole	830	1085	Bipole	158
BC2	Heavy Load	1588	Bipole	830	915	Bipole	158
BC3	Heavy Load	1594	Bipole	676	1075	Bipole	158
BC4	Heavy Load	1471	Monopole	396	1258	Bipole	182
BC5[3]	Heavy Load	1500	Offline	0	1258	Bipole	-250
BC6	Heavy Load	1415	Bipole	830	1085	Bipole	500
BC7	Intermediate Load	1261	Bipole	830	931	Bipole	500
BC8	Intermediate Load	1261	Bipole	676	1085	Bipole	500
BC9	Light Load	700	Bipole	830	370	Bipole	500
BC10	Light Load	700	Monopole	550	650	Bipole	500
BC11	Extreme Light Load	400	Bipole	415	335	Bipole	350

[3] Base Case 5 represents an extreme condition where the LIL bipole is out of service. Transient stability analysis was not performed for this mode of operation.

Table 2 - Hydro System Capability

Source	Rated Capacity (MW)	Comments
Hydro		
Bay d'Espoir	604	Bay d'Espoir generation is calculated as 6 x 75 MW + 1 x 154 MW. Units 1 to 6 at Bay d'Espoir have a sustained capacity of 73 MW per unit and a peak capacity of 75 MW. (6 x 73 + 154 = 592 MW)
Cat Arm	127	2 x 63.5 MW
Upper Salmon	84	
Hinds Lake	75	
Granite Canal	40	
Paradise River	8	
Snook's, Venam's, Roddickton	0	For load flow analysis, the value of generation is netted out with load that it supplies
Subtotal Hydro	938	
Non-Utility/PPA		
Star Lake	15	Nameplate rating
Exploits	90.8	Grand Falls + Bishop's Falls

Corner Brook Cogen	15	
Rattle Brook	4	
St. Lawrence Fermeuse	11 11	The wind farms are not considered in capacity planning due to the variability of wind but are included in this analysis to assess transient response of the wind farms to system contingencies. For the purposes of this investigation, wind farms are generating at approximately 40% of rated capacity.
Subtotal NUG/PPA	146.8	
Total capacity	1084.8 (1085)	
Standby Generation		
Hardwoods CT	50	
Stephenville CT	50	
Hawke's Bay Diesel	5	
St. Anthony Diesel	9.7	
Total Standby capacity	114.7	
Spinning Reserve Requirement	154	Largest unit on system with Holyrood offline

5. RESULTS OF DYNAMIC ANALYSIS

The transient stability of a transmission system refers to its ability to maintain synchronism following a severe disturbance such as a fault. For the purposes of this investigation, base cases were subjected to the disturbances listed in Appendix B.

It was found that a subset of the contingencies resulted in undesirable system performance such as instability, underfrequency load shedding (UFLS), or other violations to System Planning Criteria. These contingencies are categorized as follows:

1. Faults at Bay d'Espoir
2. Ac Transmission Line Faults in Western Newfoundland
3. Temporary Bipole Faults
4. Permanent Pole Faults
5. Loss of Generation within the Island System
6. Loss of a Synchronous Condenser at Soldiers Pond

These cases are described in the sections below.

5.1. FAULTS AT BAY D'ESPOIR

In peak load cases with maximum generation online within the Island Interconnected System, faults at BDE result in system instability. The scenarios are summarized in Table 3.

Table 3 – Notable System Conditions Following Faults at BDE

Base Case	Contingency	System Condition
Base Case 1	Fault at BDE, Trip of TL202	Instability
Base Case 1	Fault at BDE, Trip of TL204	Instability
Base Case 1	Fault at BDE, Trip of TL234	Instability
Base Case 1	Fault at BDE, Trip of Unit	Instability
Base Case 3	Fault at BDE, Trip of TL202	Instability
Base Case 3	Fault at BDE, Trip of TL204	Instability
Base Case 3	Fault at BDE, Trip of TL234	Instability
Base Case 3	Fault at BDE, Trip of Unit	Instability

It should be noted that faults at Bay d'Espoir have been classified as "exceptional contingencies" and it has been accepted that their occurrence under heavy load conditions may lead to instability. Detailed analysis of these faults is beyond the scope of this investigation. Some examples of instability due to BDE faults are provided in the figures below.

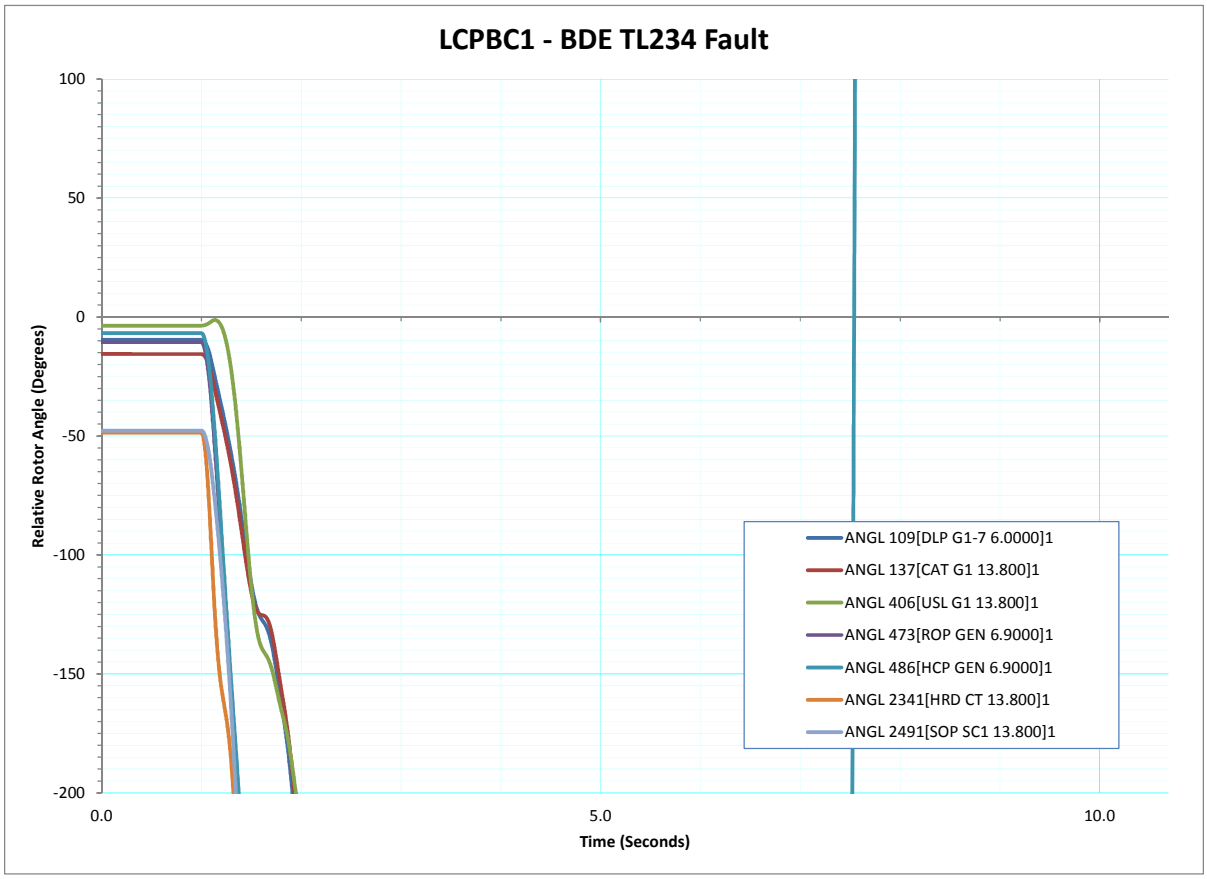

Figure 1 - LCPBC1 - BDE TL234 Fault - Relative Rotor Angle (Degrees)

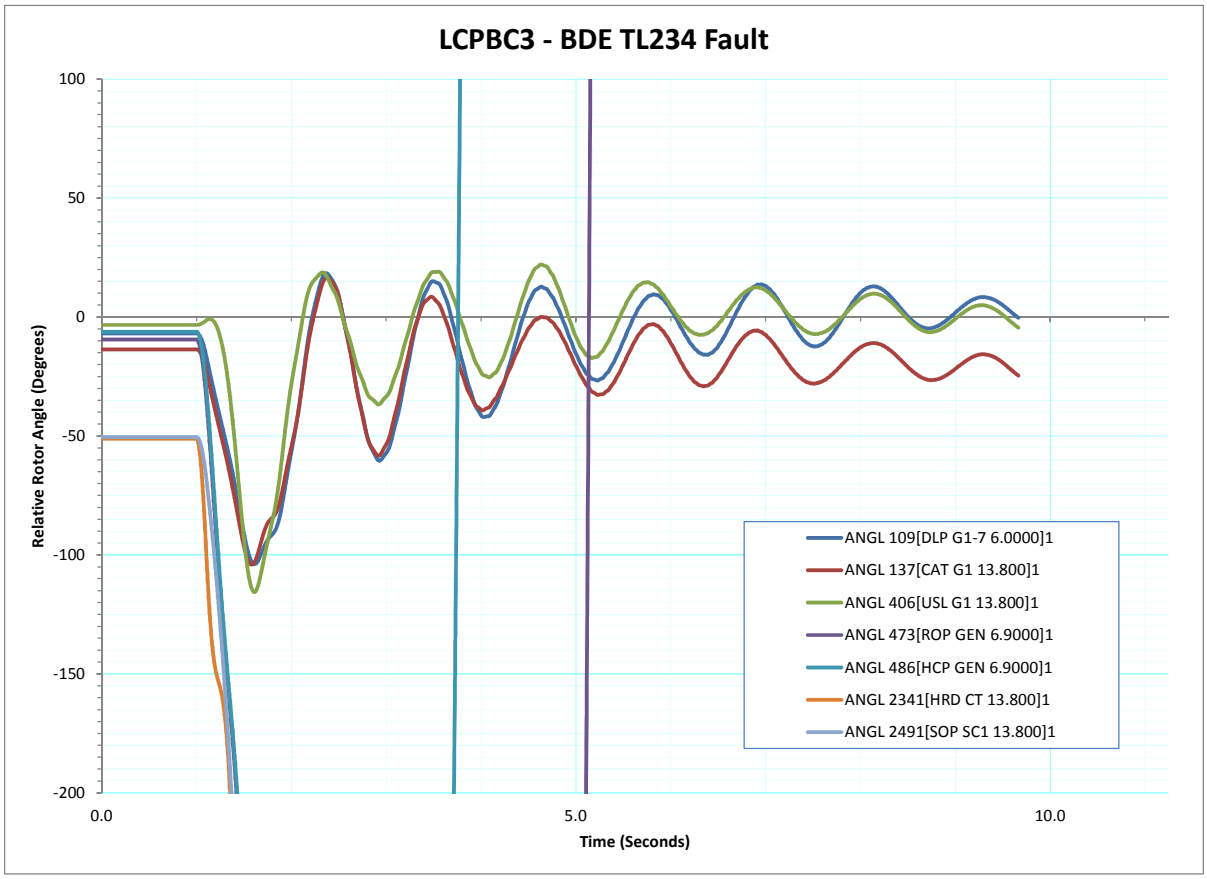

Figure 2 - LCPBC3 - BDE TL234 Fault - Relative Rotor Angle (Degrees)

5.2. AC TRANSMISSION LINE FAULTS IN WESTERN NEWFOUNDLAND

Transient analysis indicates that ac faults at selected terminals stations in western Newfoundland will cause the reactive power output of the VSC converter in BBK to exceed the specified limit of 125 MVAR per pole. This was found to be the case in load flow scenarios where the ML was operating at its rated output of 500 MW. A list of these scenarios is provided in Table 4 and illustrated in the figures below.

Analysis was performed to investigate the impact of curtailing the ML export to 250 MW in the event of these faults. The results of this analysis indicate that curtailing ML export reduces the reactive power output below specified limits in all cases. Transient stability plots of the cases with curtailed ML export are provided in Appendix C.

Table 4 – Terminal Stations Where Ac Transmission Line Faults Result in ML Reactive Power Limit Violations[4]

Terminal Station
Bottom Brook
Buchans
Granite Canal
Massey Drive
Stony Brook
Upper Salmon

[4]These violations occur in Base Cases 6, 7, 8, 9, and 10. The ML is operating at its rated output of 500 MW in these cases.

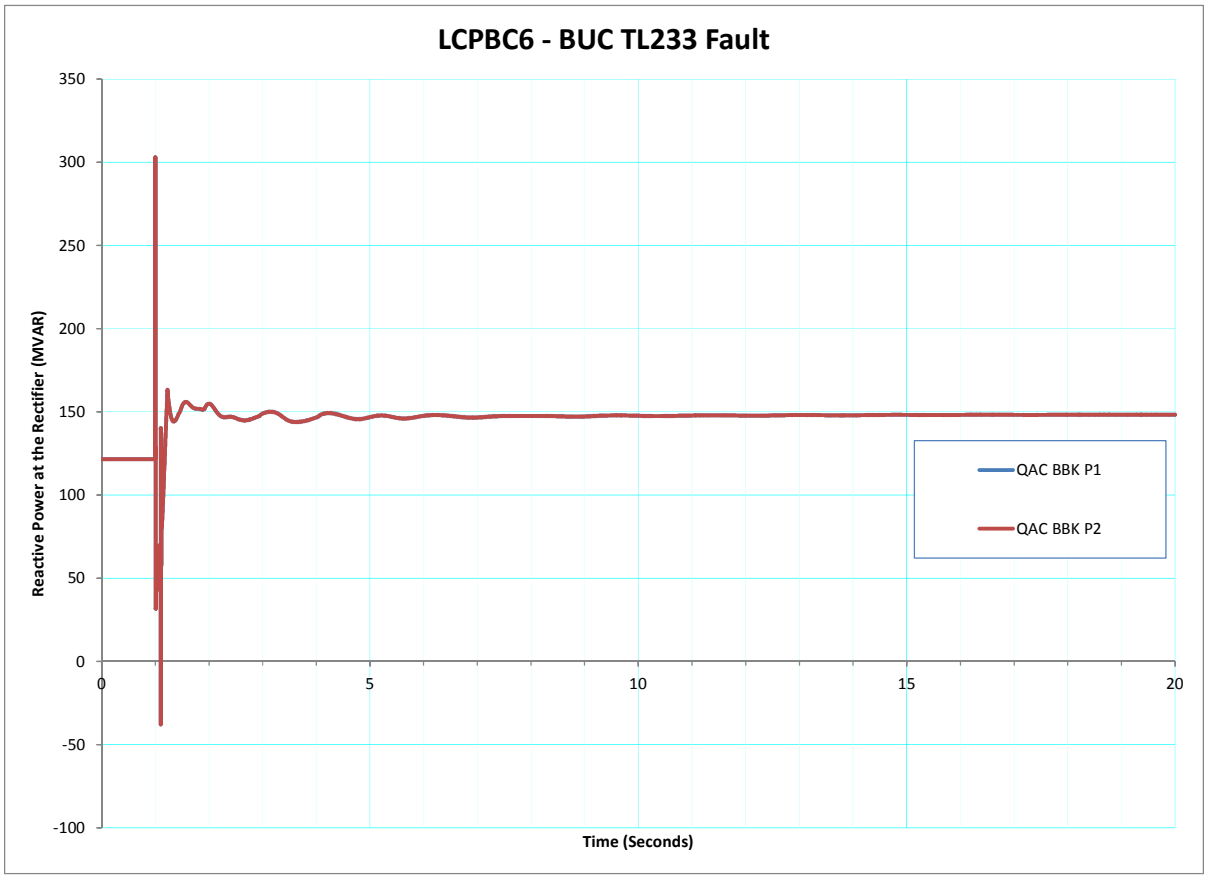

Figure 3 - LCPBC6 - BUC TL233 Fault - Reactive Power at the Rectifier (MVAR)

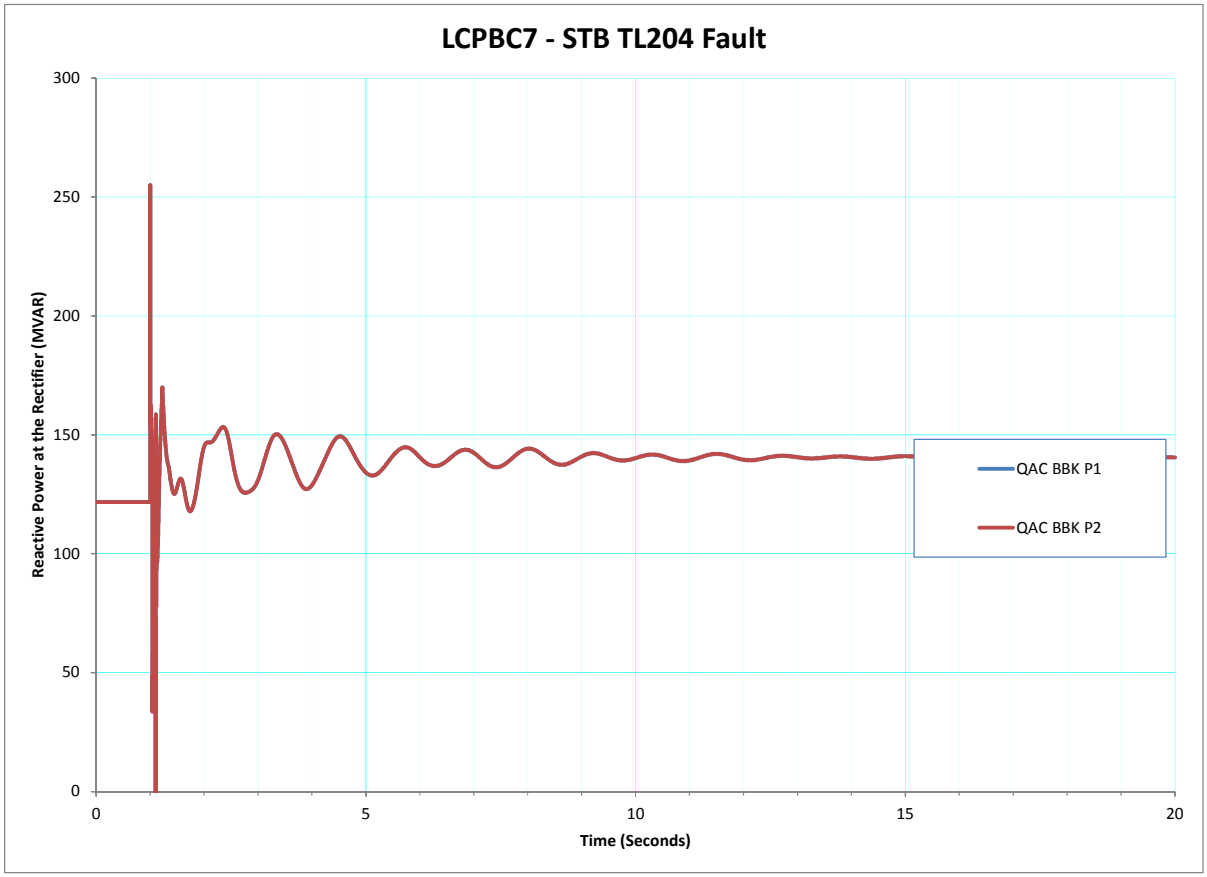

Figure 4 - LCPBC7 - STB TL204 Fault - Reactive Power at the Rectifier (MVAR)

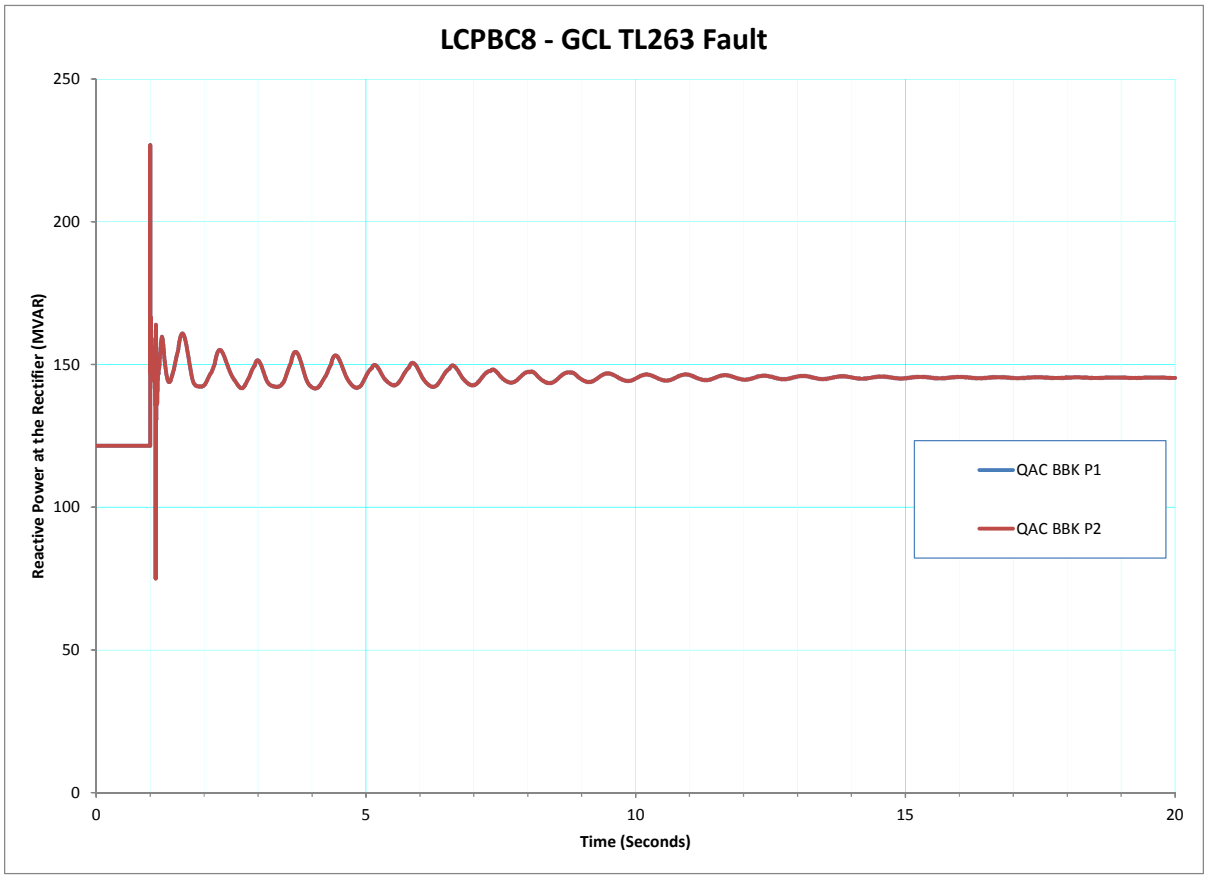

Figure 5 - LCPBC8 - GCL TL263 Fault - Reactive Power at the Rectifier (MVAR)

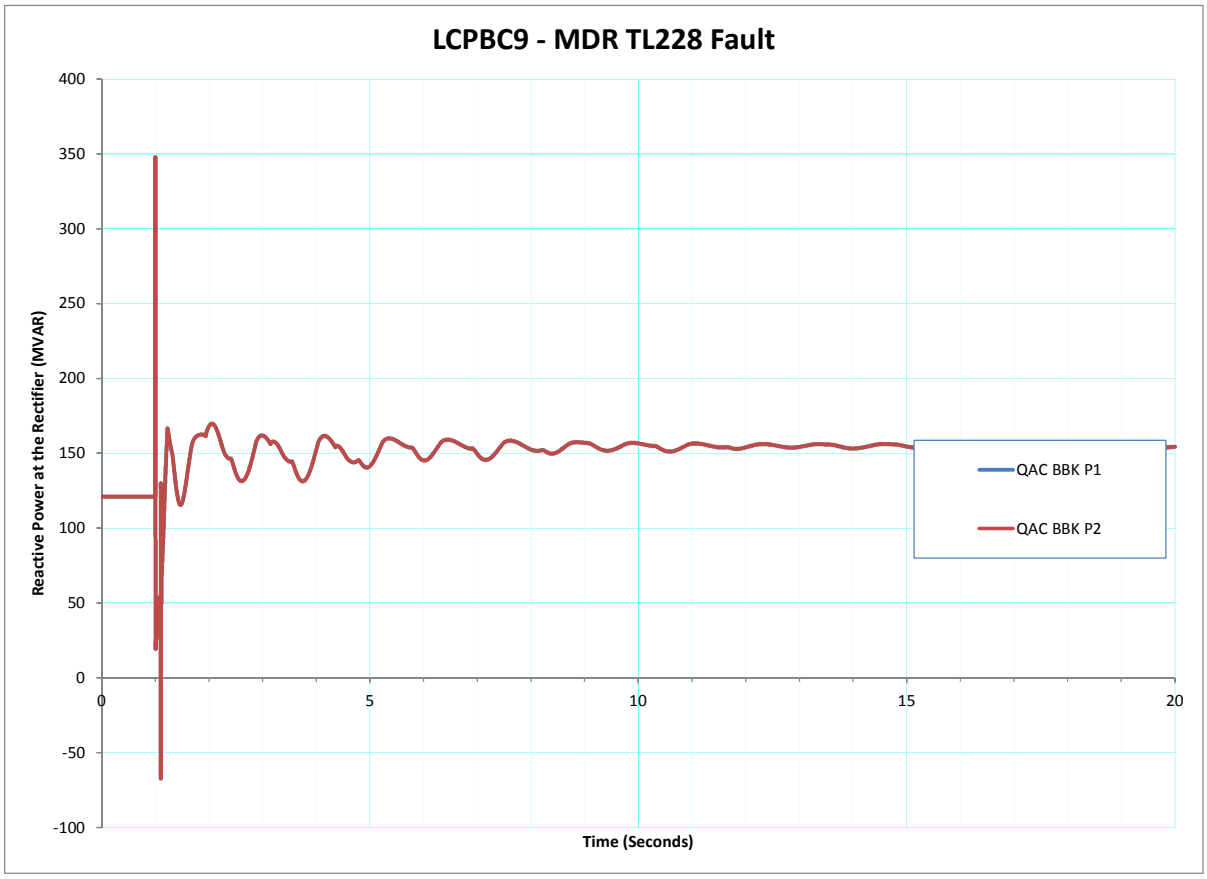

Figure 6 - LCPBC9 - MDR TL228 Fault - Reactive Power at the Rectifier (MVAR)

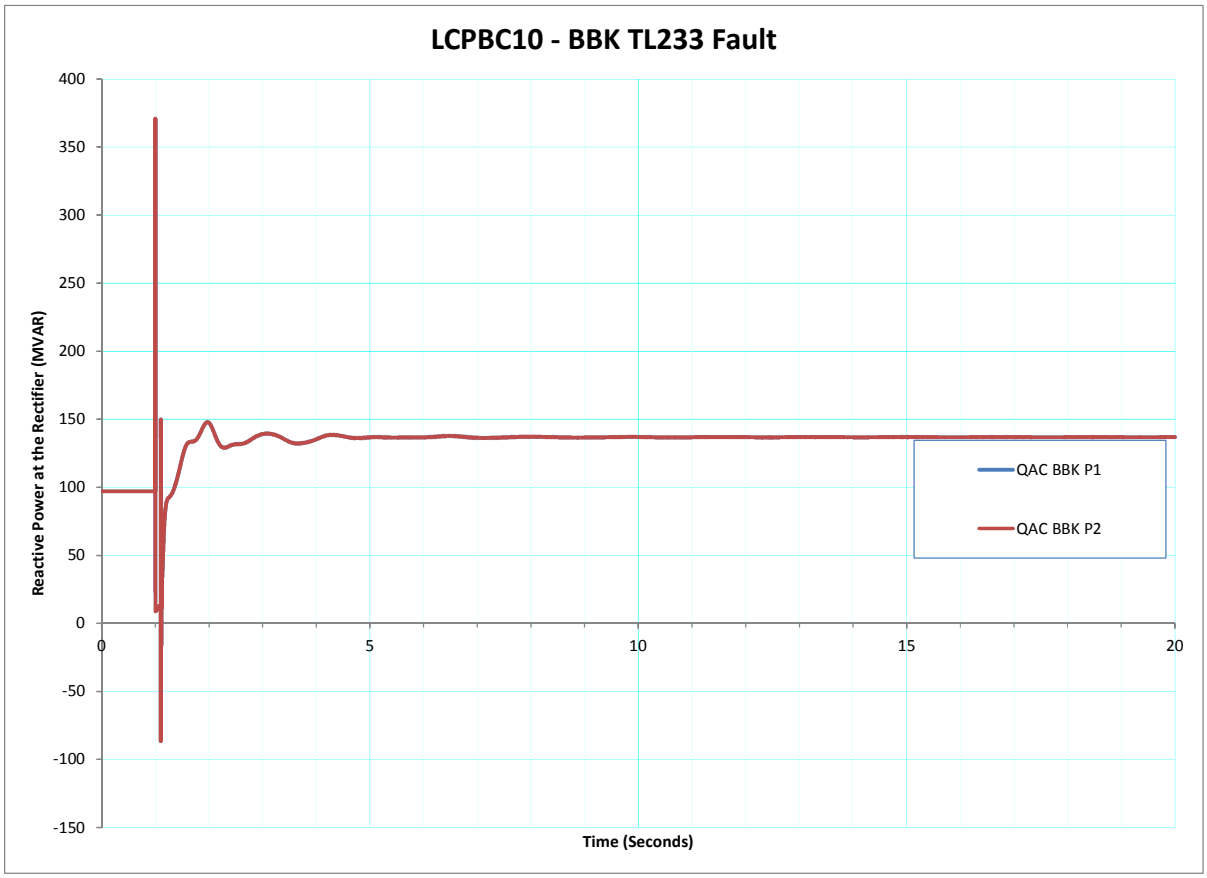

Figure 7 - LCPBC10 - BBK TL233 Fault - Reactive Power at the Rectifier (MVAR)

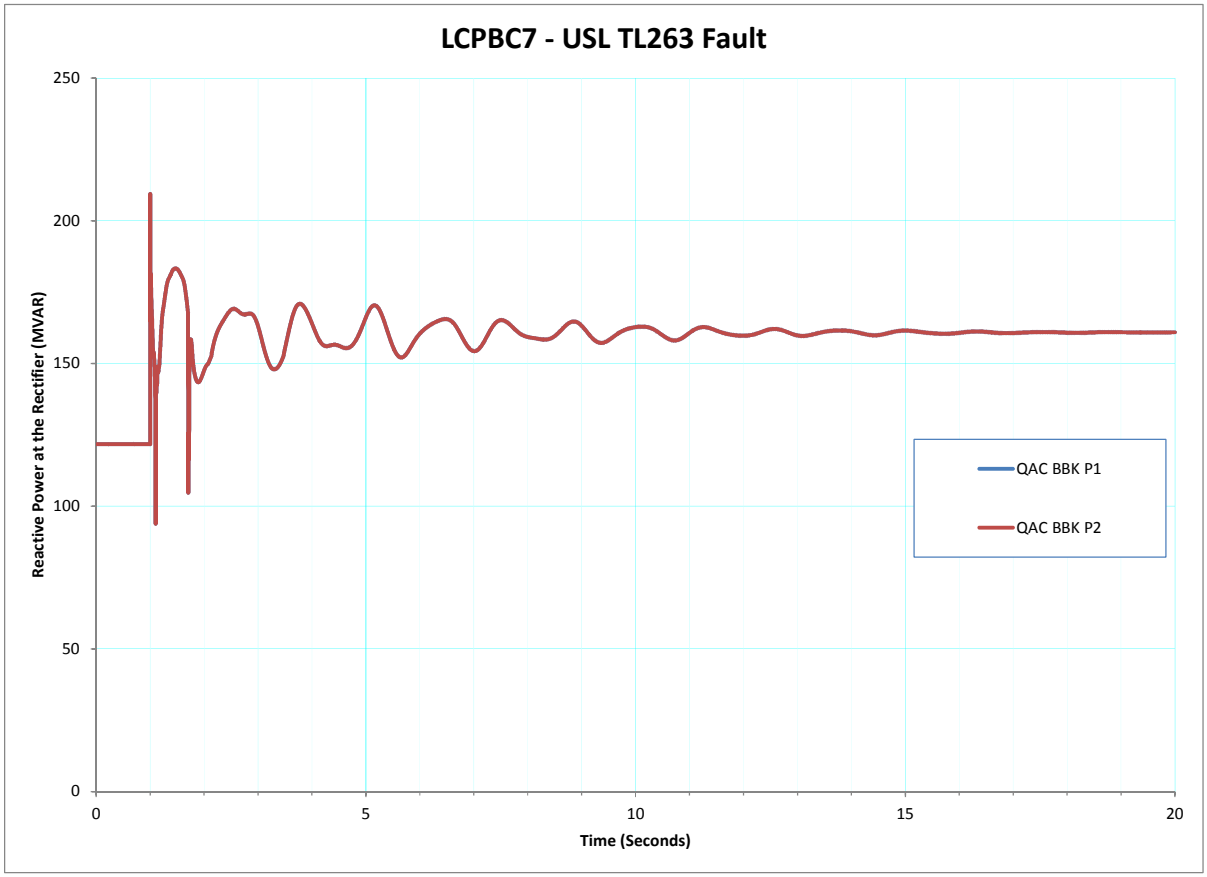

Figure 8 - LCPBC7 - USL TL263 Fault - Reactive Power at the Rectifier (MVAR)

5.3. TEMPORARY BIPOLE FAULTS

In the event of a temporary bipole fault (or a monopole fault), undesirable system conditions were found for the scenarios listed in Table 5. Plots of the system conditions are provided in the figures below.

Table 5 – Notable System Conditions Following Temporary Bipole Faults

Base Case	Contingency	System Condition
Base Case 4	Temporary Monopole Fault	LIL commutation failures
Base Case 6	Temporary Bipole Fault	UFLS
Base Case 7	Temporary Bipole Fault	UFLS
Base Case 9	Temporary Bipole Fault	UFLS
Base Case 10	Temporary Monopole Fault	LIL commutation failures

The curtailment of ML export helps to maintain system stability and to improve system performance. Appendix D contains transient stability plots demonstrating system performance in all base cases when the ML export is curtailed. In BC6 and BC7, the curtailment of ML export from 500 MW to 250 MW was sufficient to eliminate UFLS. In monopolar cases (BC4 and BC10), ML export must be curtailed to 0 MW to ensure that there are no LIL commutation failures.

It should be noted that the curtailment of ML export resulted in an undamped system response for BC9. However, this base case represents an extreme operating scenario where both the LIL and ML are operating at rated capacity while minimal generation is dispatched within the Interconnected Island System. To avoid such a response, operating limitations must be defined for the system. Such limitations will ensure that extreme operating conditions are avoided and that system performance is acceptable.

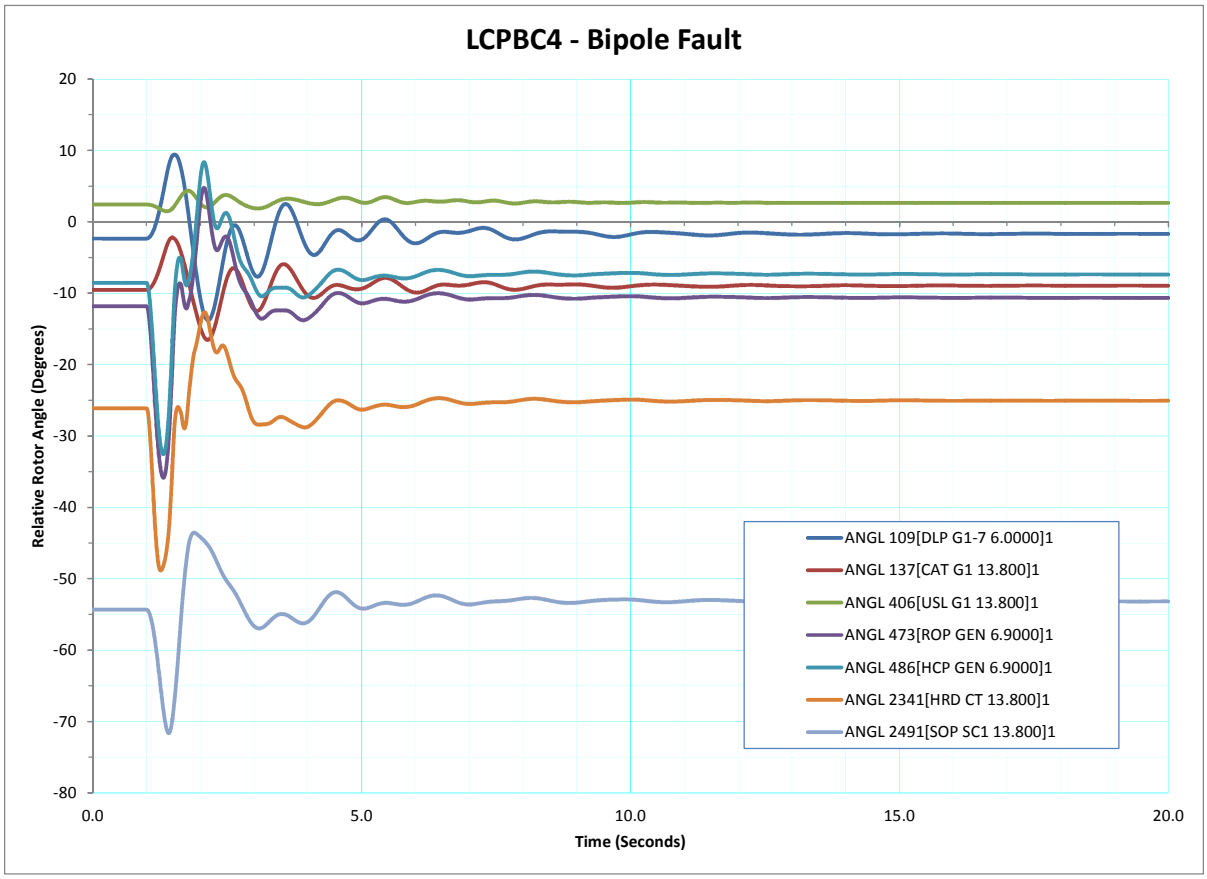

Figure 9 - LCPBC4 - Bipole Fault - Relative Rotor Angle (Degrees)

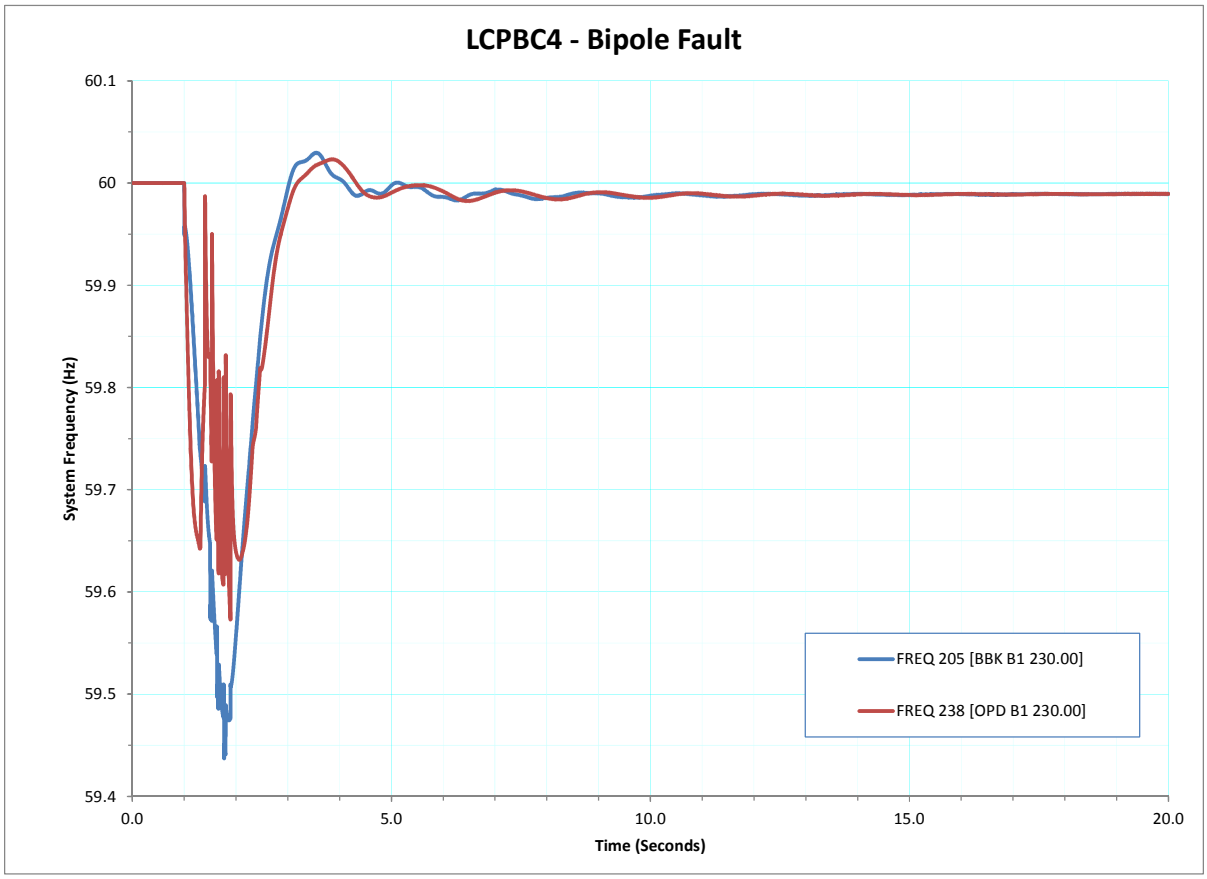

Figure 10 - LCPBC4 - Bipole Fault - System Frequency (Hz)

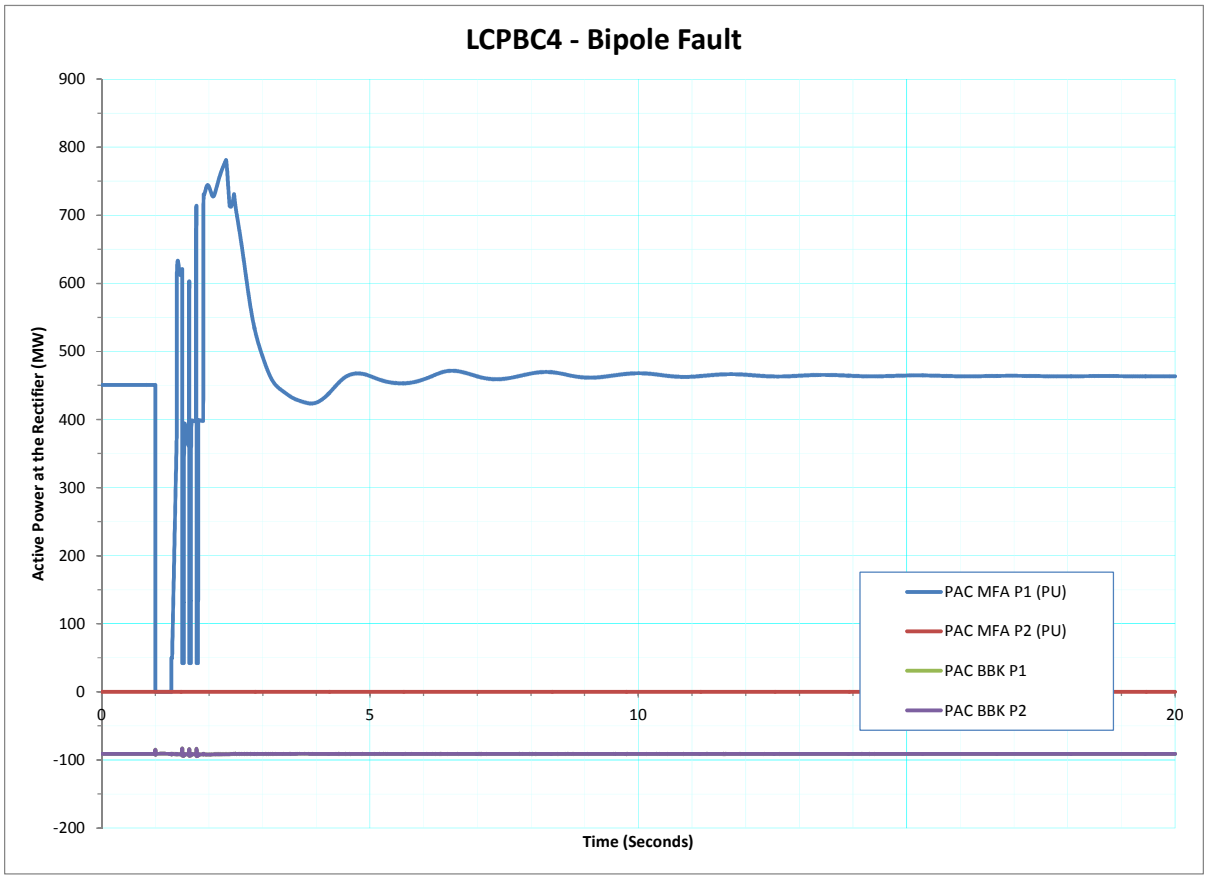

Figure 11 - LCPBC4 - Bipole Fault - Active Power at the Rectifier (MW)

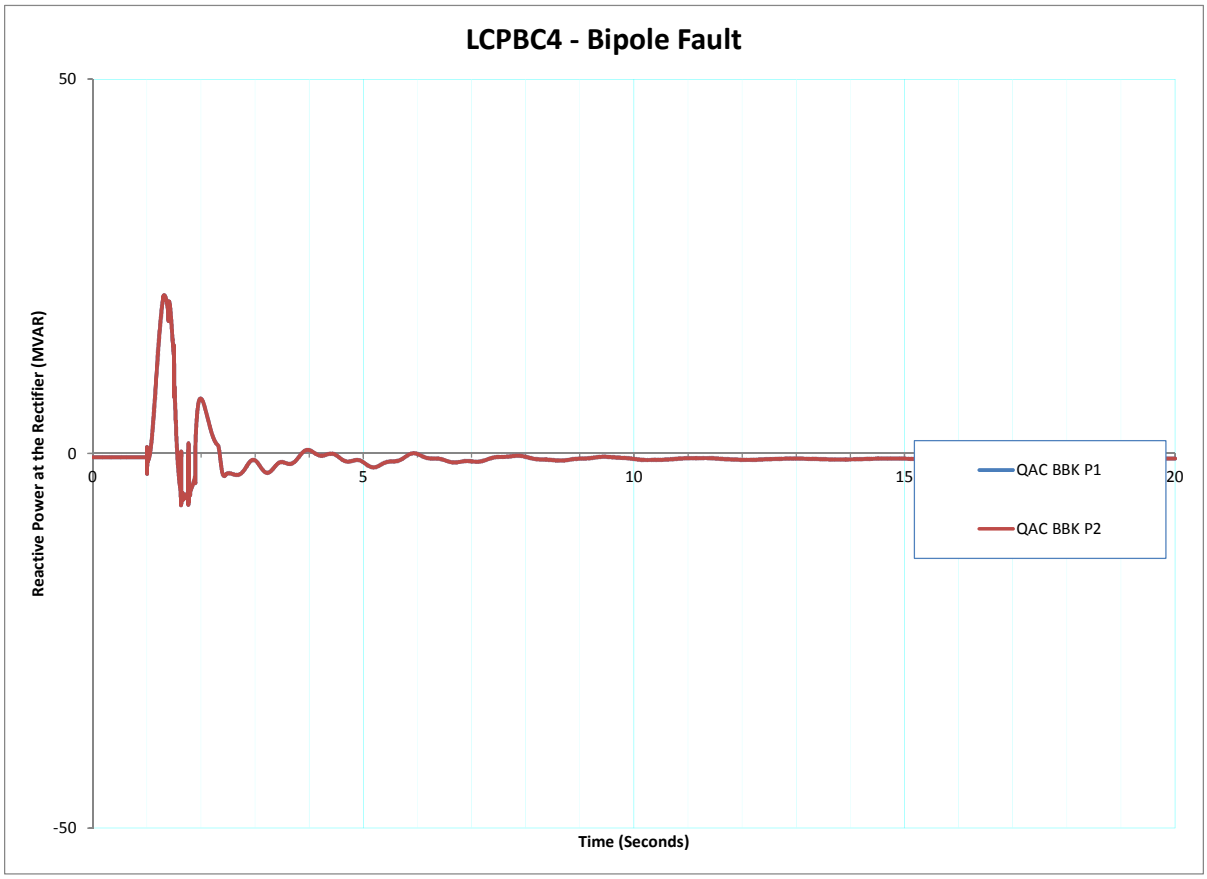

Figure 12 - LCPBC4 - Bipole Fault - Reactive Power at the Rectifier (MVAR)

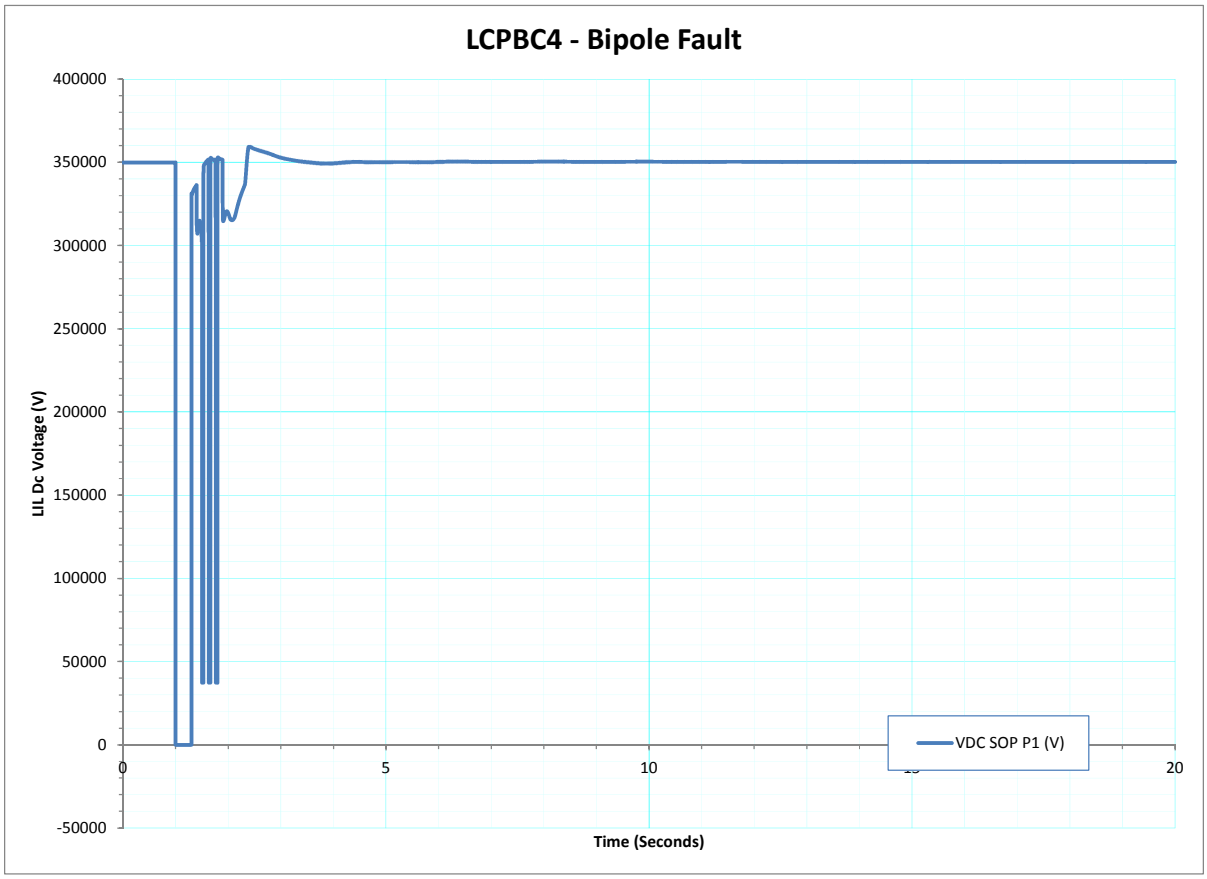

Figure 13 - LCPBC4 - Bipole Fault - LIL Dc Voltage (V)

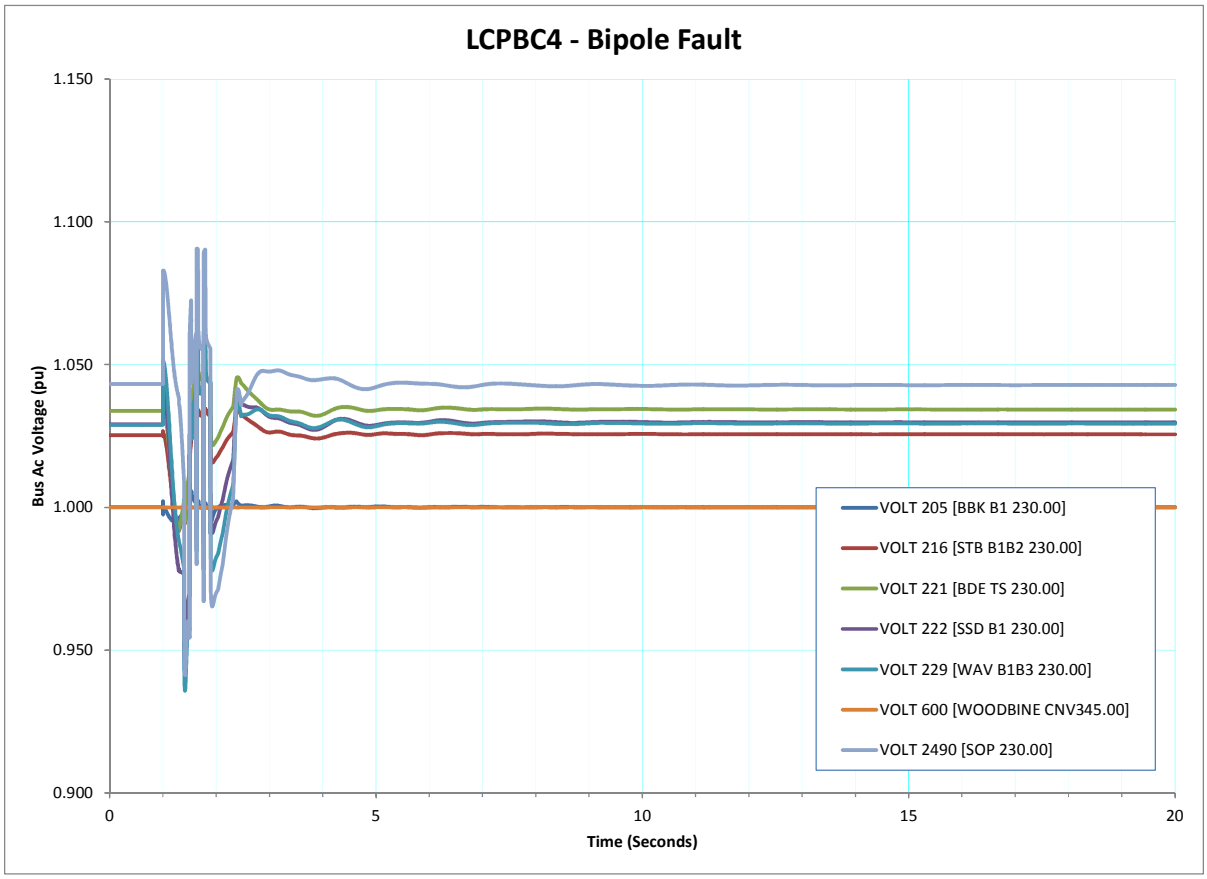

Figure 14 - LCPBC4 - Bipole Fault - Bus Ac Voltage (pu)

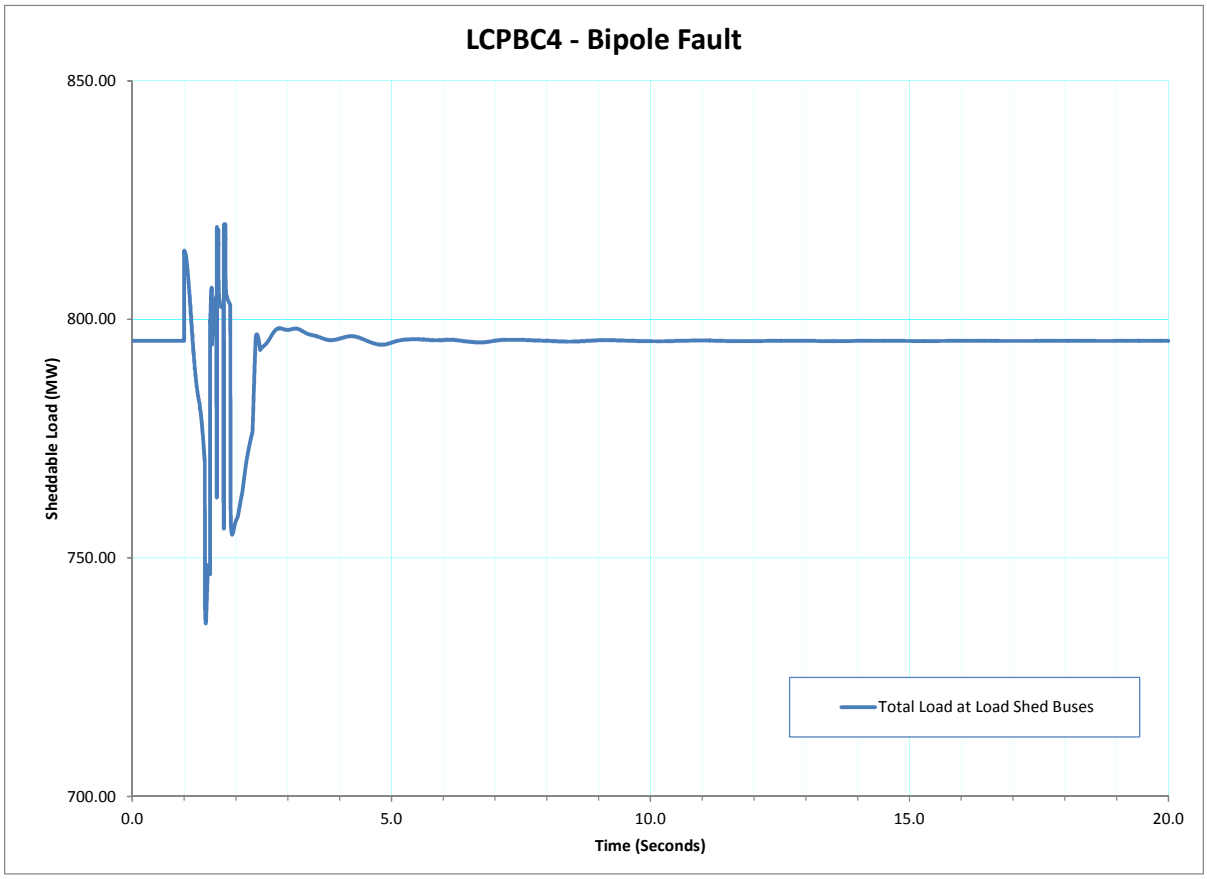

Figure 15 - LCPBC4 - Bipole Fault - Sheddable Load (MW)

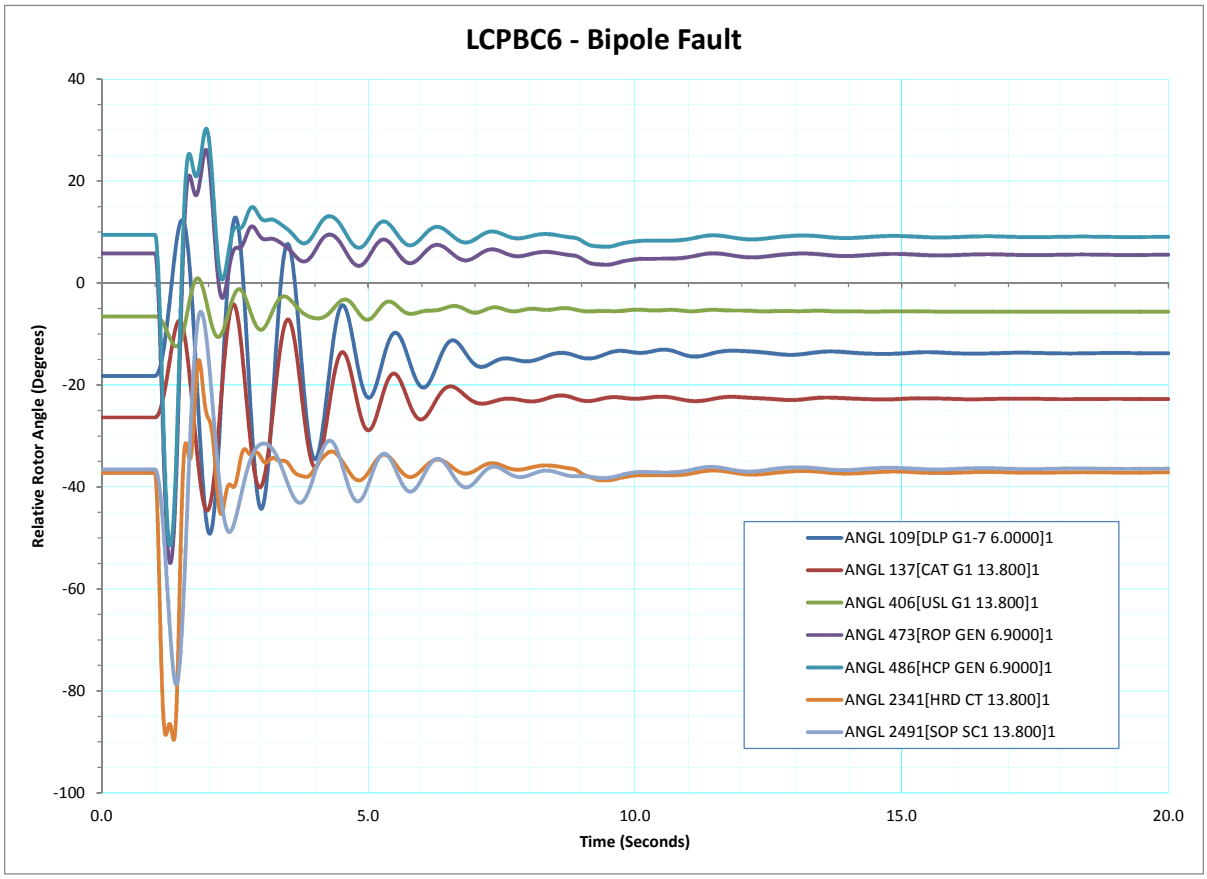

Figure 16 - LCPBC6 - Bipole Fault - Relative Rotor Angle (Degrees)

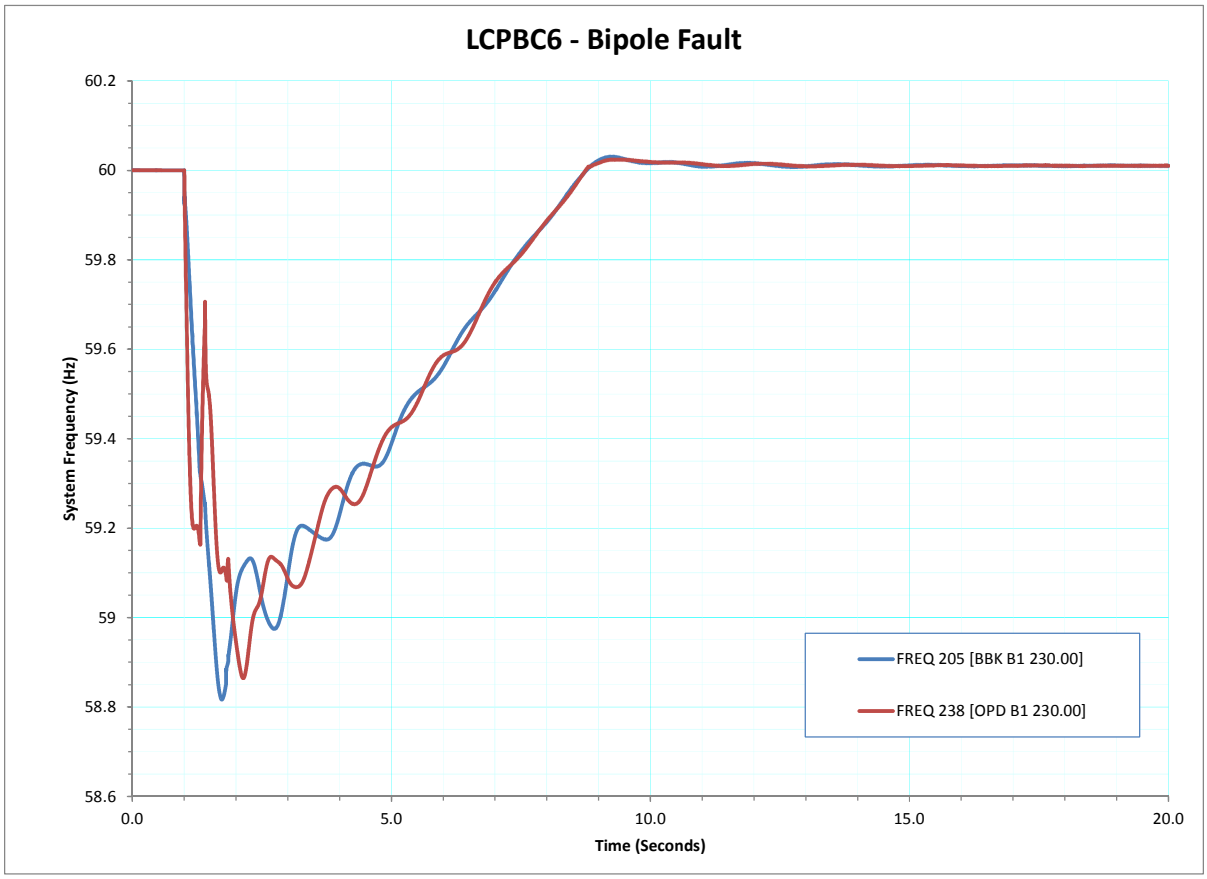

Figure 17 - LCPBC6 - Bipole Fault - System Frequency (Hz)

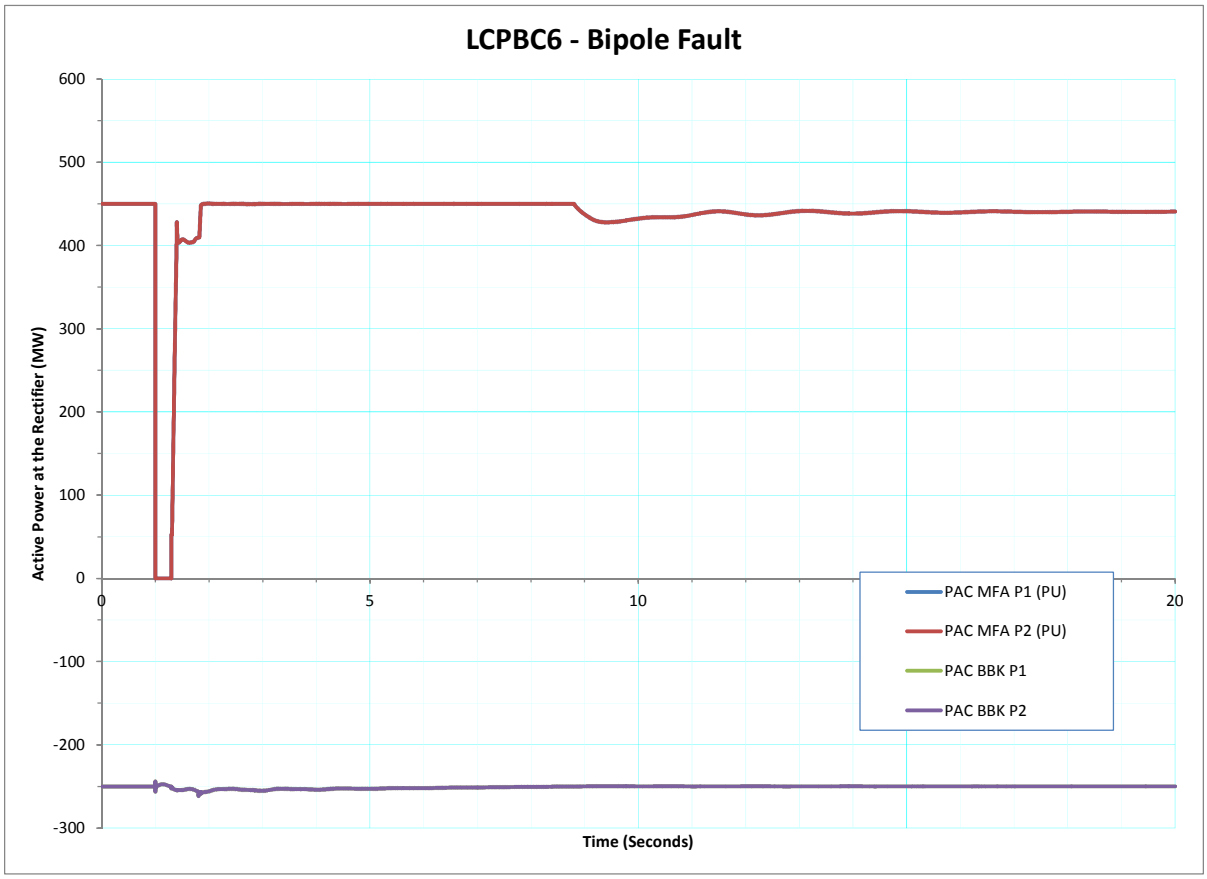

Figure 18 - LCPBC6 - Bipole Fault - Active Power at the Rectifier (MW)

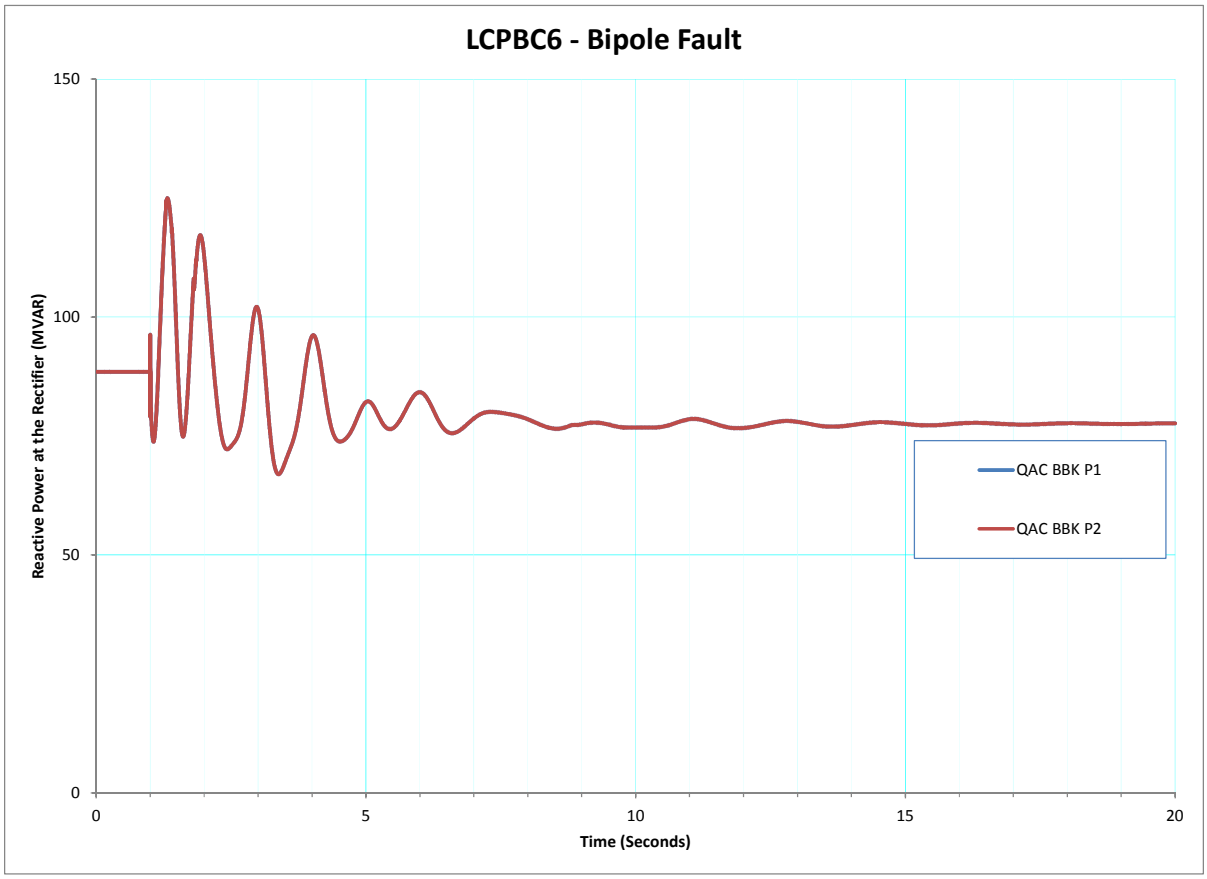

Figure 19 - LCPBC6 - Bipole Fault - Reactive Power at the Rectifier (MVAR)

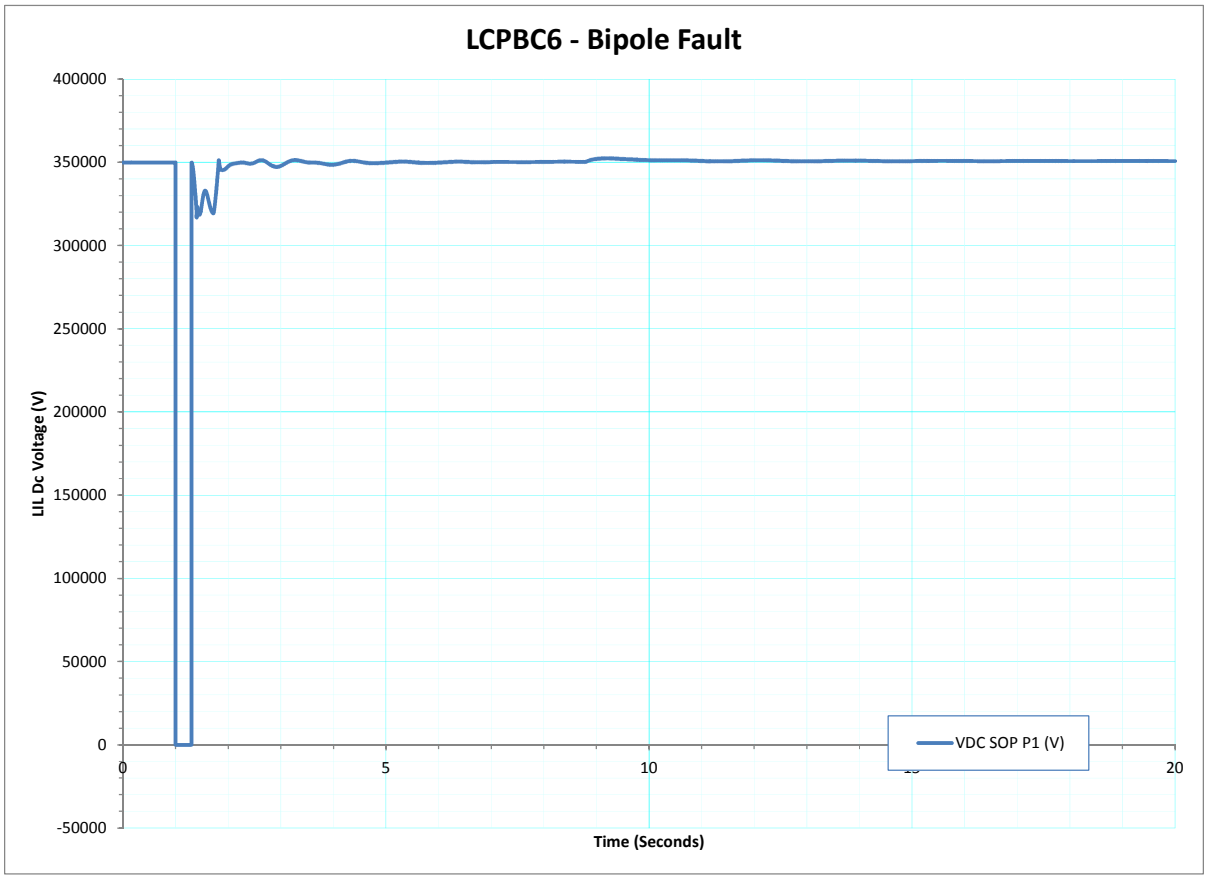

Figure 20 - LCPBC6 - Bipole Fault - LIL Dc Voltage (V)

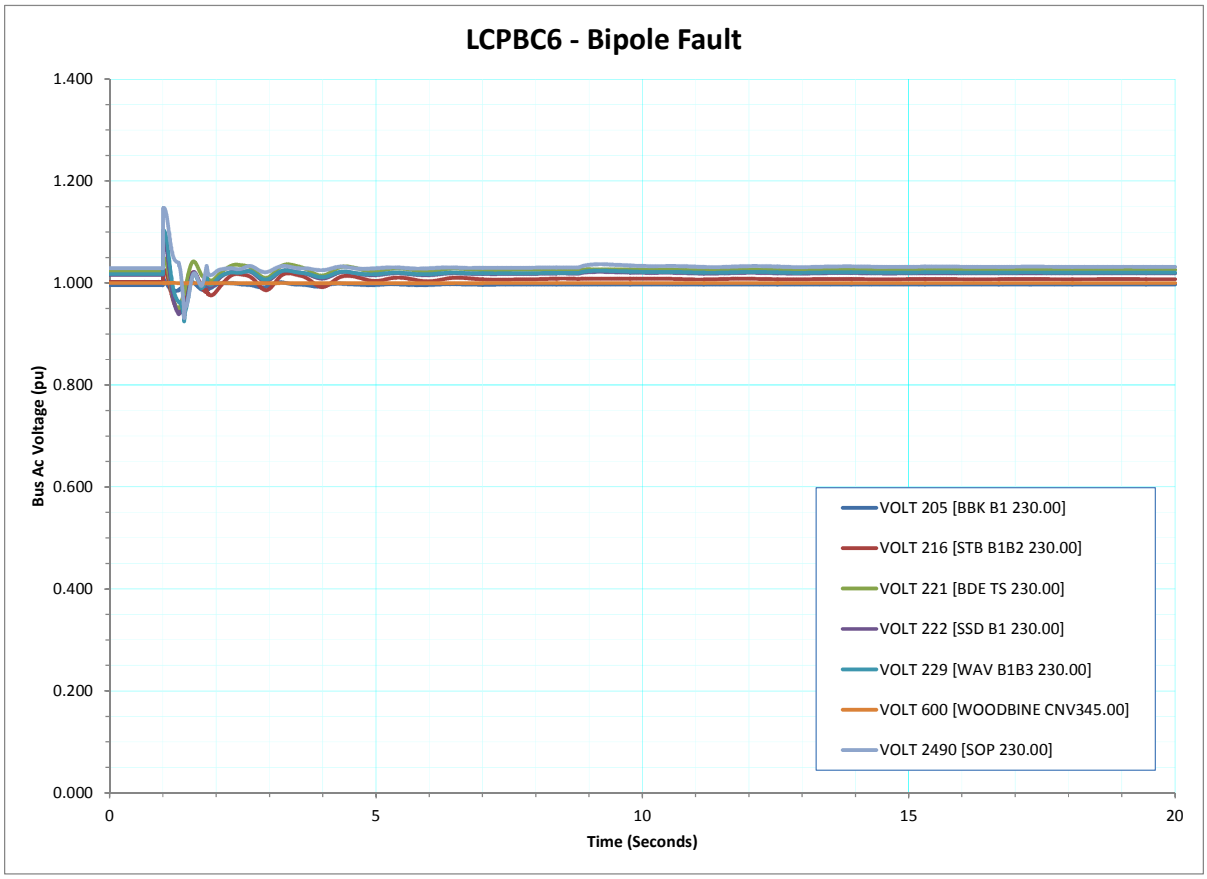

Figure 21 - LCPBC6 - Bipole Fault - Bus Ac Voltage (pu)

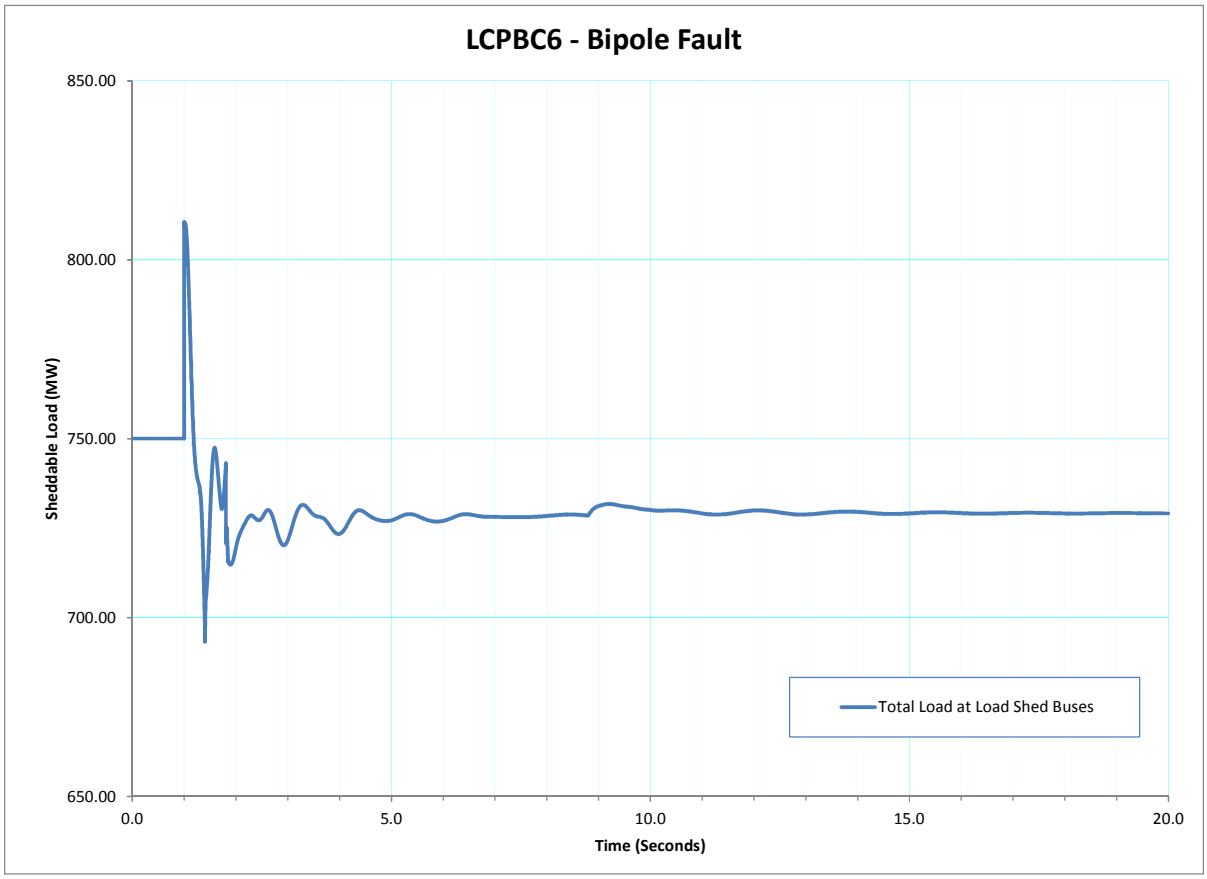

Figure 22 - LCPBC6 - Bipole Fault - Sheddable Load (MW)

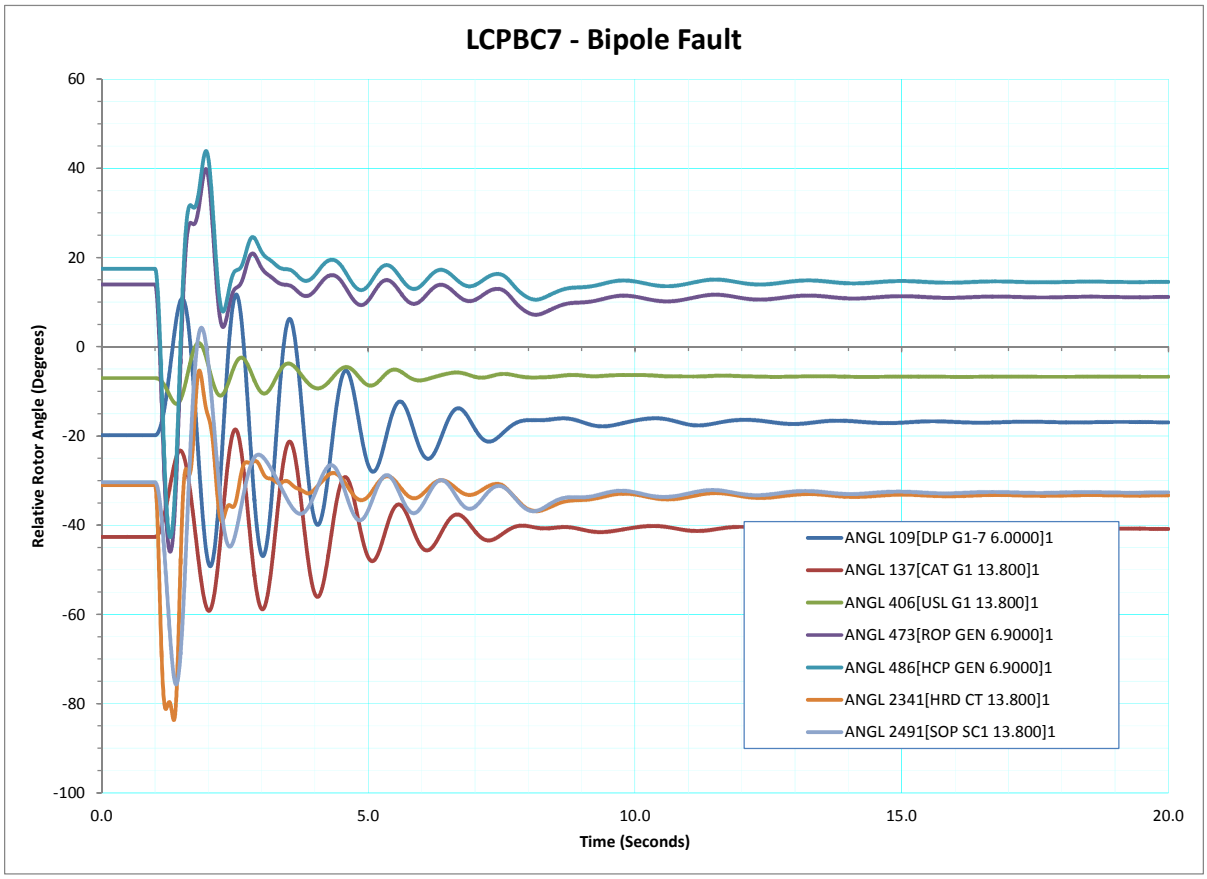

Figure 23 - LCPBC7 - Bipole Fault - Relative Rotor Angle (Degrees)

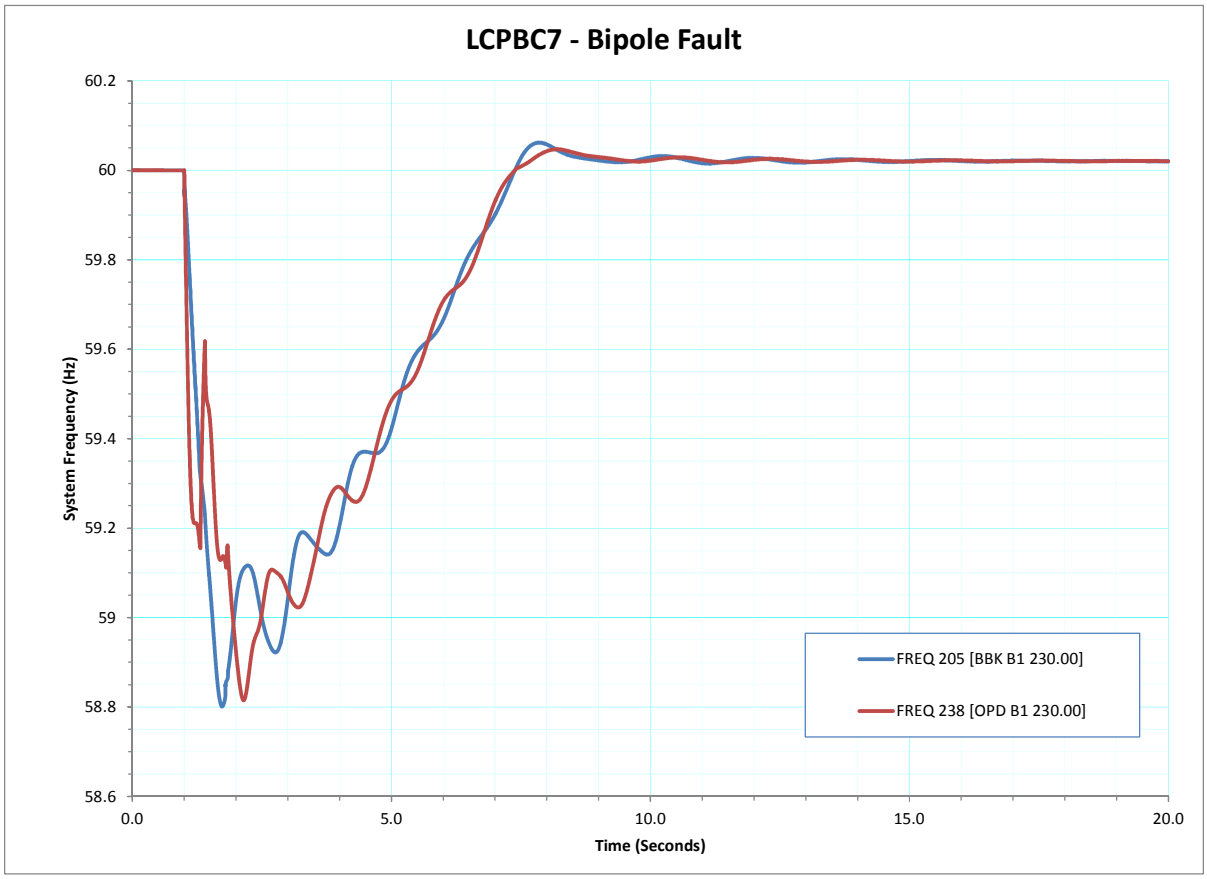

Figure 24 - LCPBC7 - Bipole Fault - System Frequency (Hz)

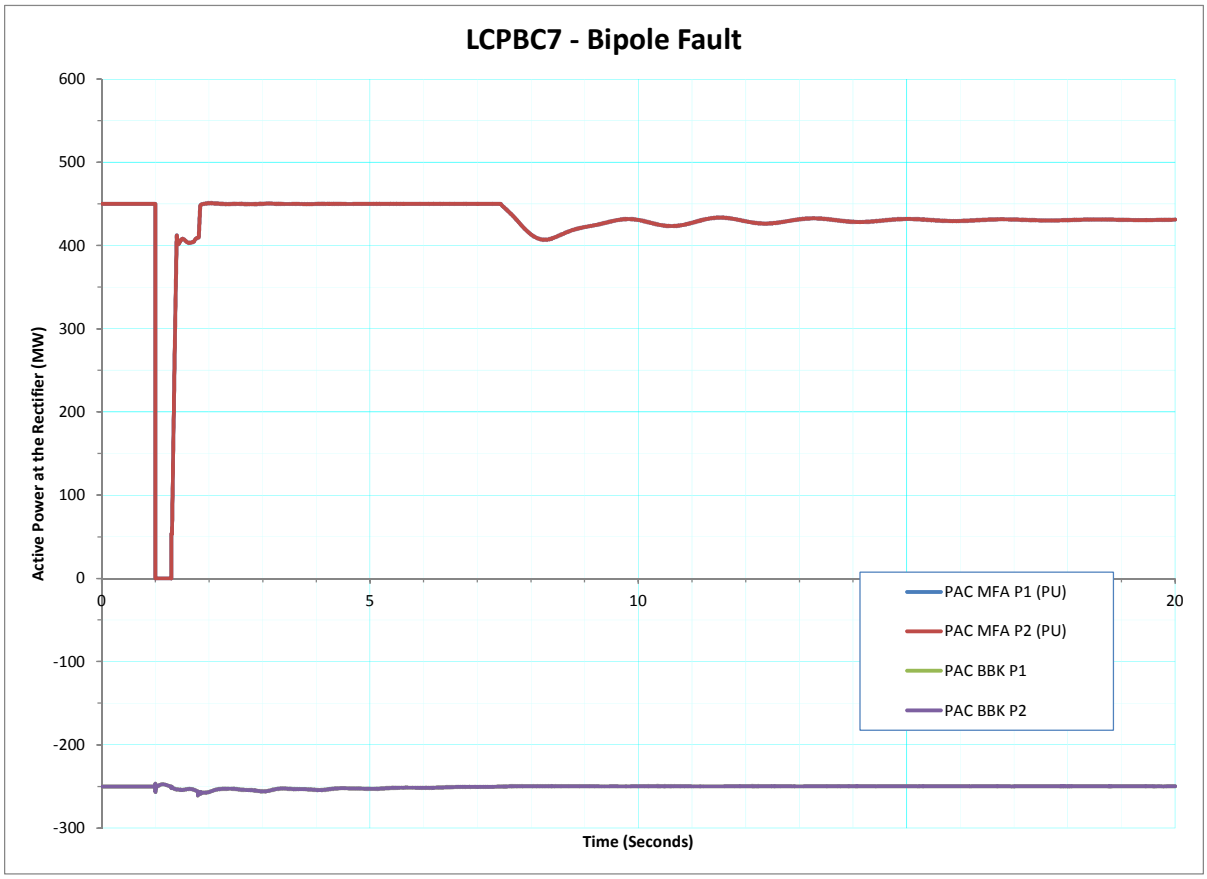

Figure 25 - LCPBC7 - Bipole Fault - Active Power at the Rectifier (MW)

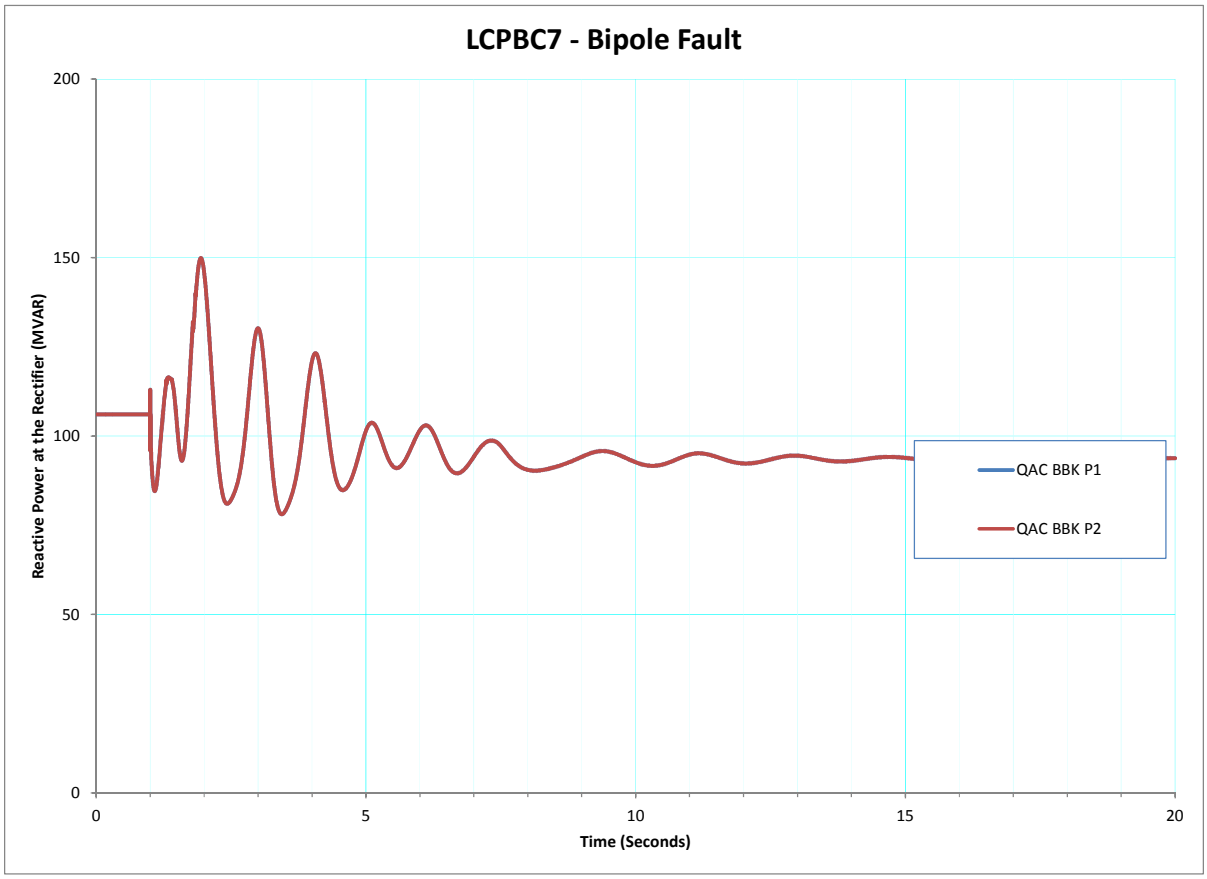

Figure 26 - LCPBC7 - Bipole Fault - Reactive Power at the Rectifier (MVAR)

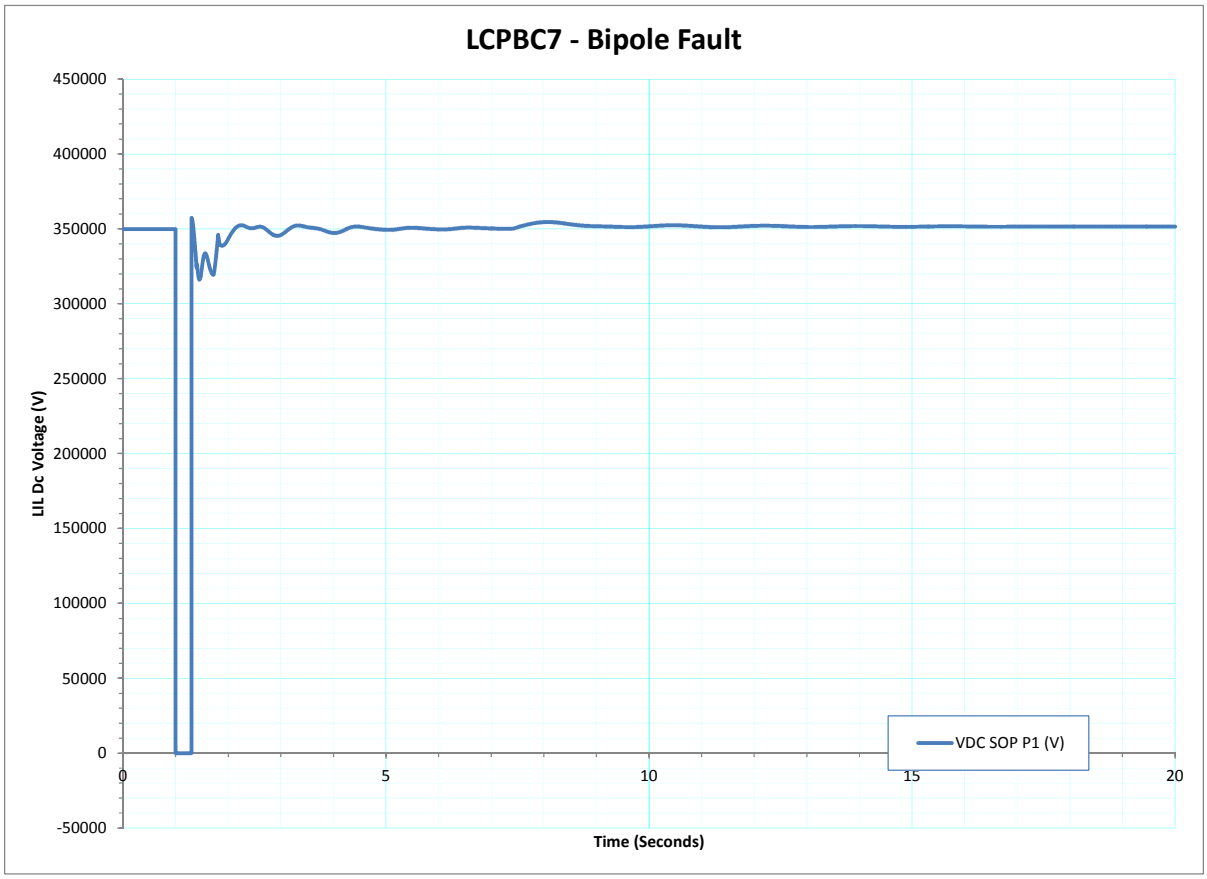

Figure 27 - LCPBC7 - Bipole Fault - LIL Dc Voltage (V)

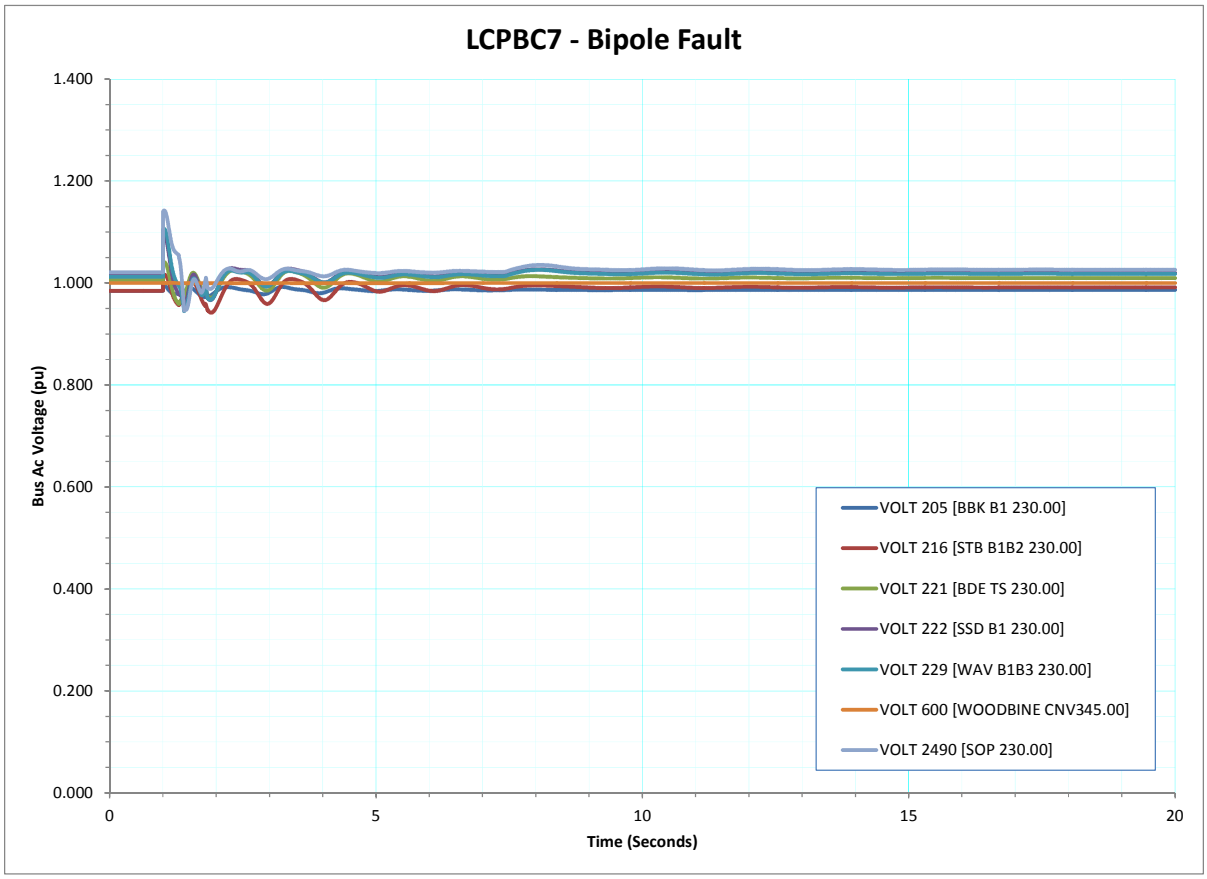

Figure 28 - LCPBC7 - Bipole Fault - Bus Ac Voltage (pu)

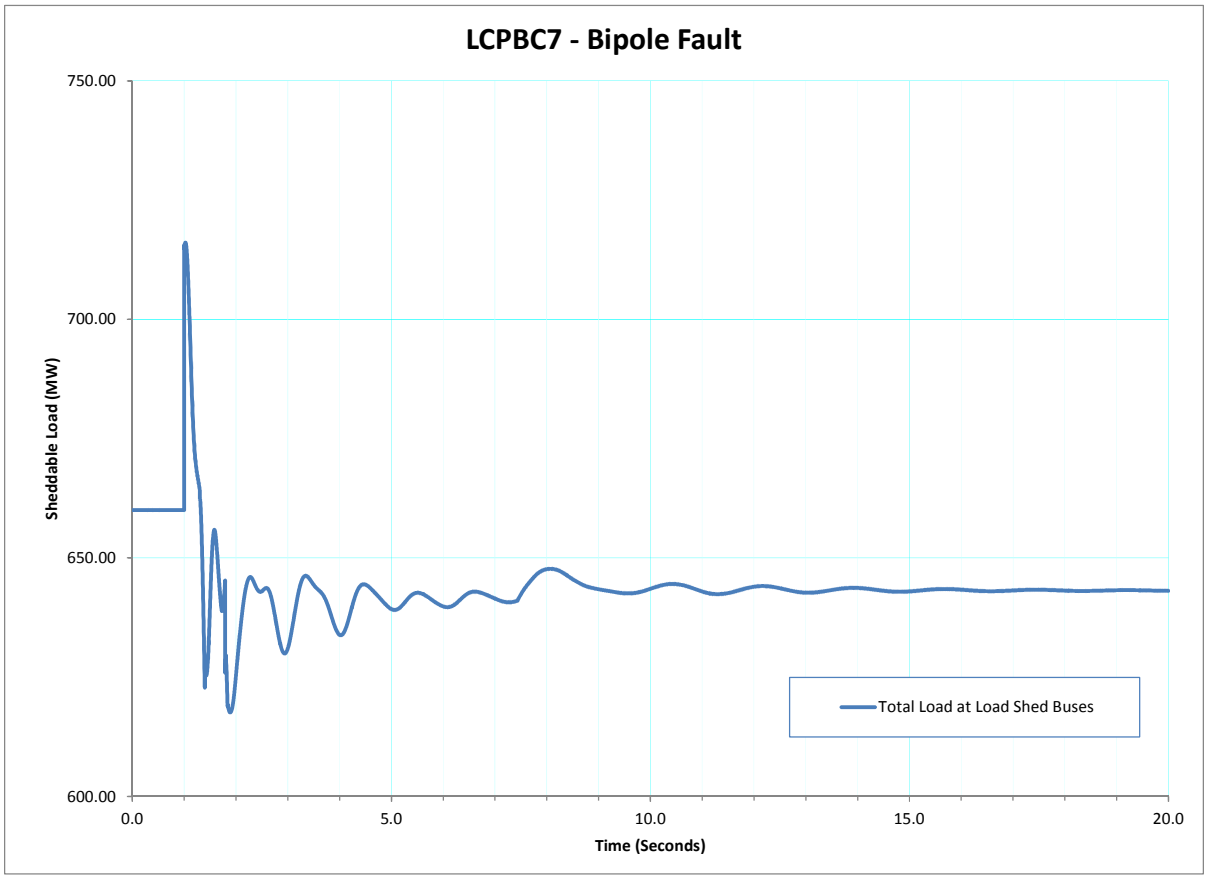

Figure 29 - LCPBC7 - Bipole Fault - Sheddable Load (MW)

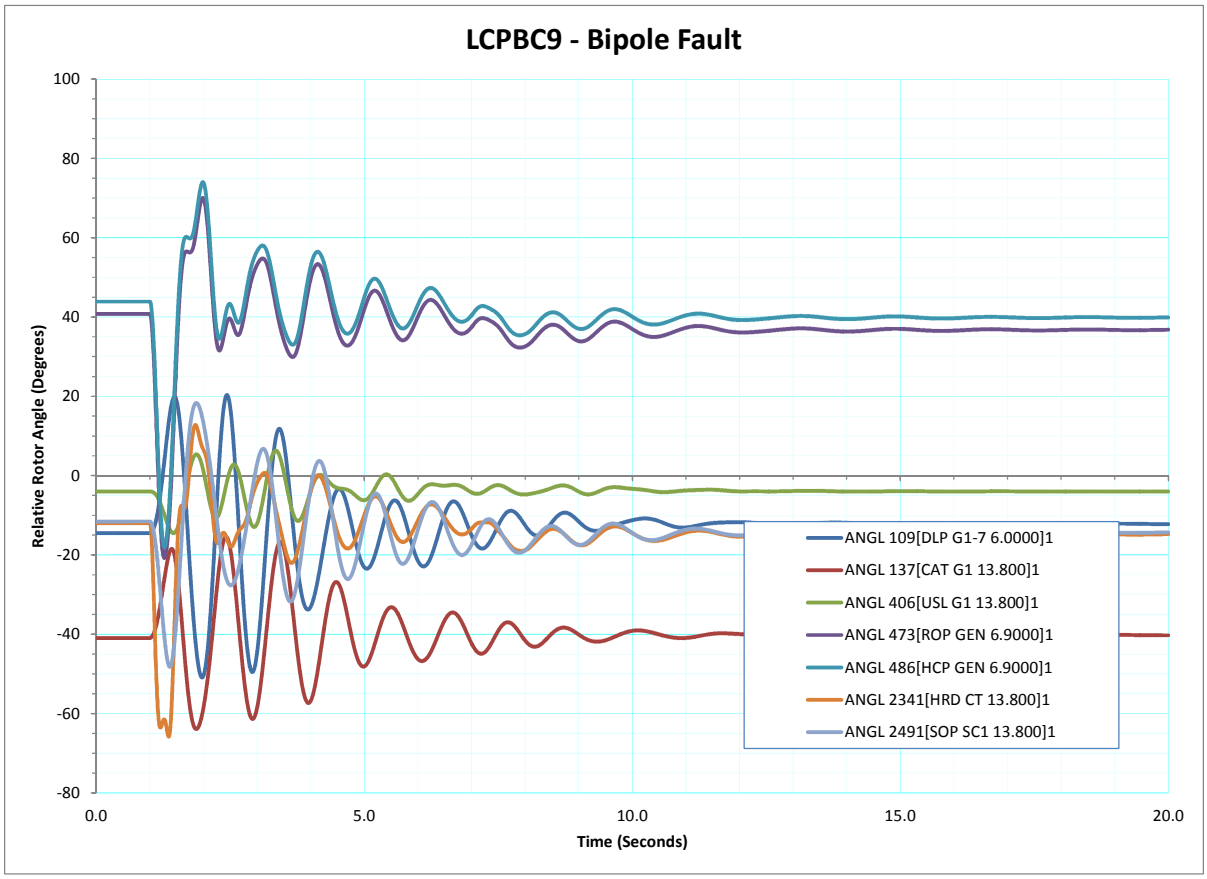

Figure 30 - LCPBC9 - Bipole Fault - Relative Rotor Angle (Degrees)

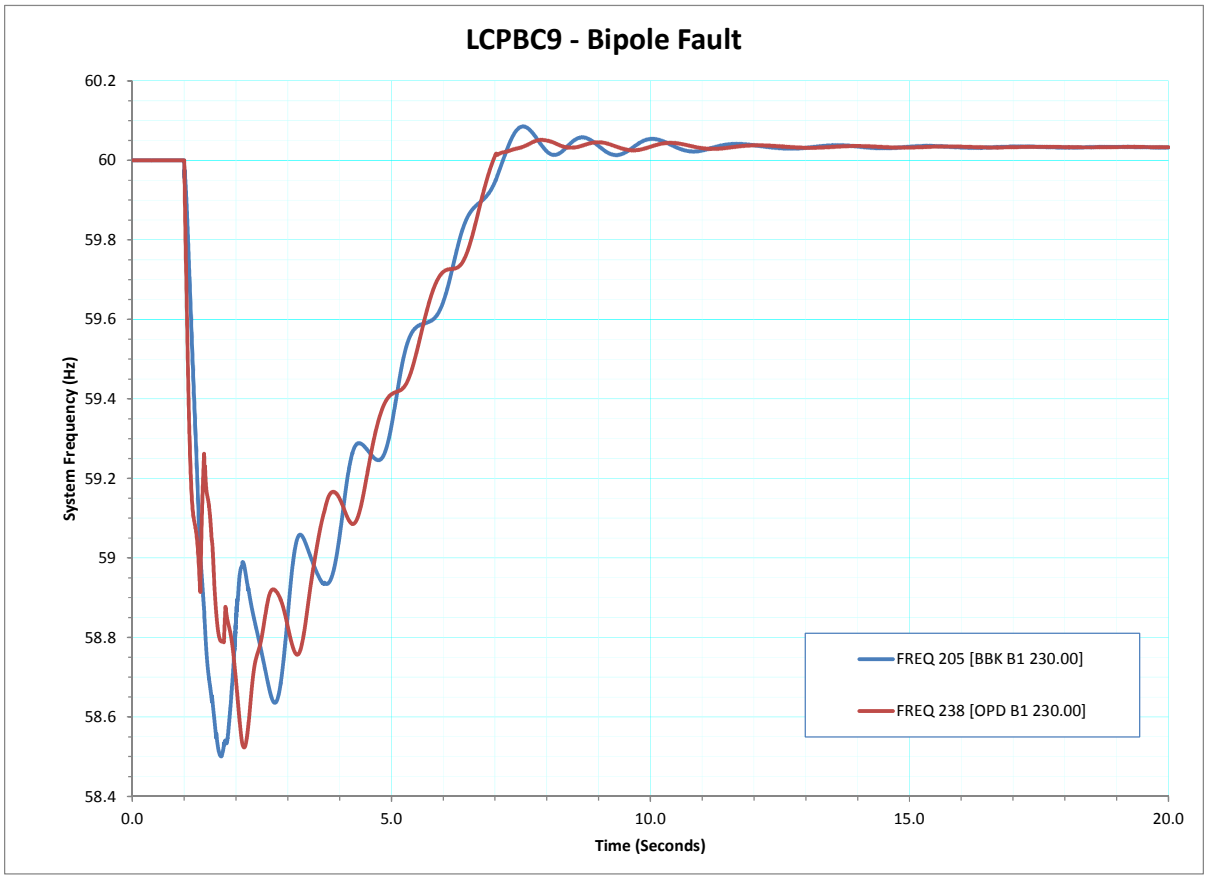

Figure 31 - LCPBC9 - Bipole Fault - System Frequency (Hz)

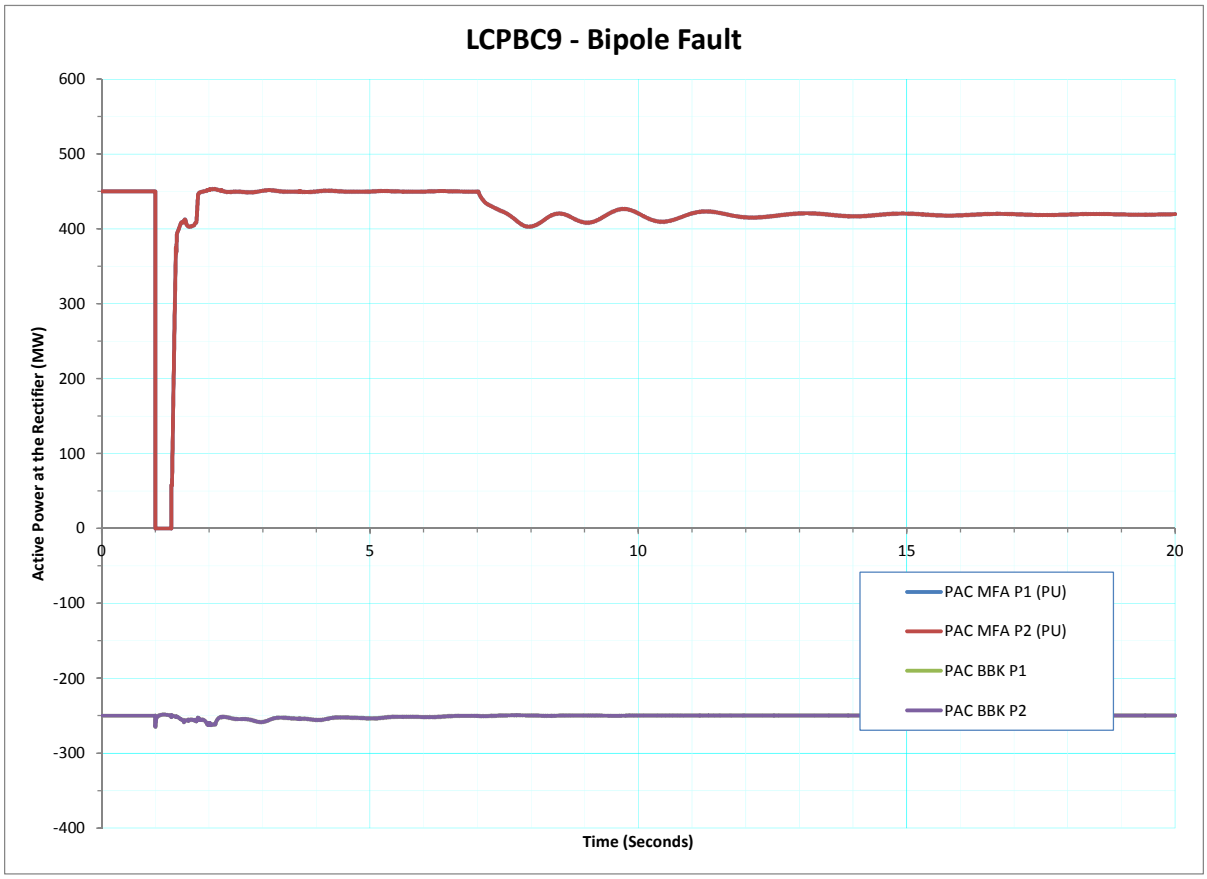

Figure 32 - LCPBC9 - Bipole Fault - Active Power at the Rectifier (MW)

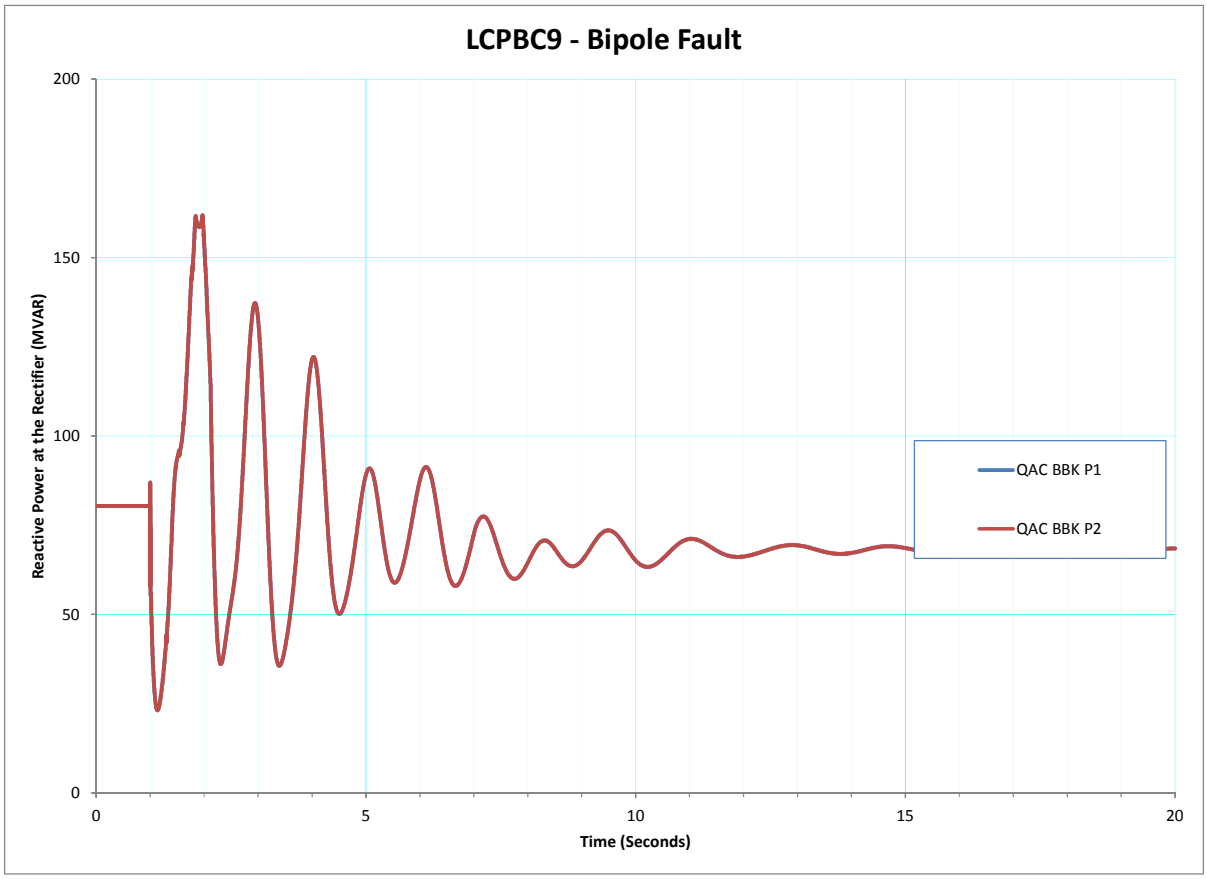

Figure 33 - LCPBC9 - Bipole Fault - Reactive Power at the Rectifier (MVAR)

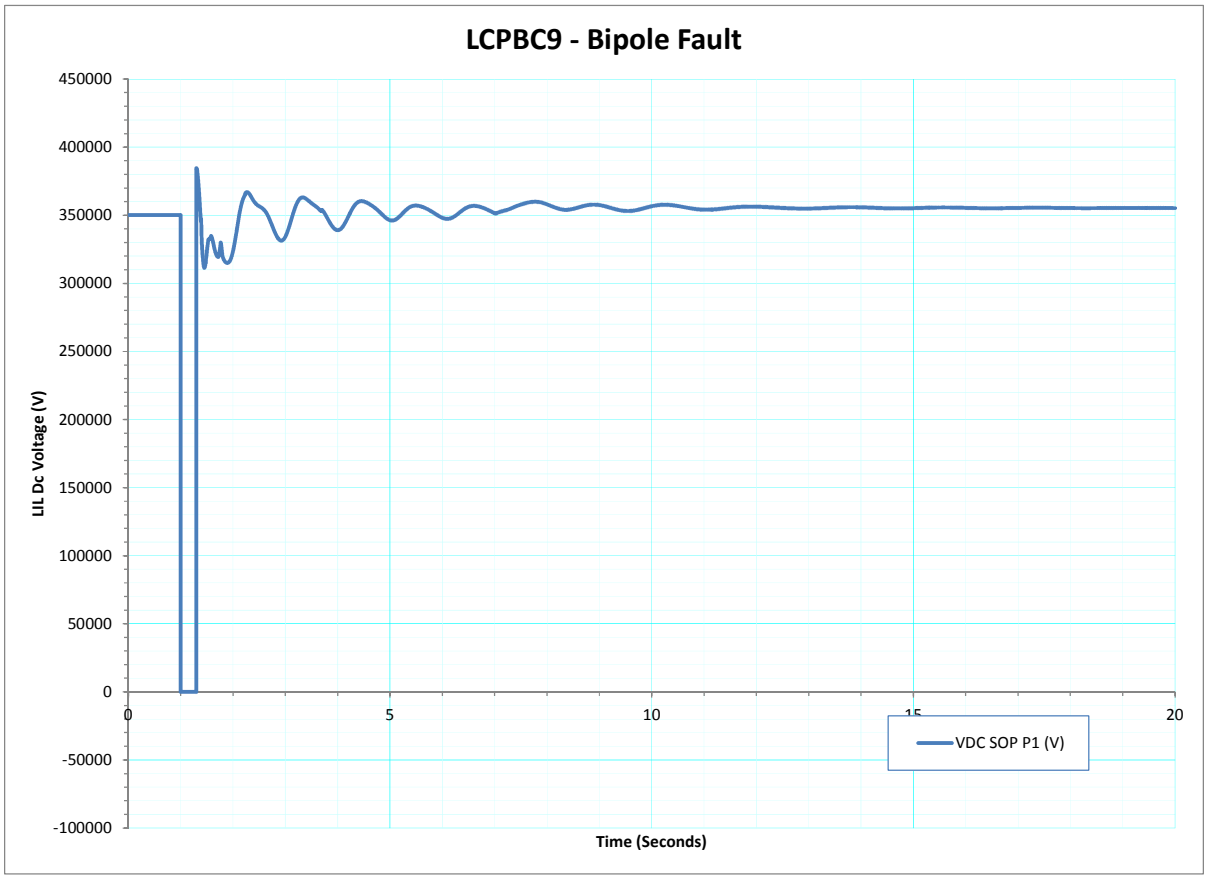

Figure 34 - LCPBC9 - Bipole Fault - LIL Dc Voltage (V)

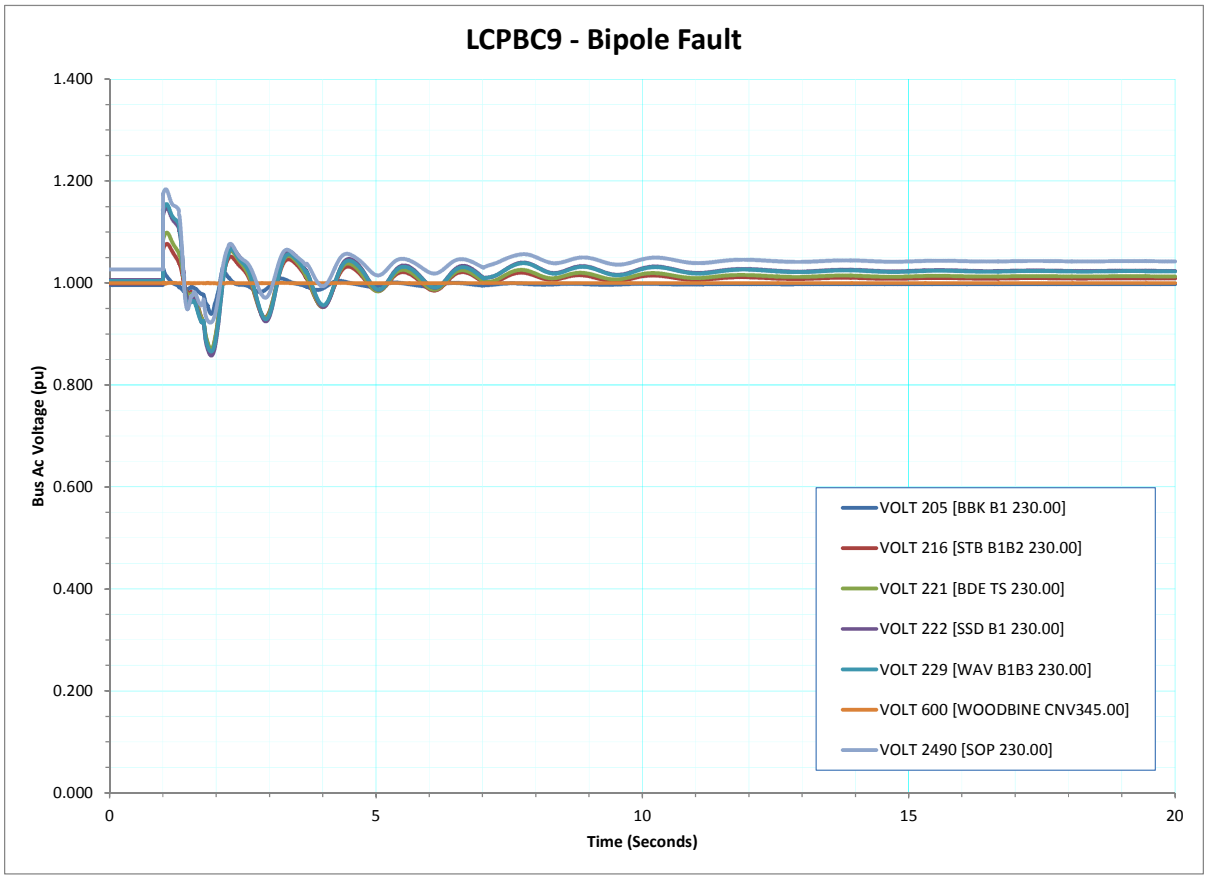

Figure 35 - LCPBC9 - Bipole Fault - Bus Ac Voltage (pu)

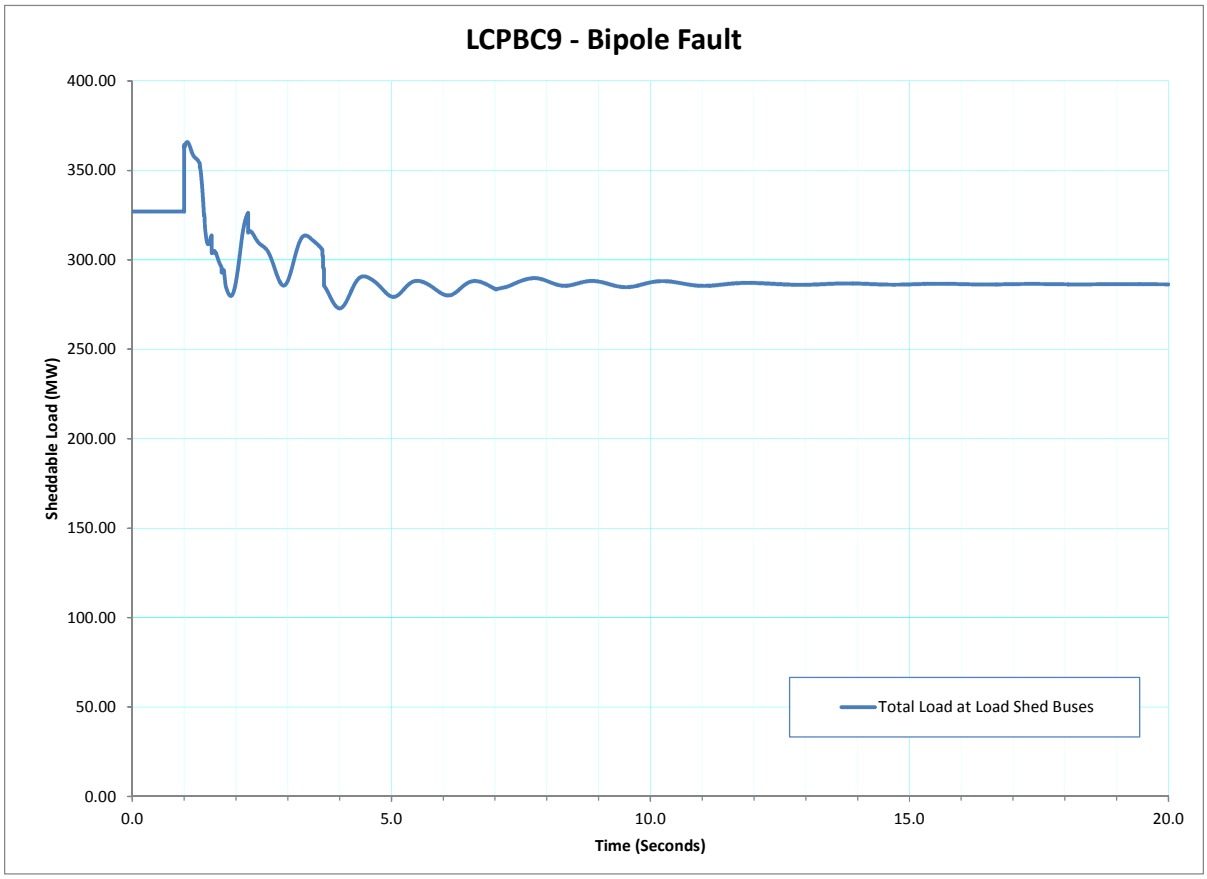

Figure 36 - LCPBC9 - Bipole Fault - Sheddable Load (MW)

5.4. PERMANENT POLE FAULTS

Analysis indicated that underfrequency load shedding and instability can result from the permanent loss of a pole on the LIL if no remedial action is taken with respect to ML export. These results are listed in Table 6.

Table 6 – Notable System Conditions Following Permanent Pole Faults

Base Case	Contingency	System Condition
Base Case 1	Permanent Pole Fault	UFLS
Base Case 2	Permanent Pole Fault	UFLS
Base Case 3	Permanent Pole Fault	UFLS
Base Case 4	Permanent Pole Fault	f < 58 Hz
Base Case 6	Permanent Pole Fault	UFLS
Base Case 7	Permanent Pole Fault	UFLS
Base Case 8	Permanent Pole Fault	UFLS
Base Case 9	Permanent Pole Fault	UFLS
Base Case 10	Permanent Pole Fault	Instability

Instability was found in BC10, a monopolar cases where 550 MW is being imported over the LIL, while 500 MW is exported over the ML. This instability is illustrated in the figures below.

It should be noted that for all other cases (with the exception of BC11) the permanent loss of a pole results in underfrequency load shedding within the Island Interconnected System if ML export is not curtailed. Appendix E illustrates how underfrequency load shedding can

be avoided in all base cases if the ML export is curtailed. In Base Cases 6, 7, 8, and 9, where ML export is at 500 MW, curtailing export to 250 MW is sufficient to avoid underfrequency load shedding. In other cases, ML export is below 250 MW and must be reduced to 0 MW.

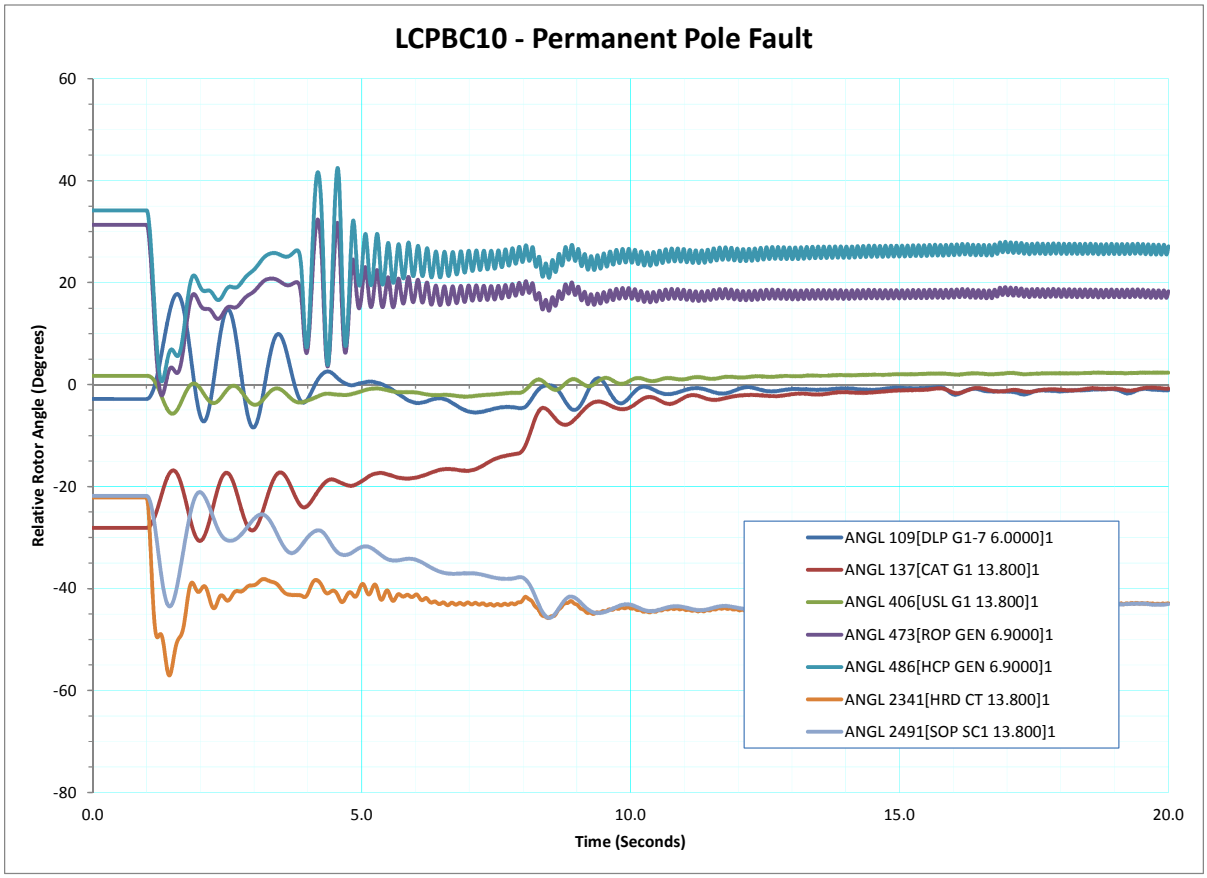

Figure 37 - LCPBC10 - Permanent Pole Fault - Relative Rotor Angle (Degrees)

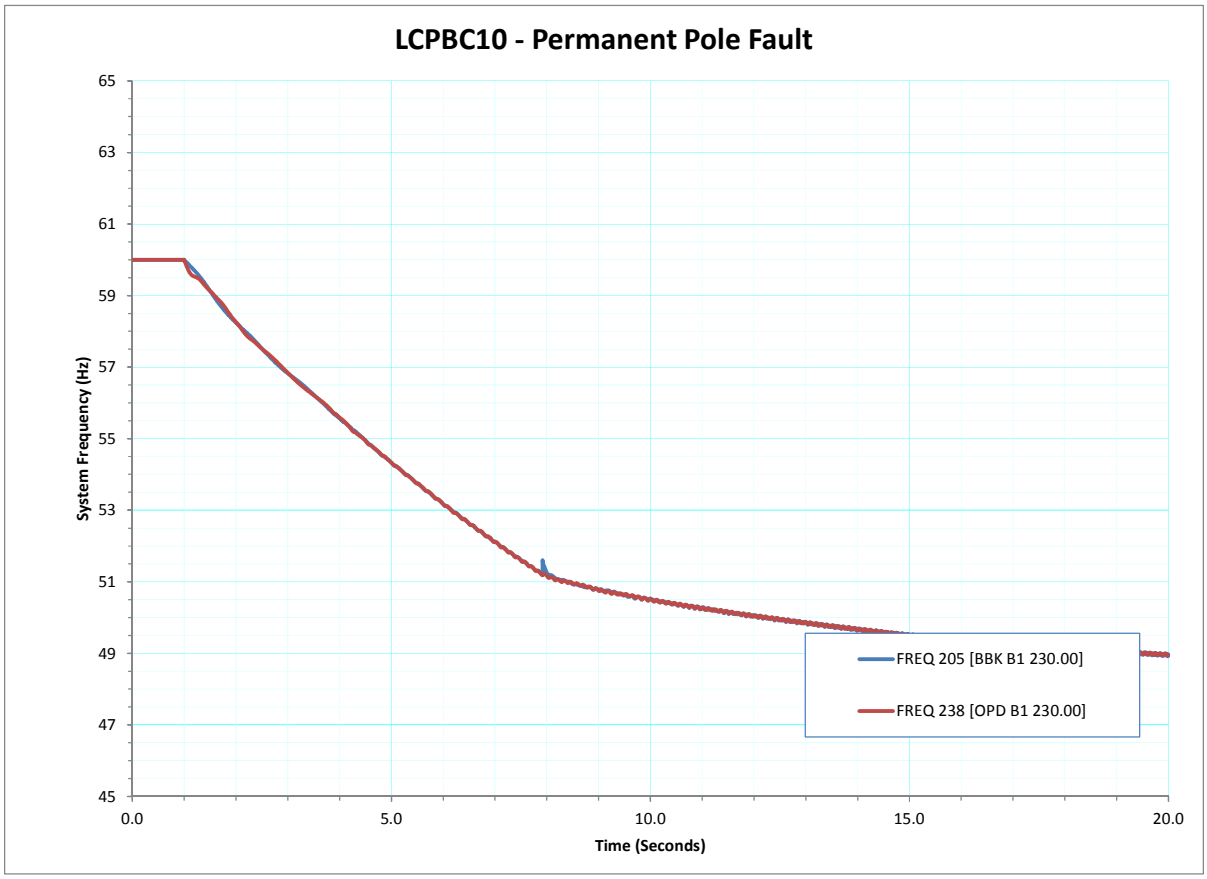

Figure 38 - LCPBC10 - Permanent Pole Fault - System Frequency (Hz)

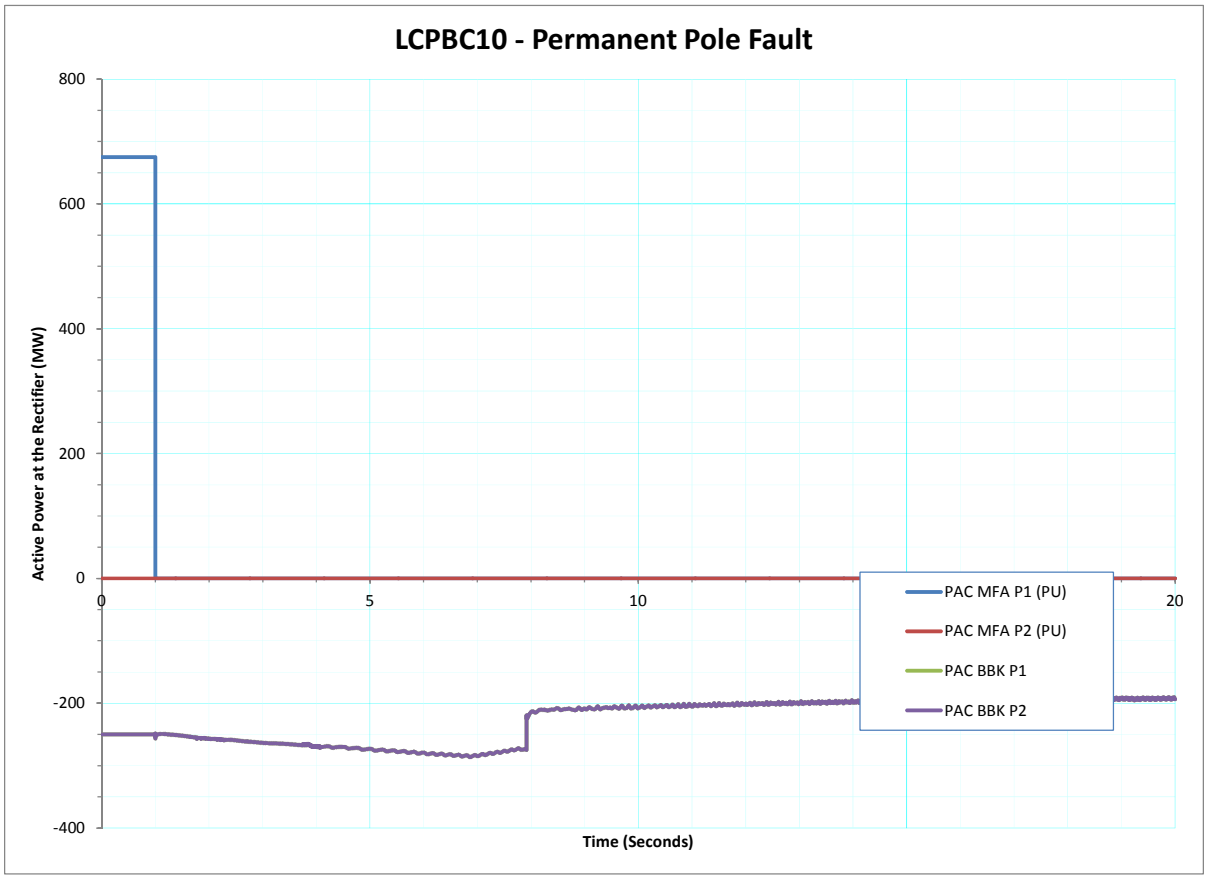

Figure 39 - LCPBC10 - Permanent Pole Fault - Active Power at the Rectifier (MW)

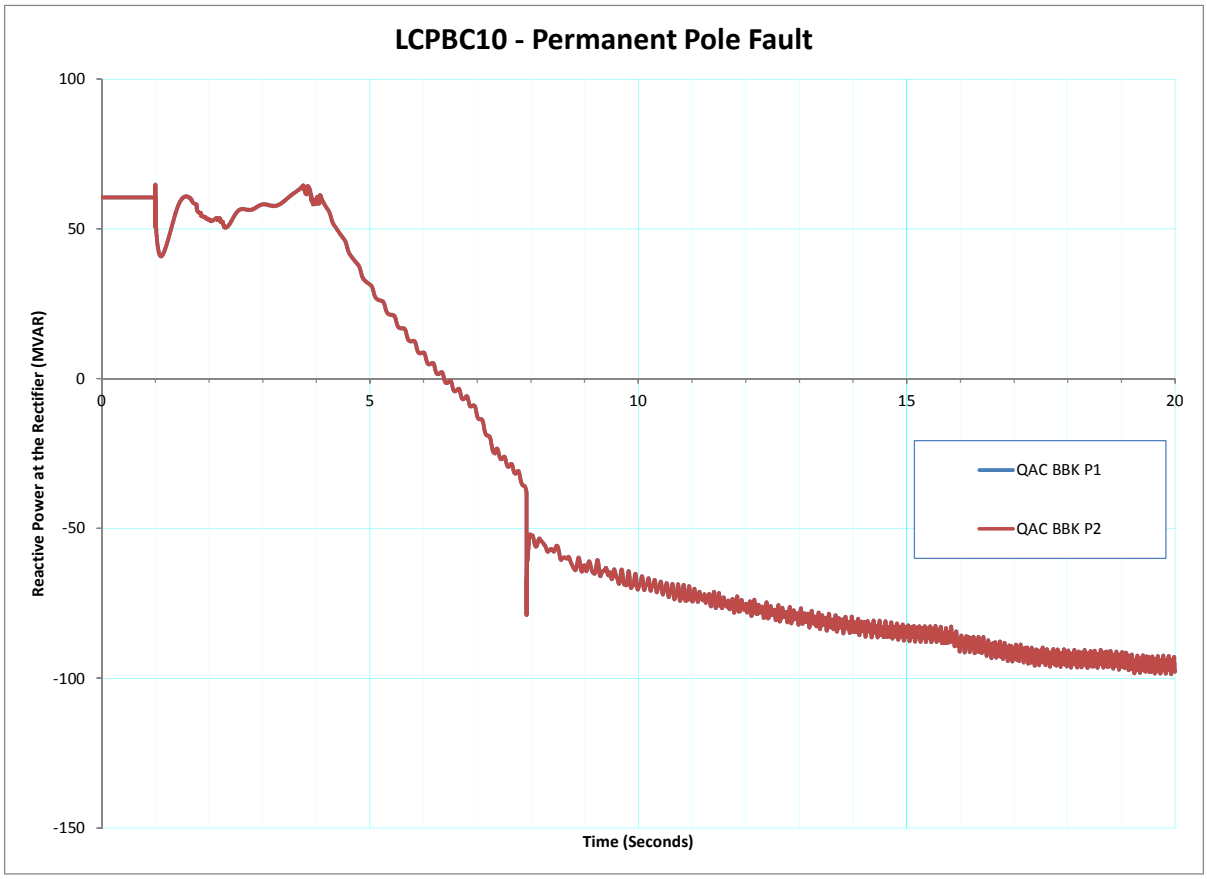

Figure 40 - LCPBC10 - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

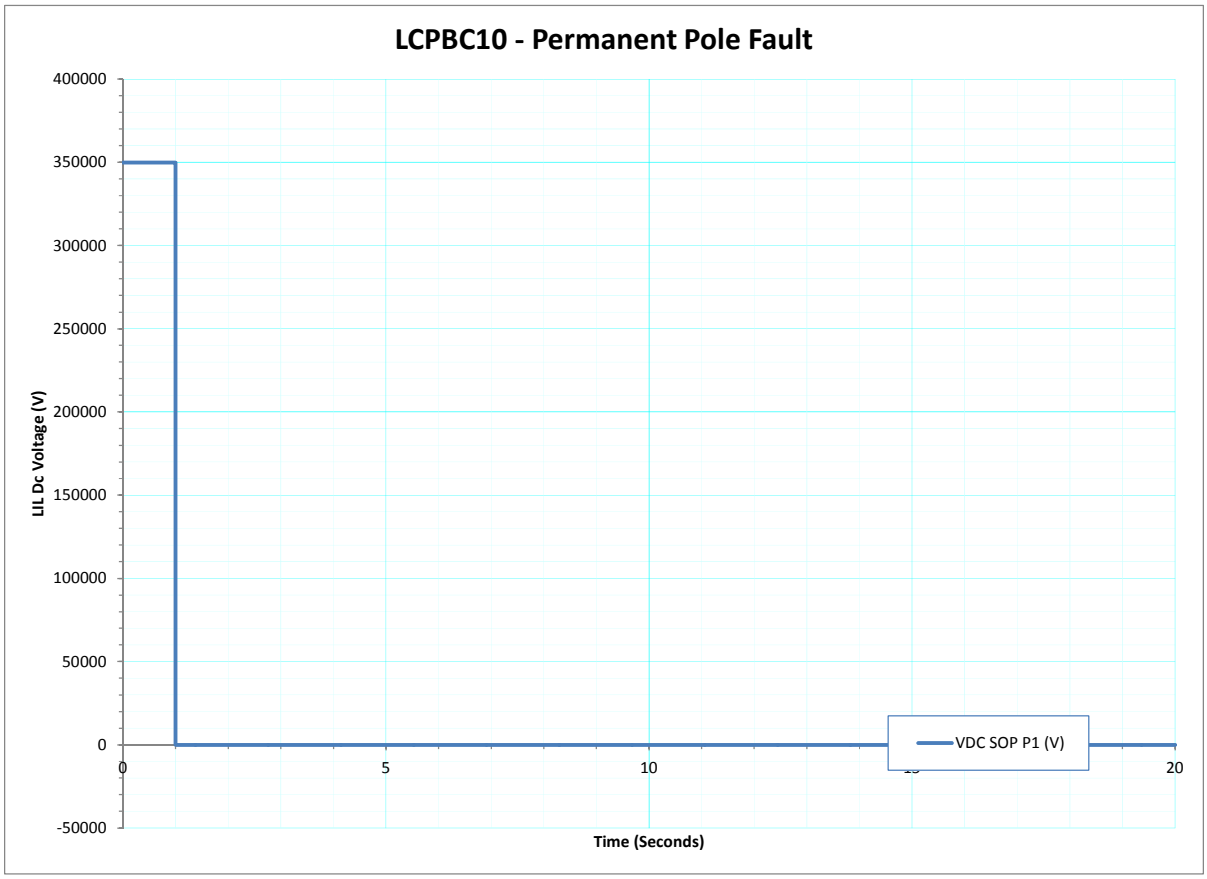

Figure 41 - LCPBC10 - Permanent Pole Fault - LIL Dc Voltage (V)

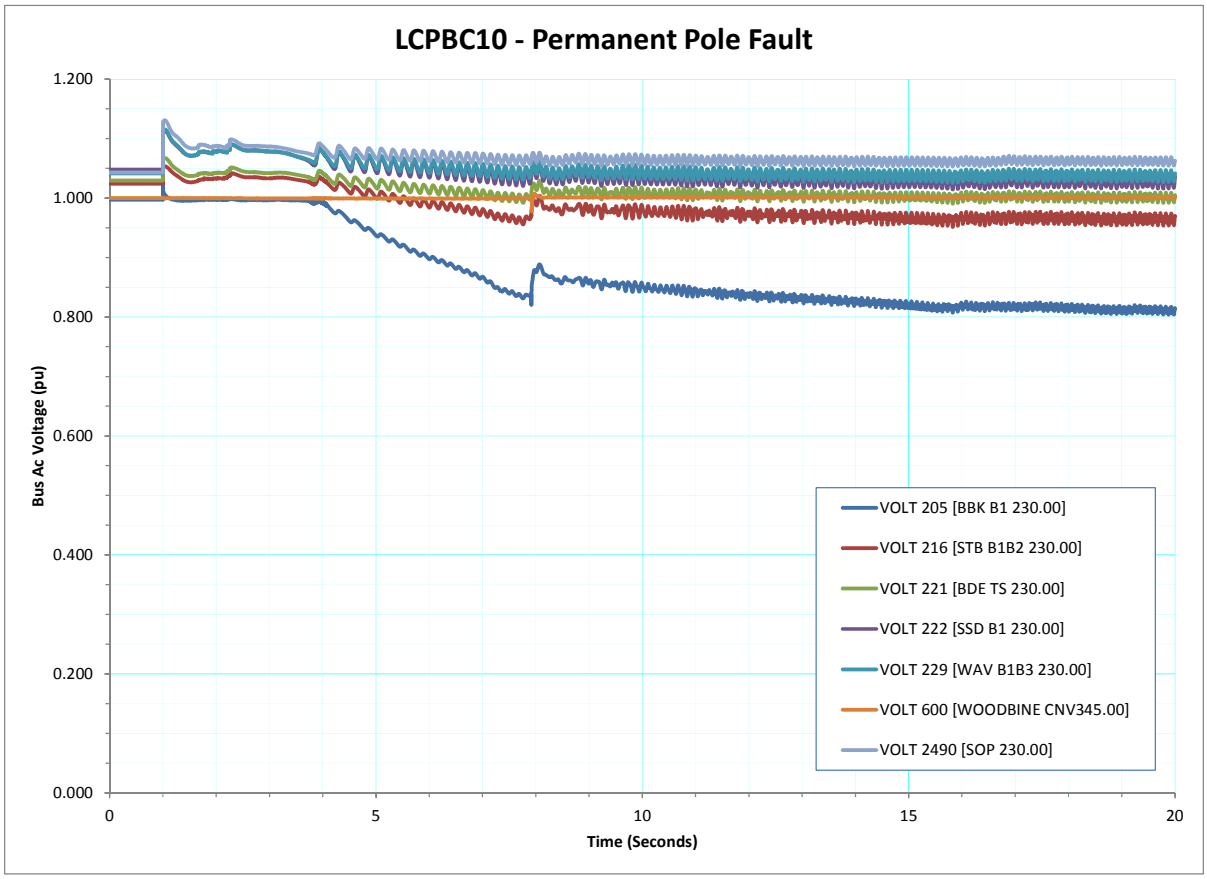

Figure 42 - LCPBC10 - Permanent Pole Fault - Bus Ac Voltage (pu)

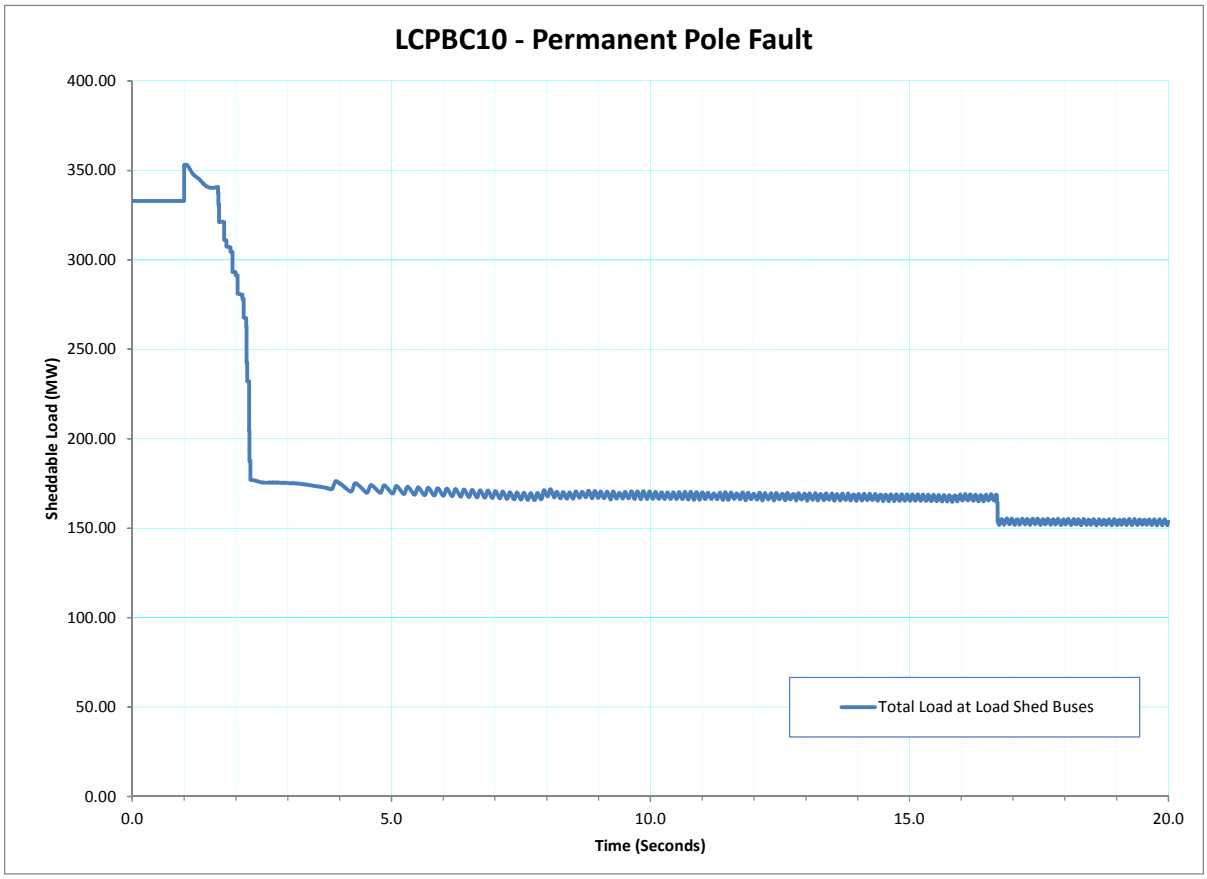

Figure 43 - LCPBC10 - Permanent Pole Fault - Sheddable Load (MW)

5.5. LOSS OF GENERATION WITHIN THE ISLAND SYSTEM

When the LIL is operating at or near rated capacity, the loss of generation within the Island Interconnected Transmission System results in UFLS. This was found to be the case for contingencies involving the loss of generation at USL, BDE, or the isolation of Cat Arm (CAT) generation during the tripping of TL248 and cross-tripping of TL247[5]. These cases are listed in Table 7 with examples provided in the figures below.

Table 7 – Notable System Conditions Following Loss of Island Generation

Base Case	Contingency	System Condition
Base Case 1	USL Fault, Trip Unit	UFLS
Base Case 1	MDR Fault, Trip TL248	UFLS
Base Case 1	BDE Fault, Trip Unit 7[6]	Instability
Base Case 2	MDR Fault, Trip TL248	UFLS
Base Case 2	BDE Fault, Trip Unit 7	UFLS
Base Case 3	BDE Fault, Trip Unit 7[7]	Instability
Base Case 4	MDR Fault, Trip TL248	UFLS
Base Case 6	USL Fault, Trip Unit	UFLS
Base Case 6	MDR Fault, Trip TL248	UFLS

[5] Faults at Deer Lake Terminal Station (DLK) or CAT followed by the tripping of TL247 or TL248 would also result in the isolation of CAT generation.

[6] Discussed in Section 5.1

[7] Discussed in Section 5.1

Base Case 6	BDE Fault, Trip Unit 7	UFLS
Base Case 7	USL Fault, Trip Unit	UFLS
Base Case 7	BDE Fault, Trip Unit 7	UFLS
Base Case 8	BDE Fault, Trip Unit 7	UFLS
Base Case 9	USL Fault, Trip Unit	UFLS
Base Case 9	MDR Fault, Trip TL248	UFLS
Base Case 9	BDE Fault, Trip Unit 7	UFLS

To avoid UFLS, export over the ML must be curtailed during these events. Appendix F illustrates how underfrequency can be avoided in all base cases if the ML export is curtailed. In Base Cases 6, 7, 8, and 9, where ML export is at 500 MW, curtailing export to 250 MW is sufficient to avoid underfrequency load shedding. In other cases, ML export is below 250 MW and must be reduced to 0 MW.

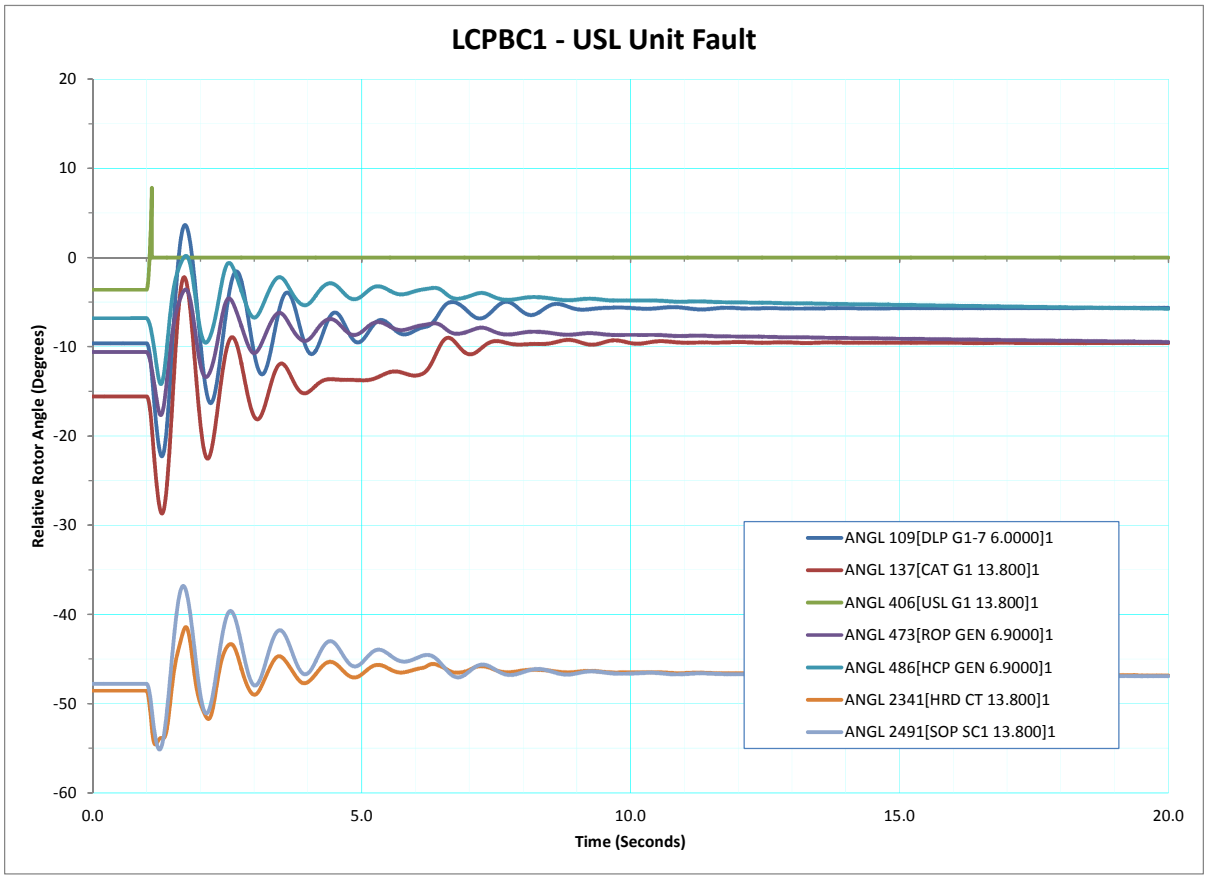

Figure 44 - LCPBC1 - USL Unit Fault - Relative Rotor Angle (Degrees)

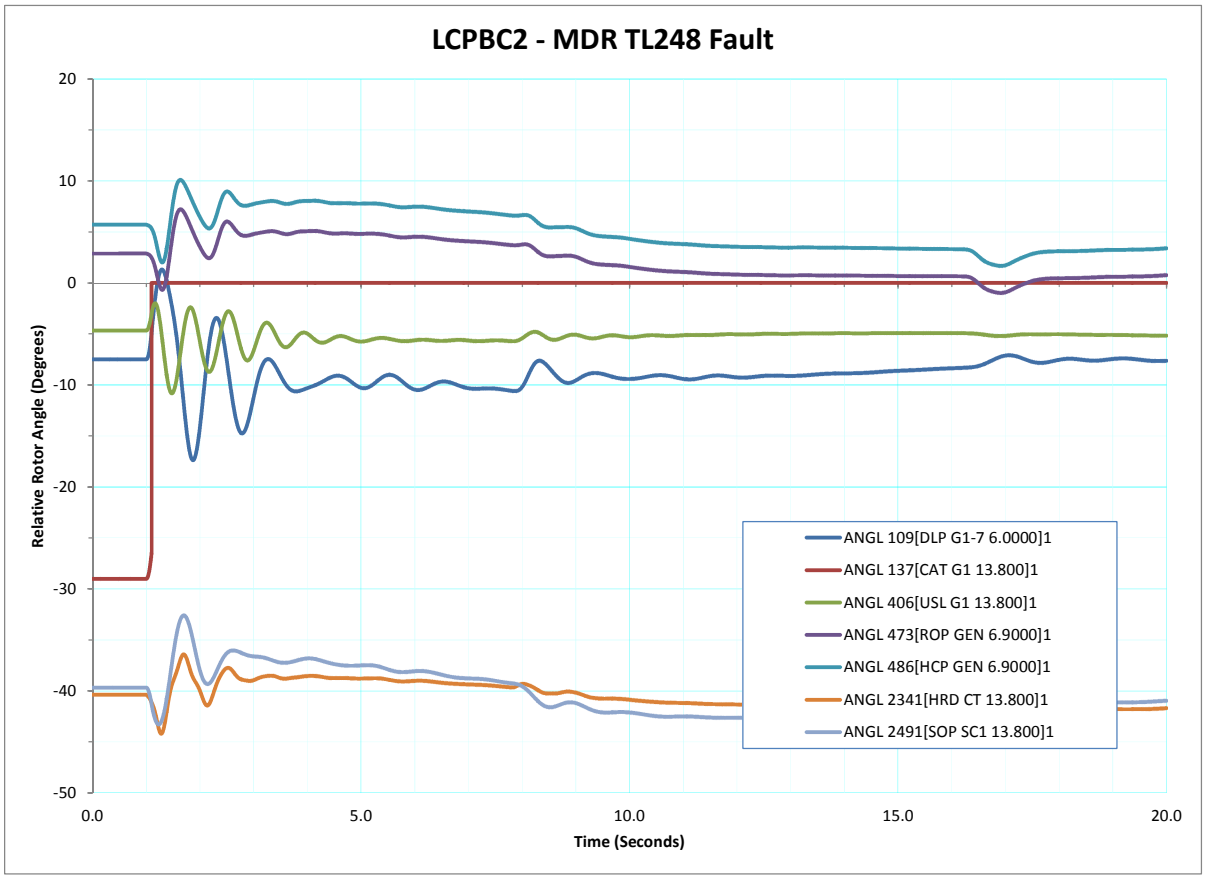

Figure 45 - LCPBC2 - MDR TL248 Fault - Relative Rotor Angle (Degrees)

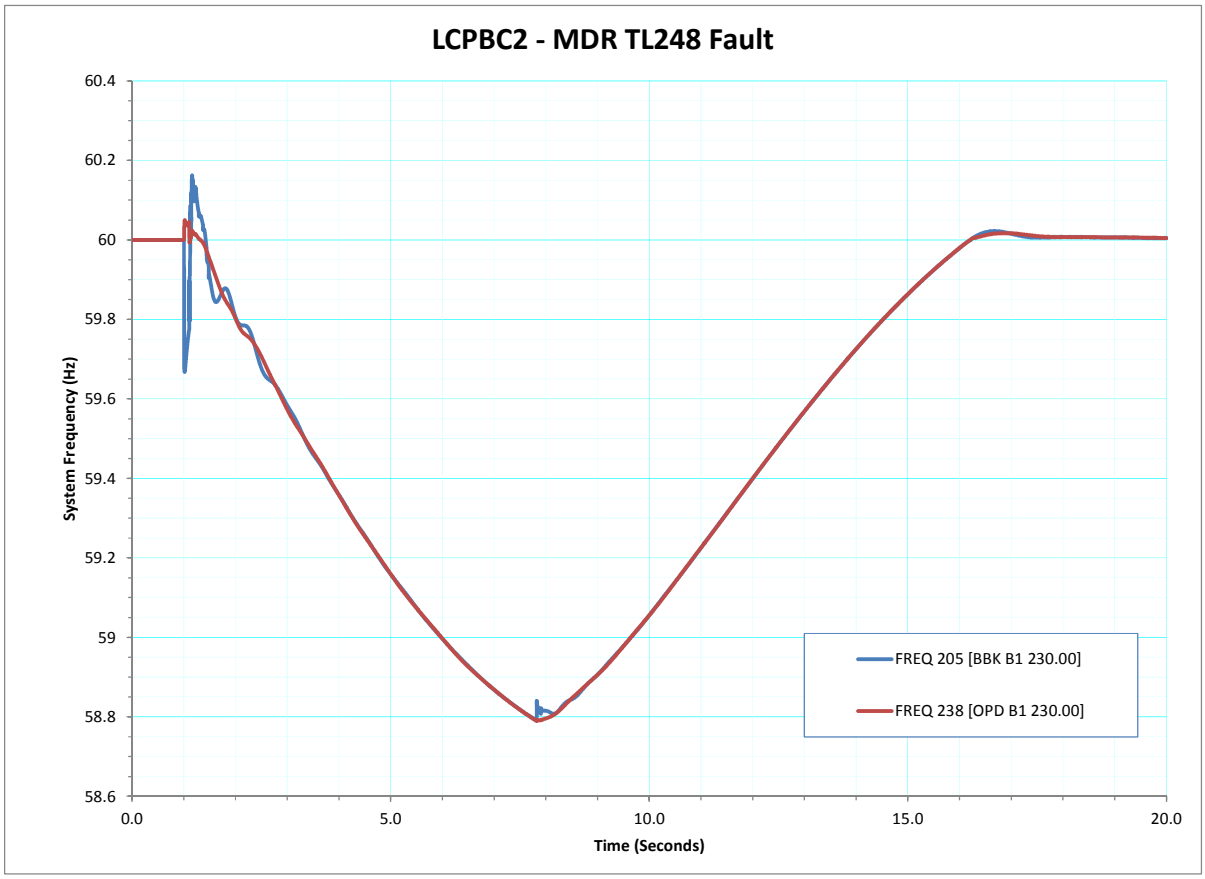

Figure 46 - LCPBC2 - MDR TL248 Fault - System Frequency (Hz)

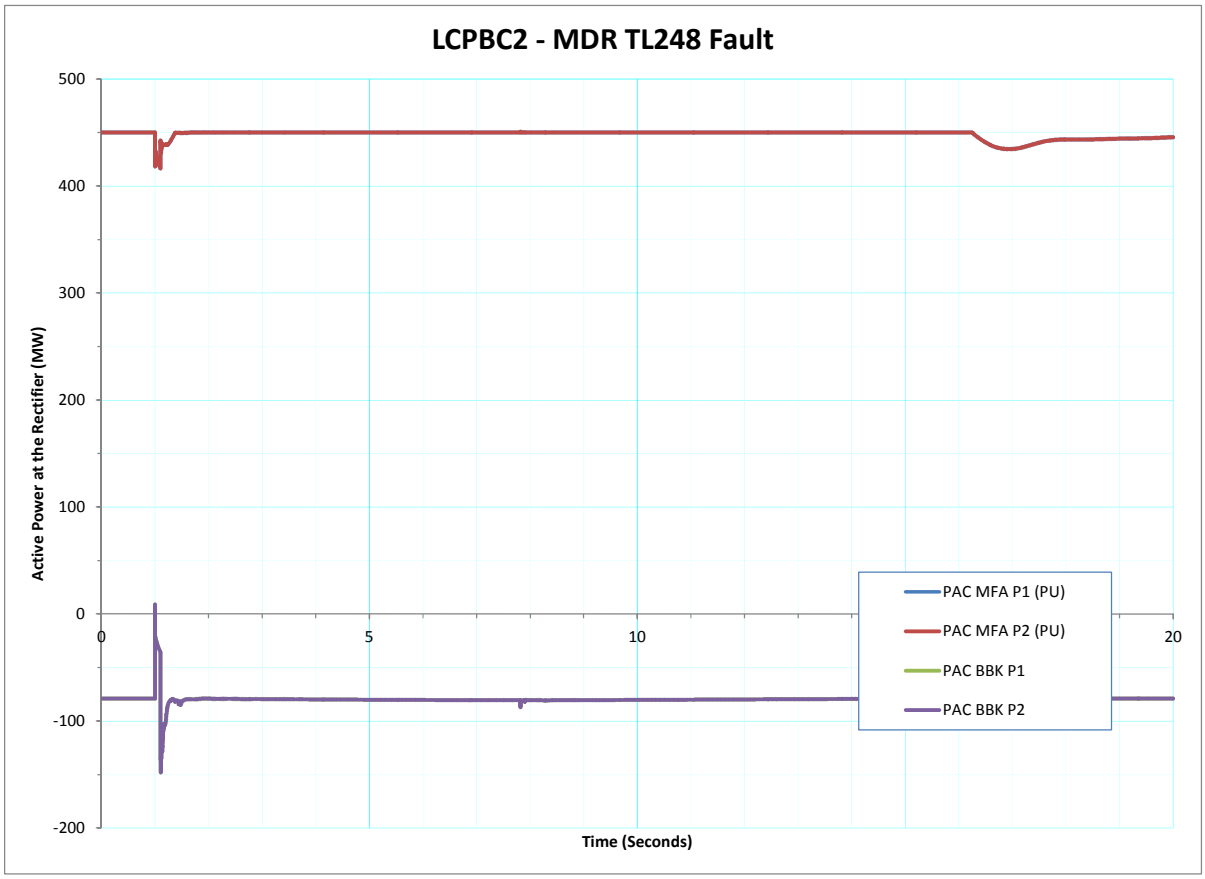

Figure 47 - LCPBC2 - MDR TL248 Fault - Active Power at the Rectifier (MW)

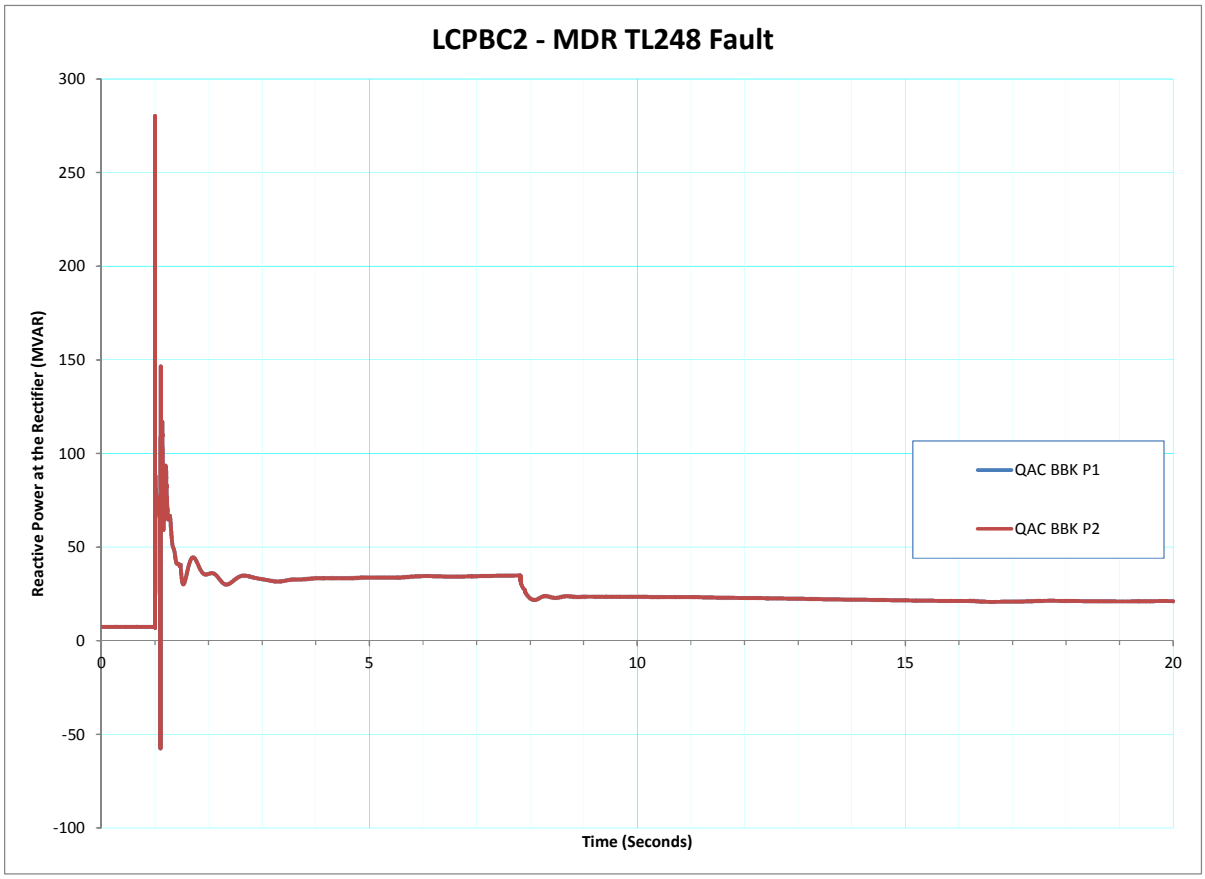

Figure 48 - LCPBC2 - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

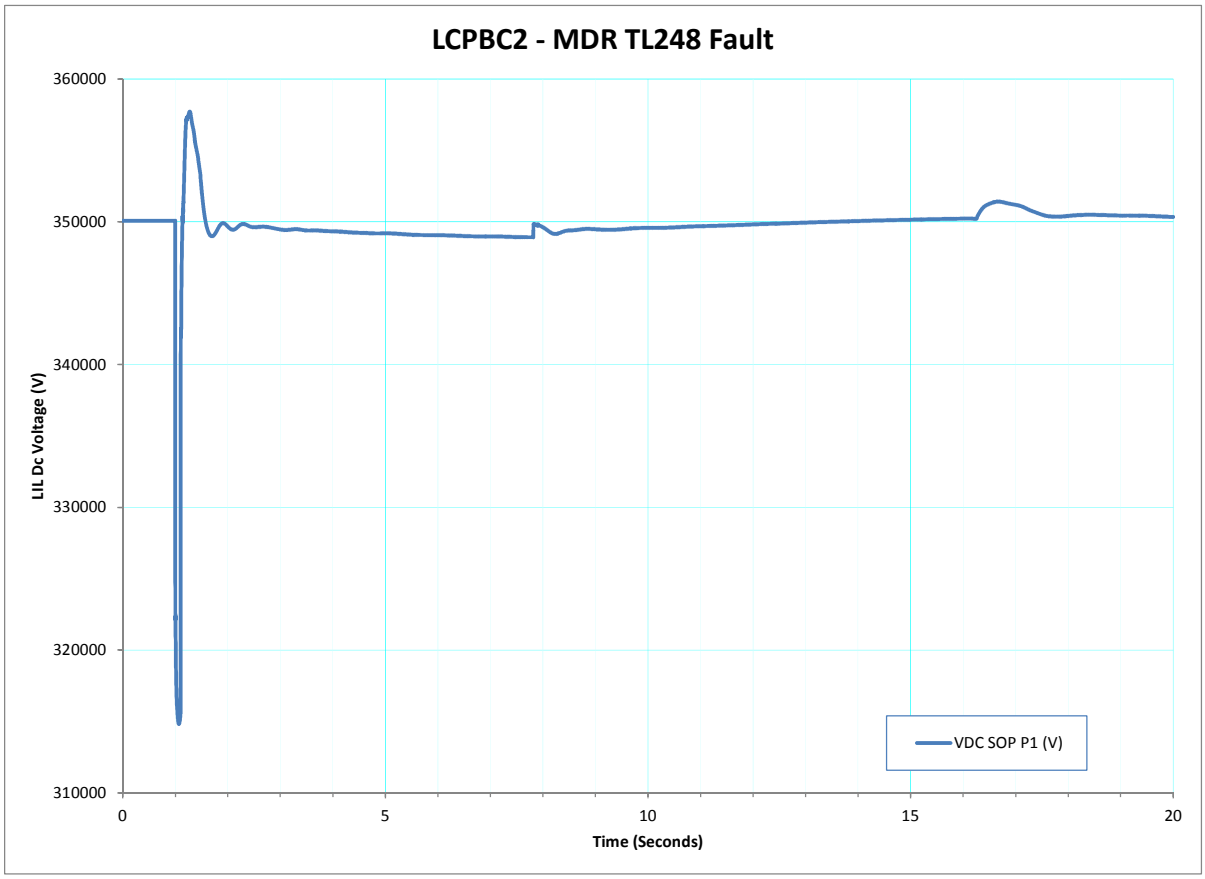

Figure 49 - LCPBC2 - MDR TL248 Fault - LIL Dc Voltage (V)

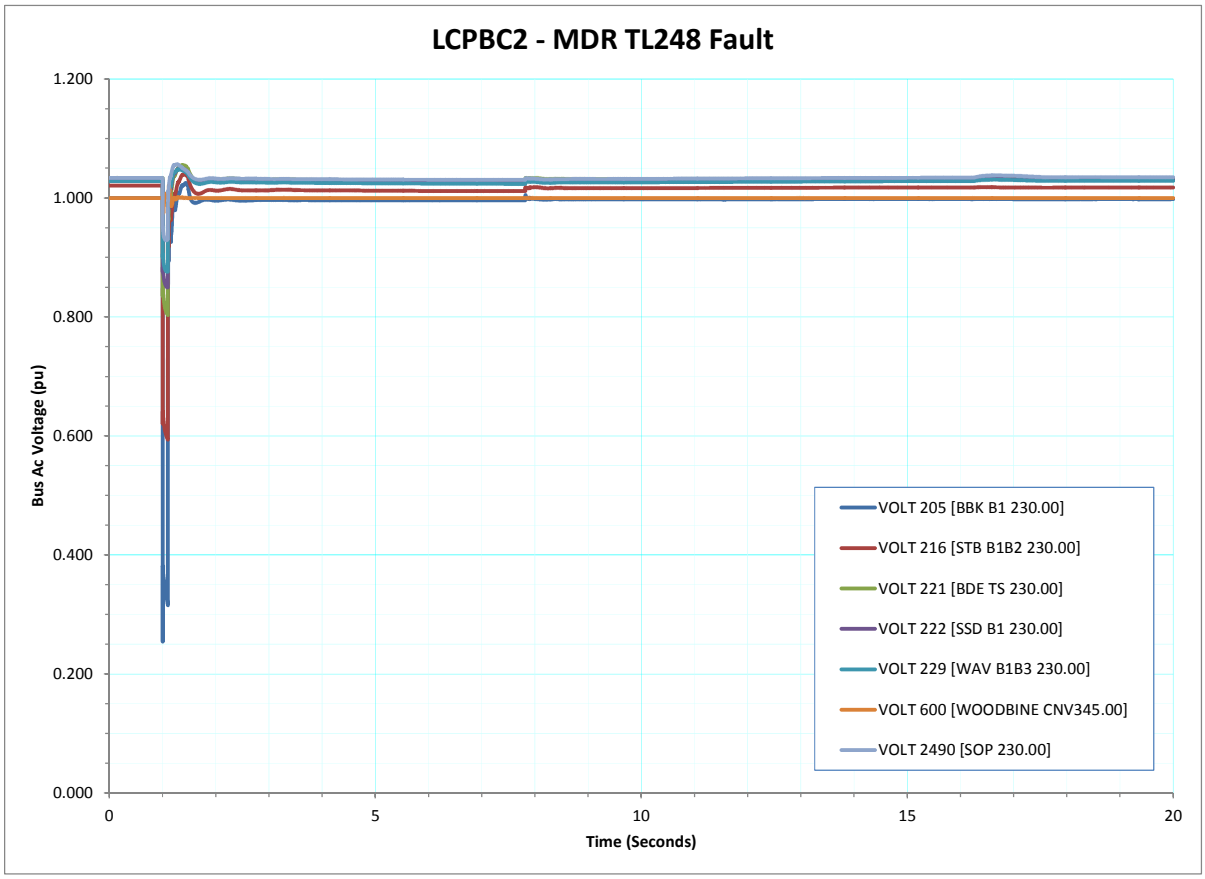

Figure 50 - LCPBC2 - MDR TL248 Fault - Bus Ac Voltage (pu)

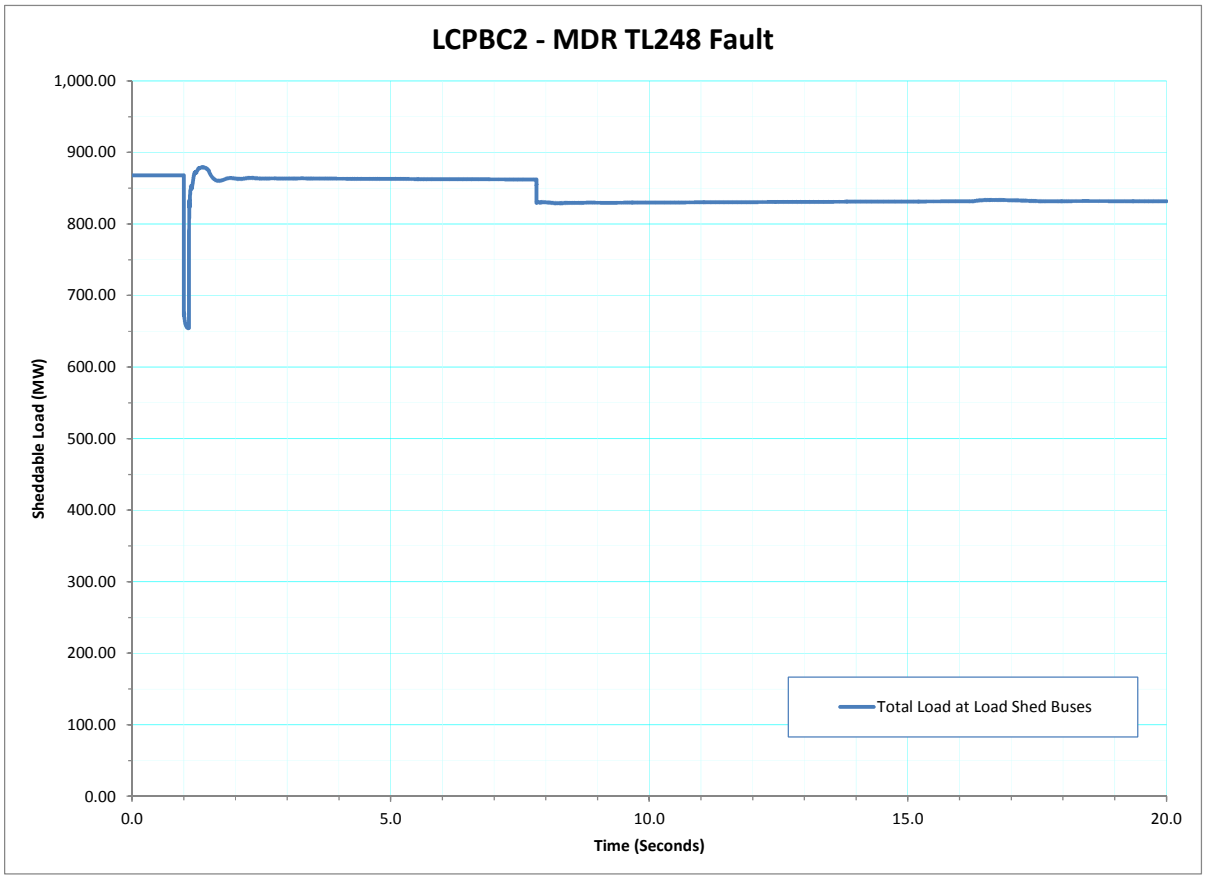

Figure 51 - LCPBC2 - MDR TL248 Fault - Sheddable Load (MW)

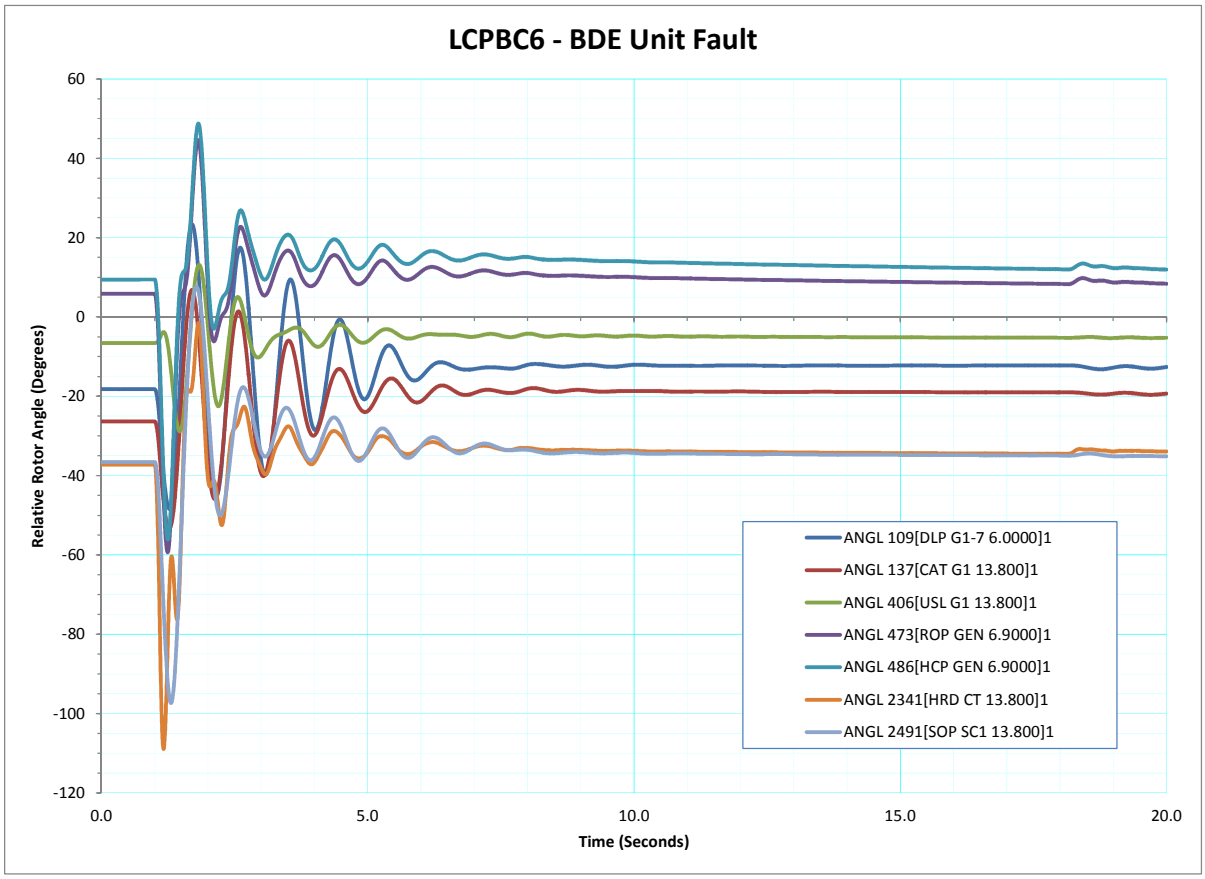

Figure 52 - LCPBC6 - BDE Unit Fault - Relative Rotor Angle (Degrees)

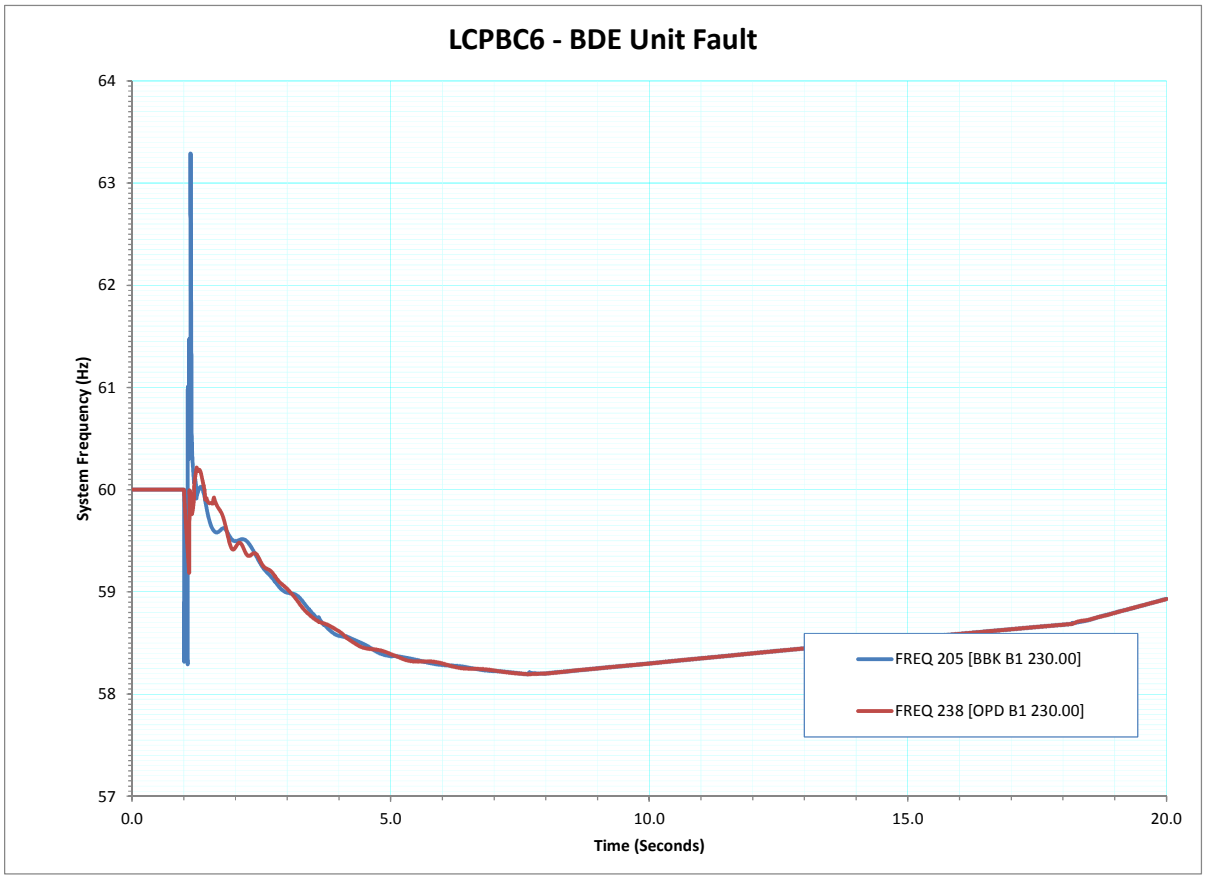

Figure 53 - LCPBC6 - BDE Unit Fault - System Frequency (Hz)

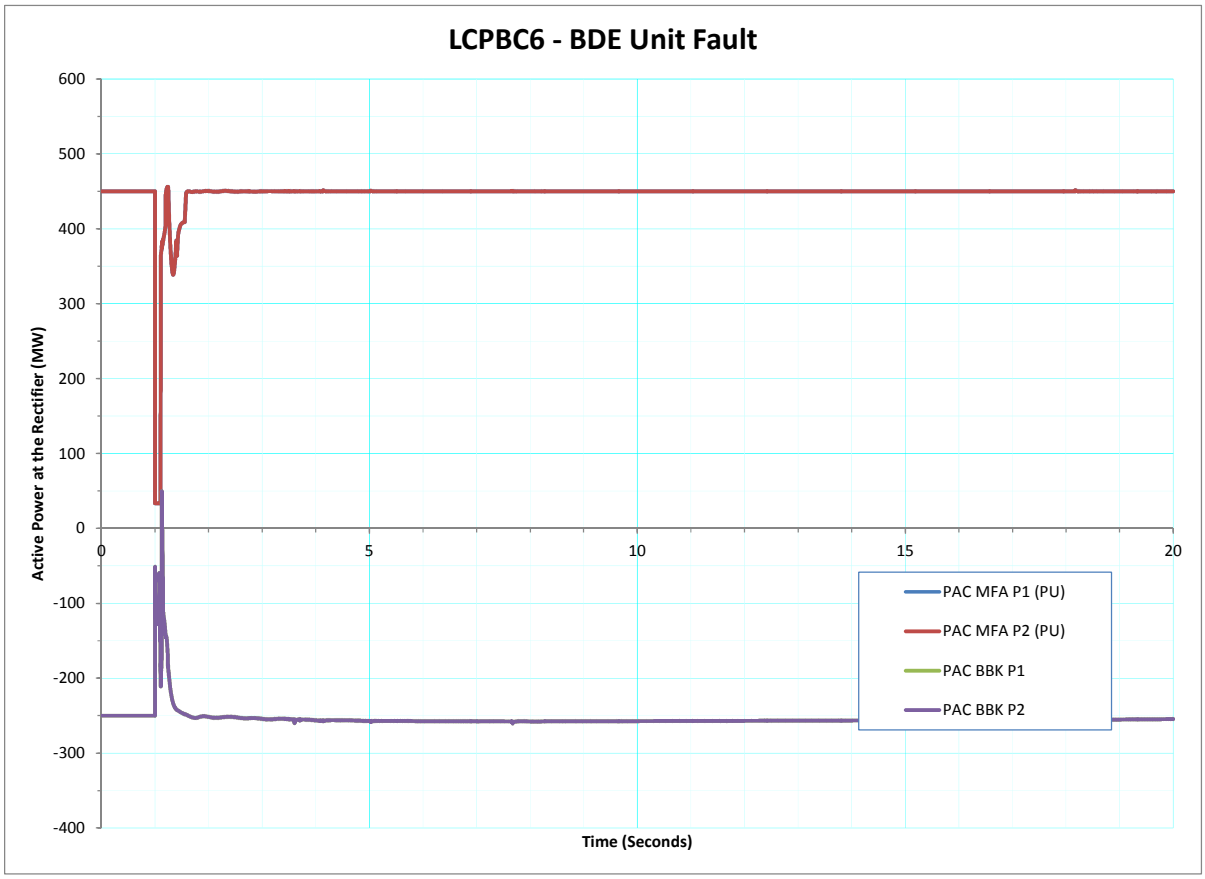

Figure 54 - LCPBC6 - BDE Unit Fault - Active Power at the Rectifier (MW)

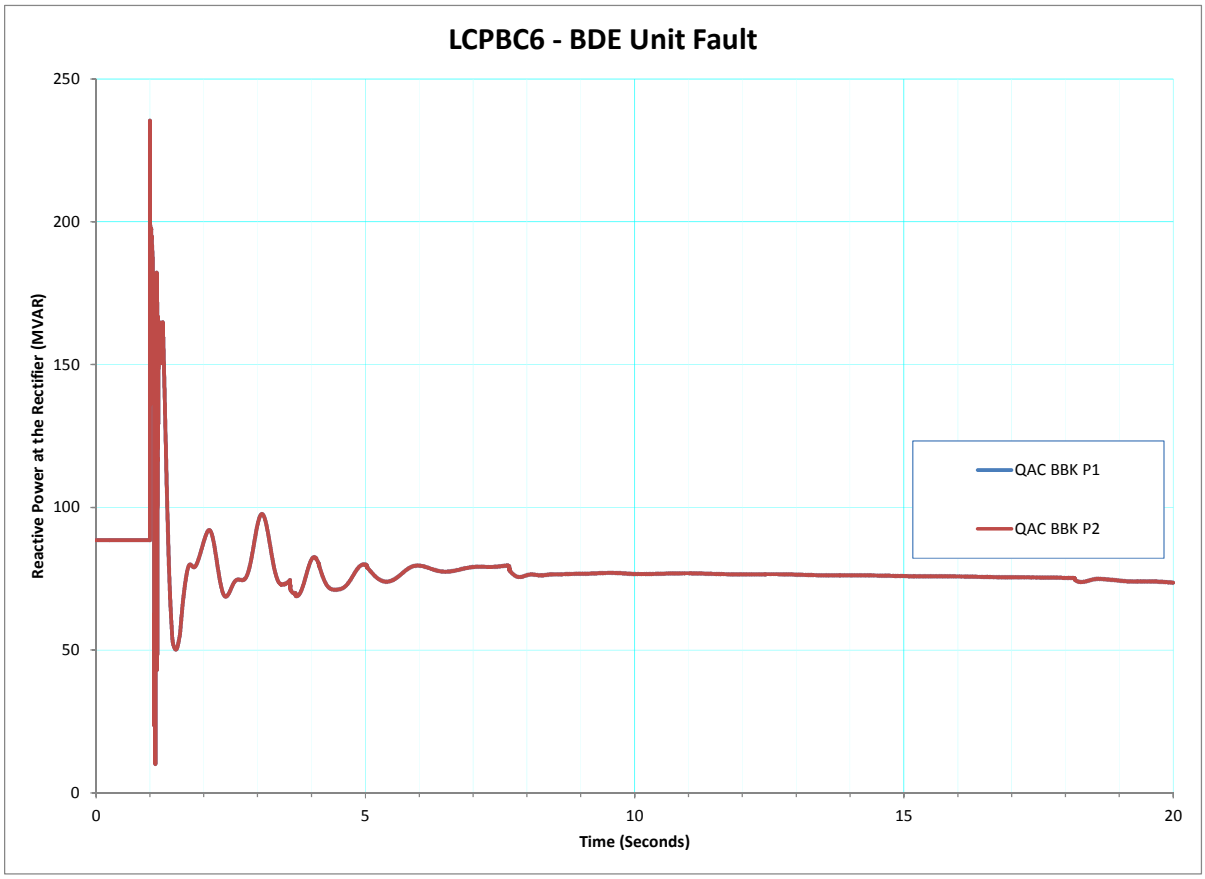

Figure 55 - LCPBC6 - BDE Unit Fault - Reactive Power at the Rectifier (MVAR)

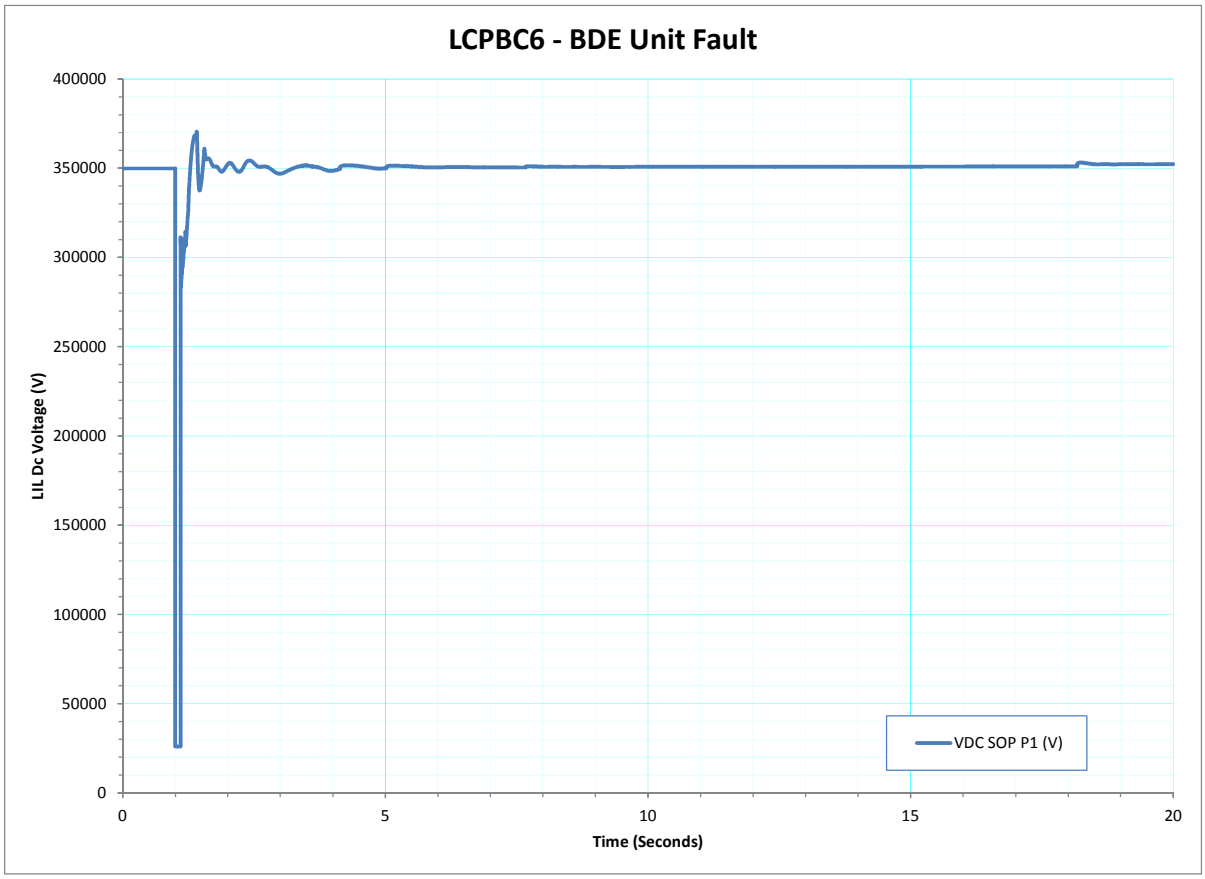

Figure 56 - LCPBC6 - BDE Unit Fault - LIL Dc Voltage (V)

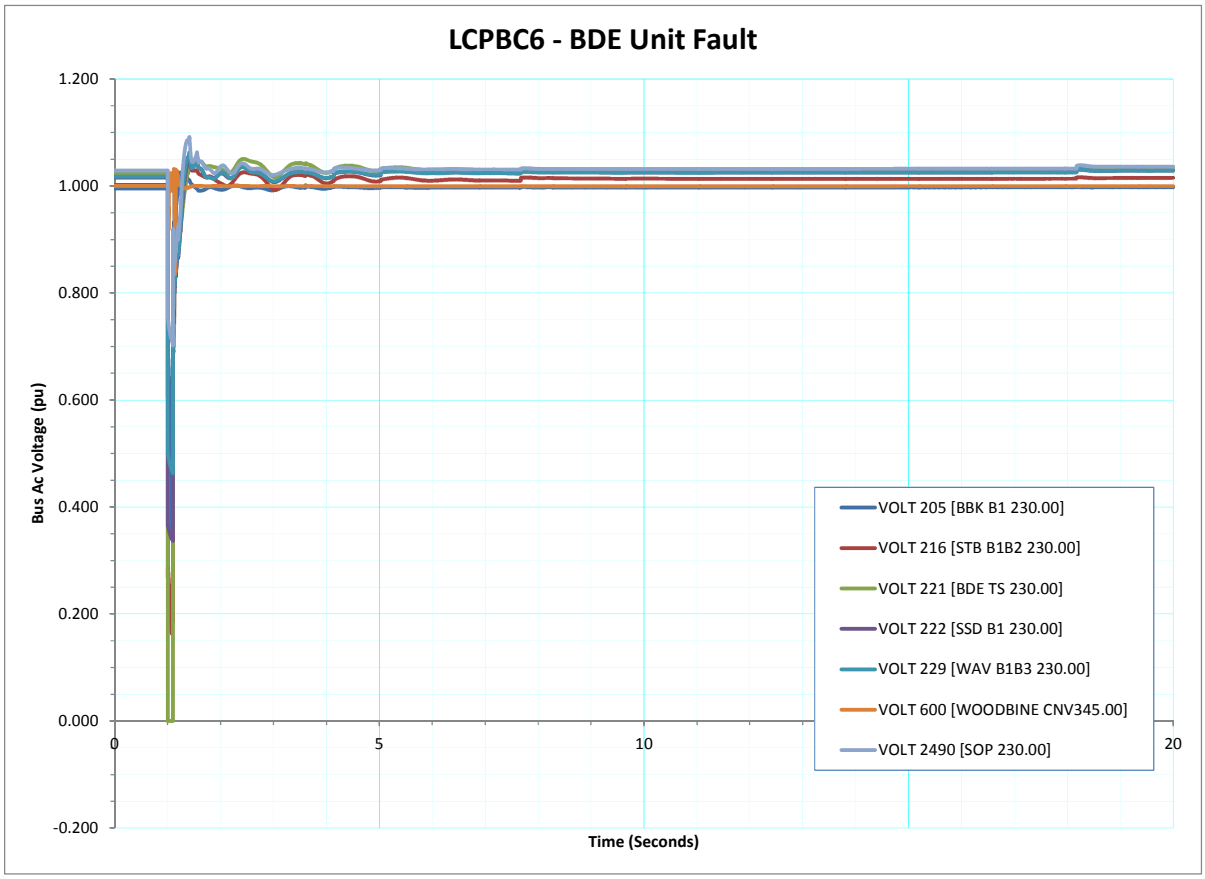

Figure 57 - LCPBC6 - BDE Unit Fault - Bus Ac Voltage (pu)

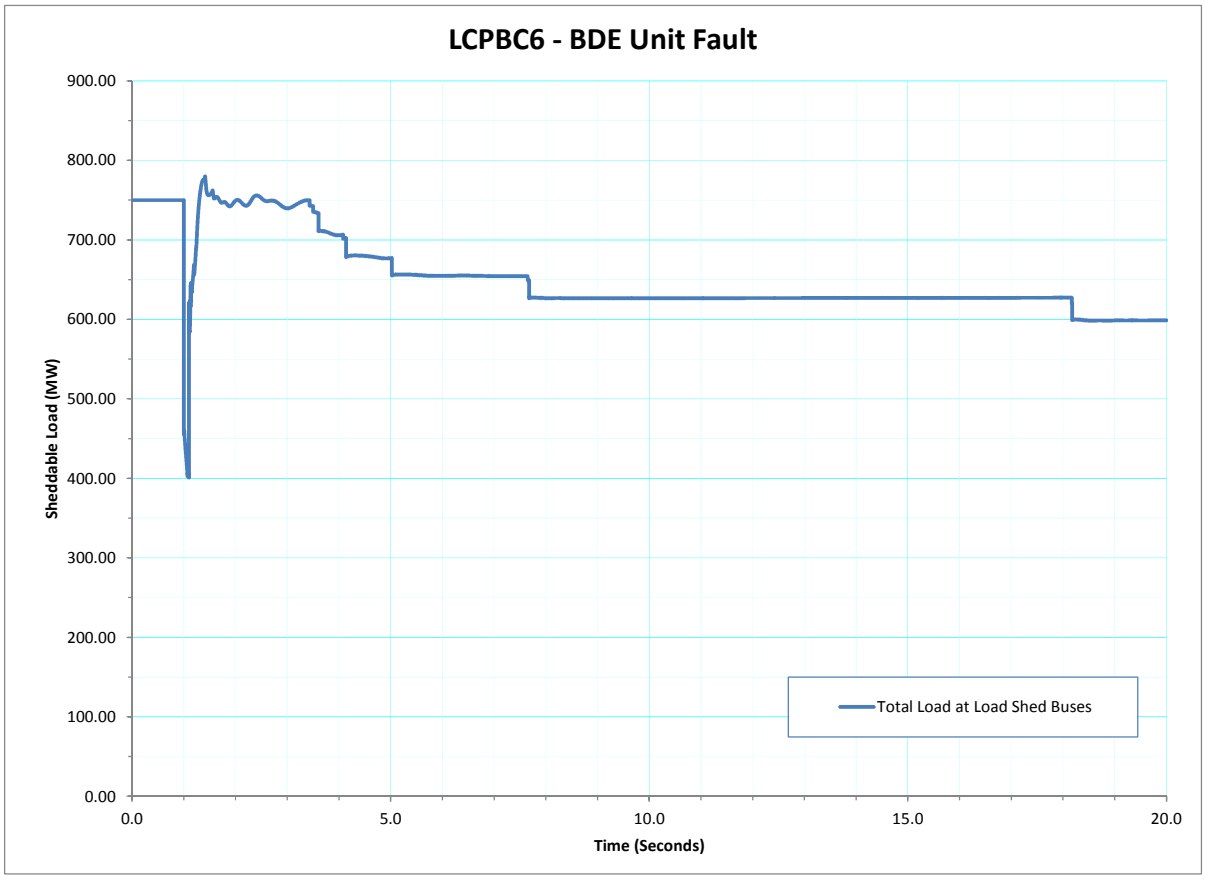

Figure 58 - LCPBC6 - BDE Unit Fault - Sheddable Load (MW)

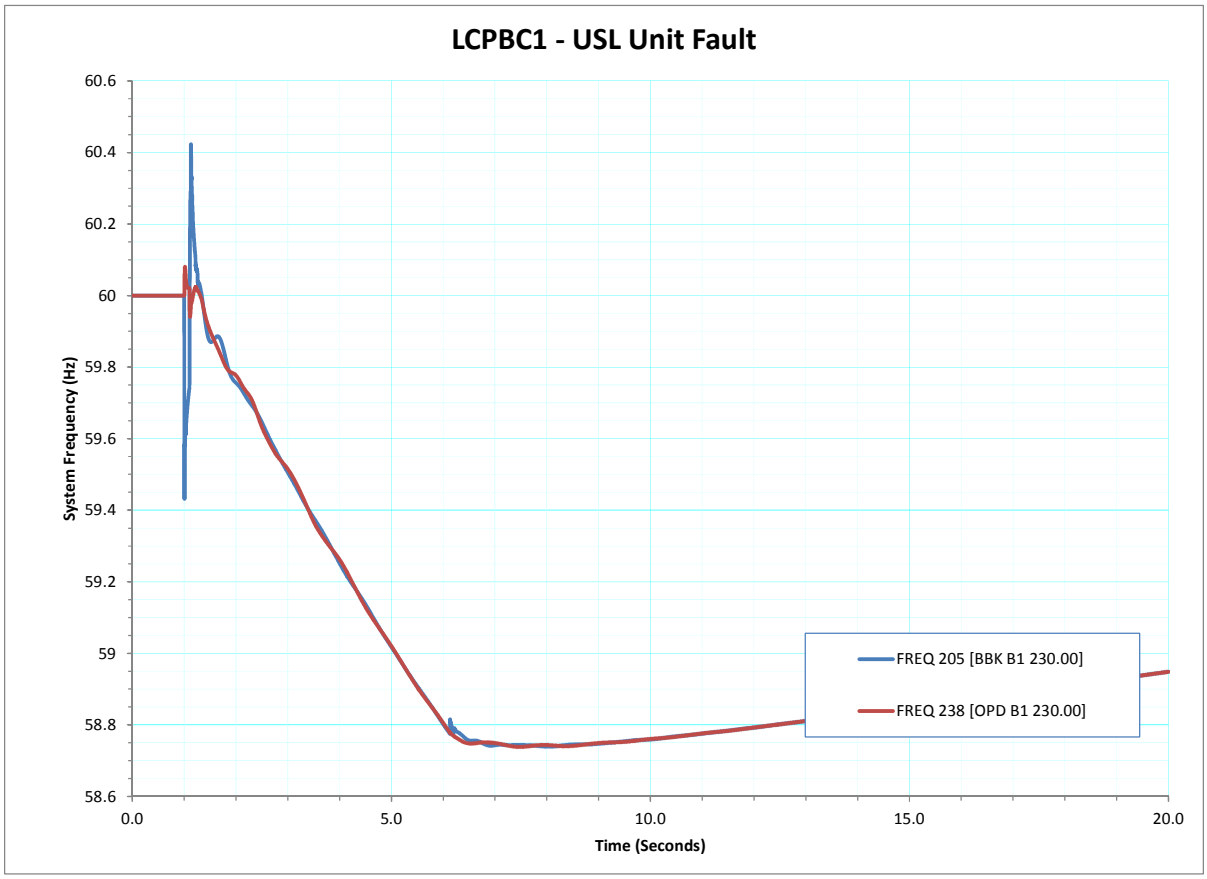

Figure 59 - LCPBC1 - USL Unit Fault - System Frequency (Hz)

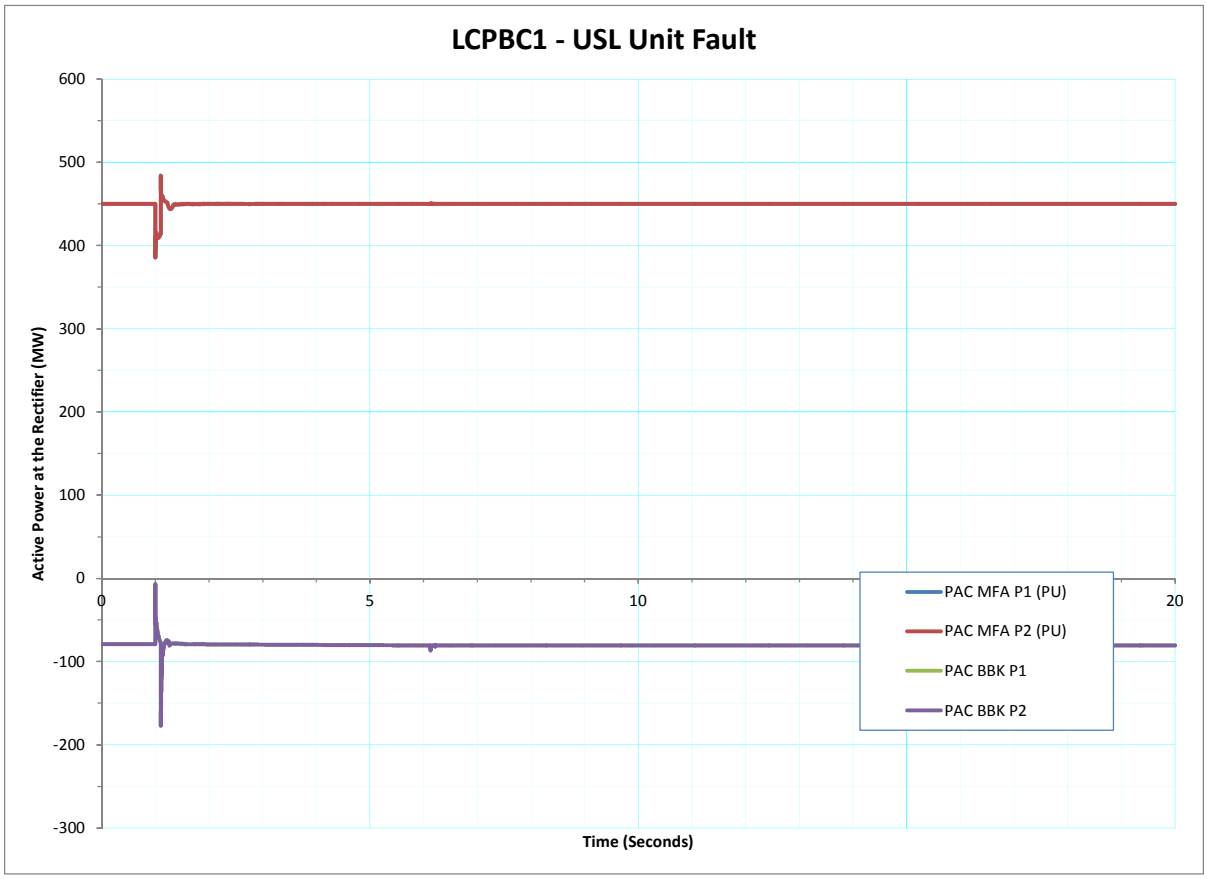

Figure 60 - LCPBC1 - USL Unit Fault - Active Power at the Rectifier (MW)

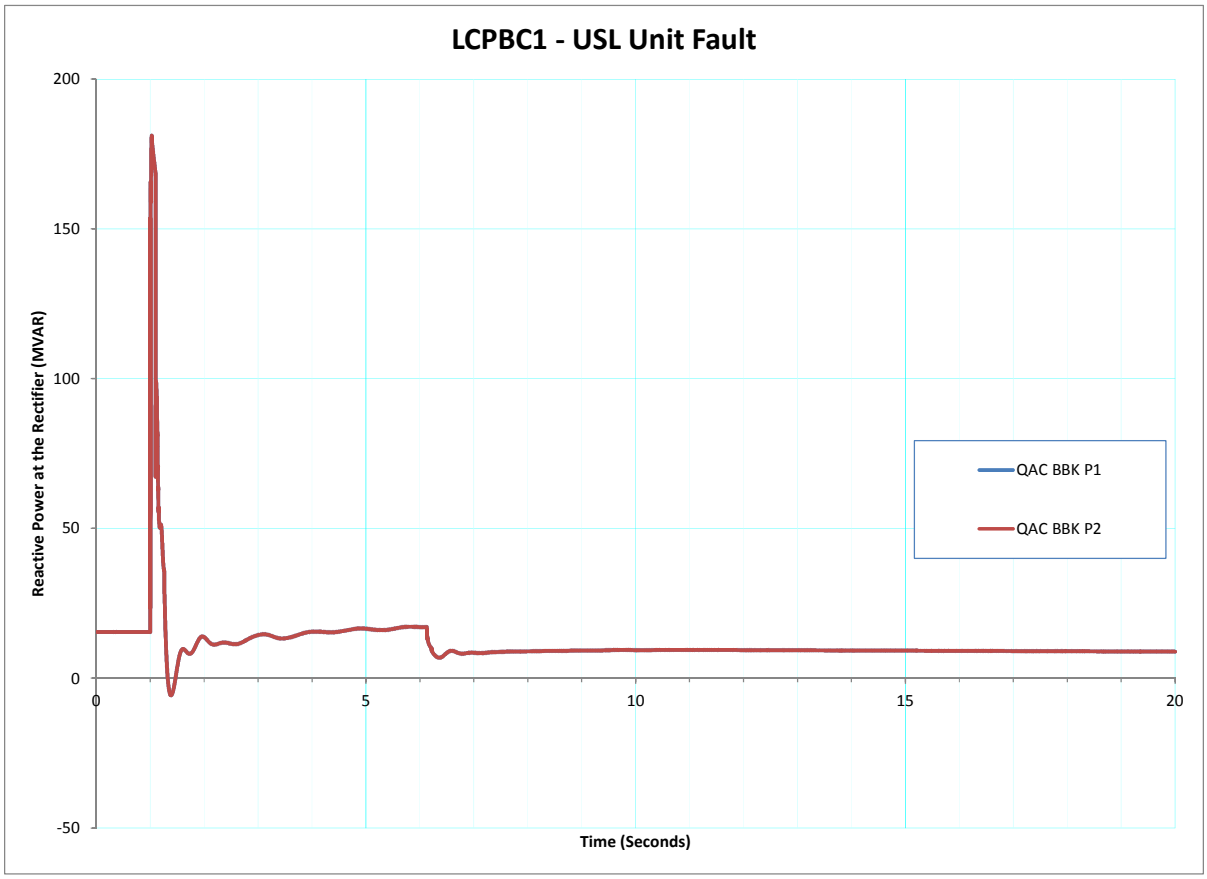

Figure 61 - LCPBC1 - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

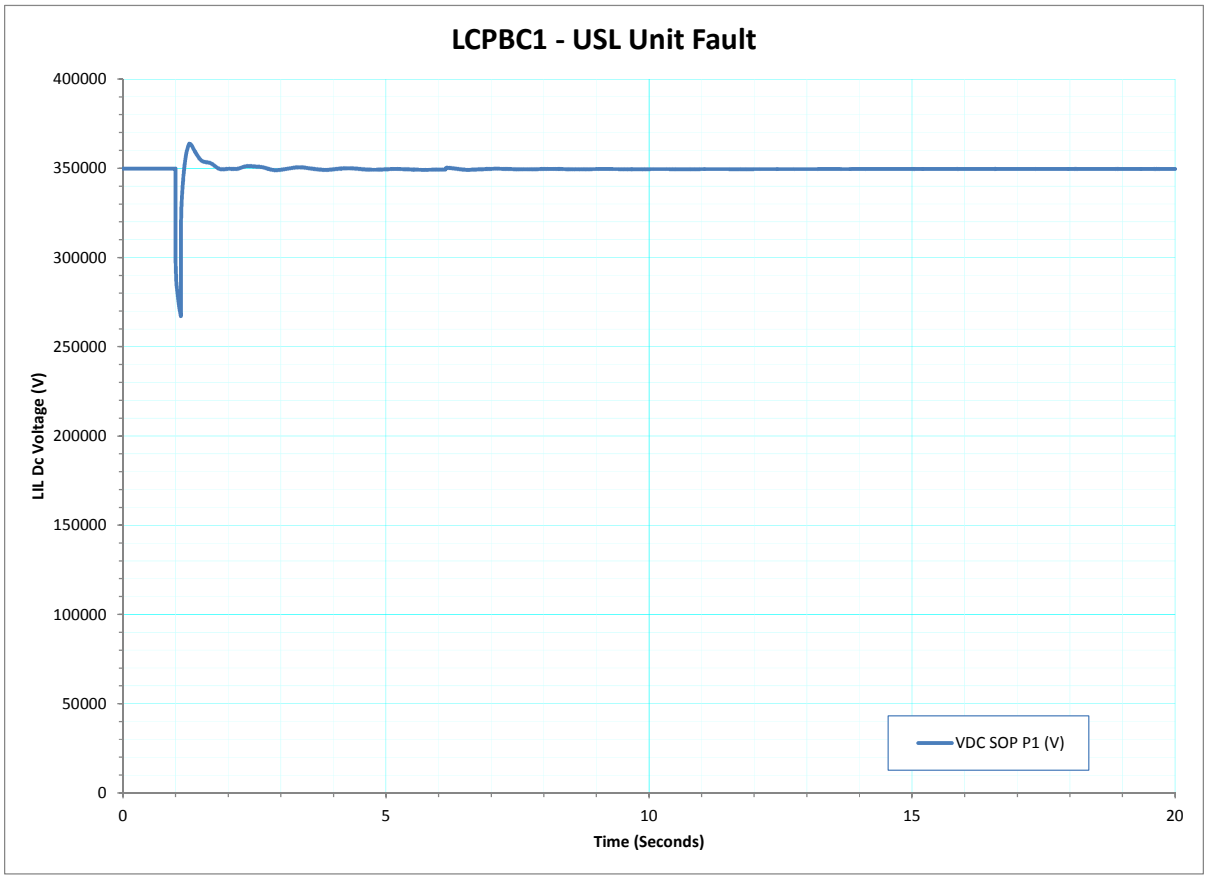

Figure 62 - LCPBC1 - USL Unit Fault - LIL Dc Voltage (V)

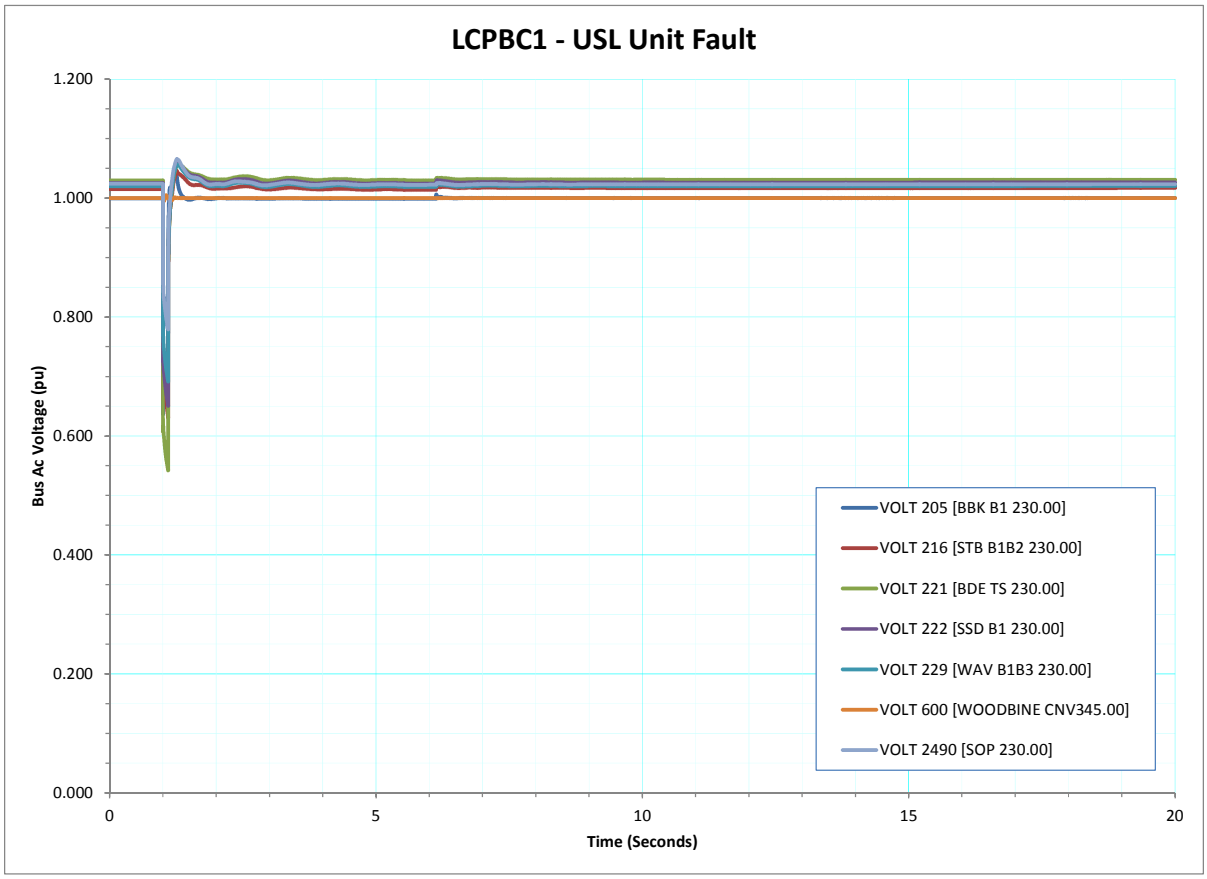

Figure 63 - LCPBC1 - USL Unit Fault - Bus Ac Voltage (pu)

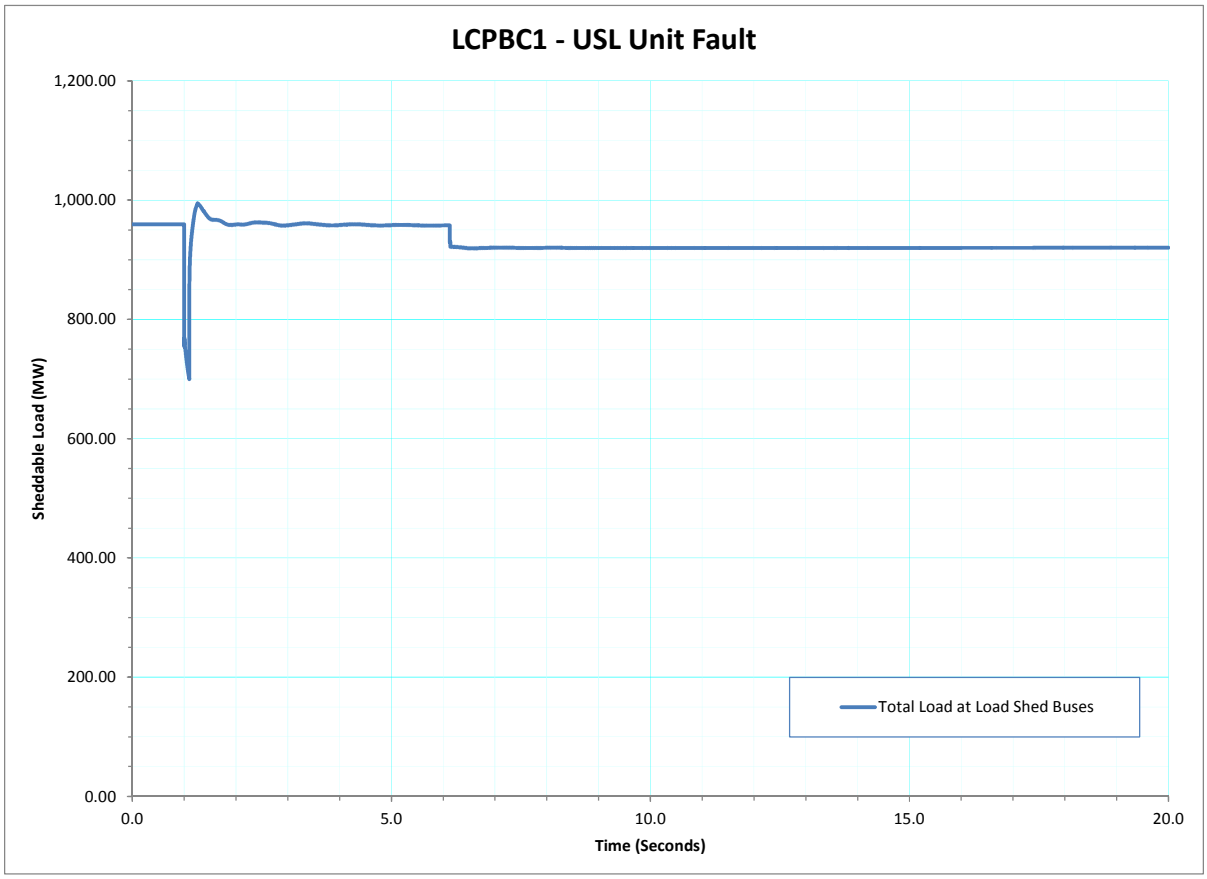

Figure 64 - LCPBC1 - USL Unit Fault - Sheddable Load (MW)

5.6. LOSS OF A SYNCHRONOUS CONDENSER AT SOLDIERS POND

As per Table 8, it was found that a three-phase fault at SOP followed by the tripping of a synchronous condenser in BC9 results in commutation failure during post-fault recovery of the HVdc voltage.

Table 8 – Notable System Conditions Following Fault at SOP and the Tripping of a Synchronous Condenser

Base Case	Contingency	System Condition
Base Case 9	SOP Fault, Trip Synchronous Condenser	LIL commutation failure

In this case, the LIL and ML are operating at capacity, while the generation on the Island Interconnected Transmission System is reduced to approximately 370 MW. The loss of a synchronous condenser at SOP results in a deficit of reactive power, particularly as the export of 500 MW over the ML is not interrupted by the fault. This is illustrated in the figures below.

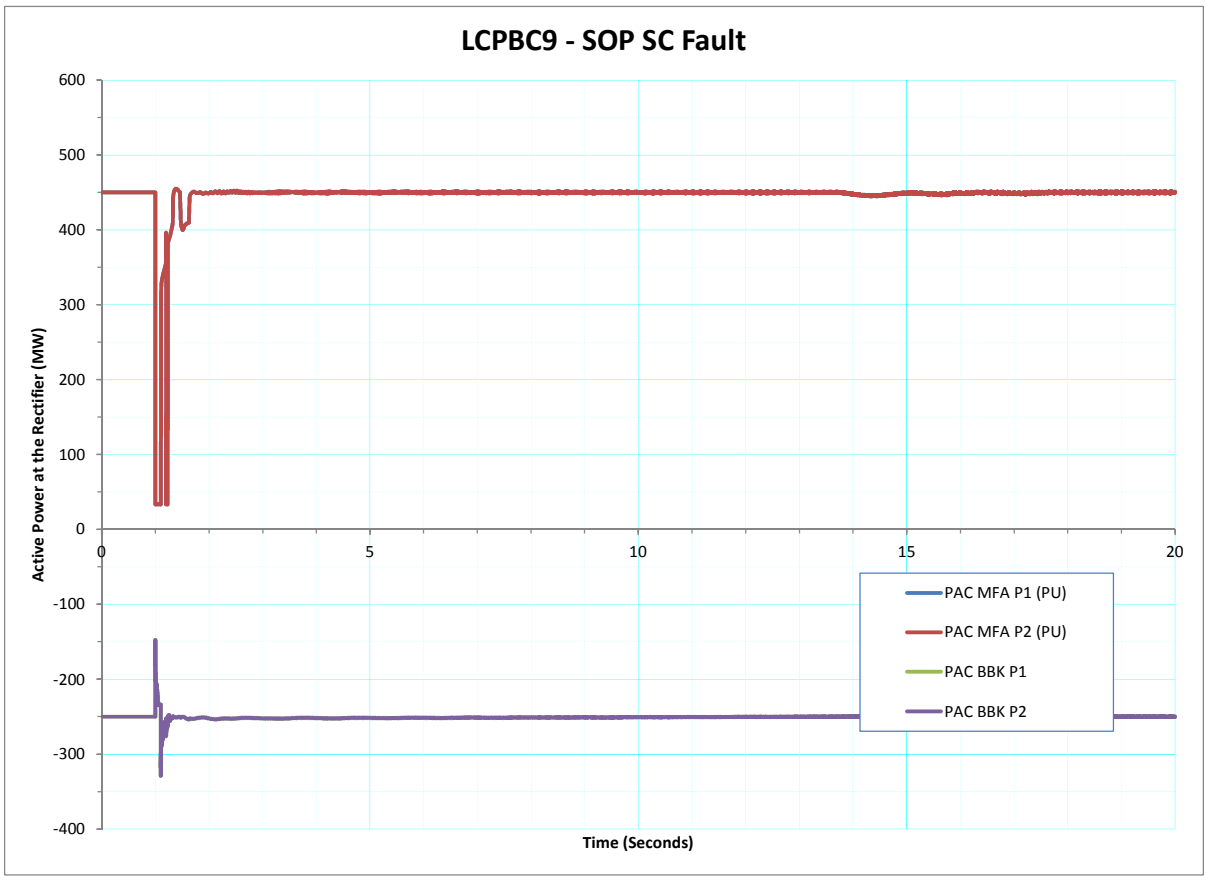

Figure 65 - LCPBC9 - SOP SC Fault - Active Power at the Rectifier (MW)

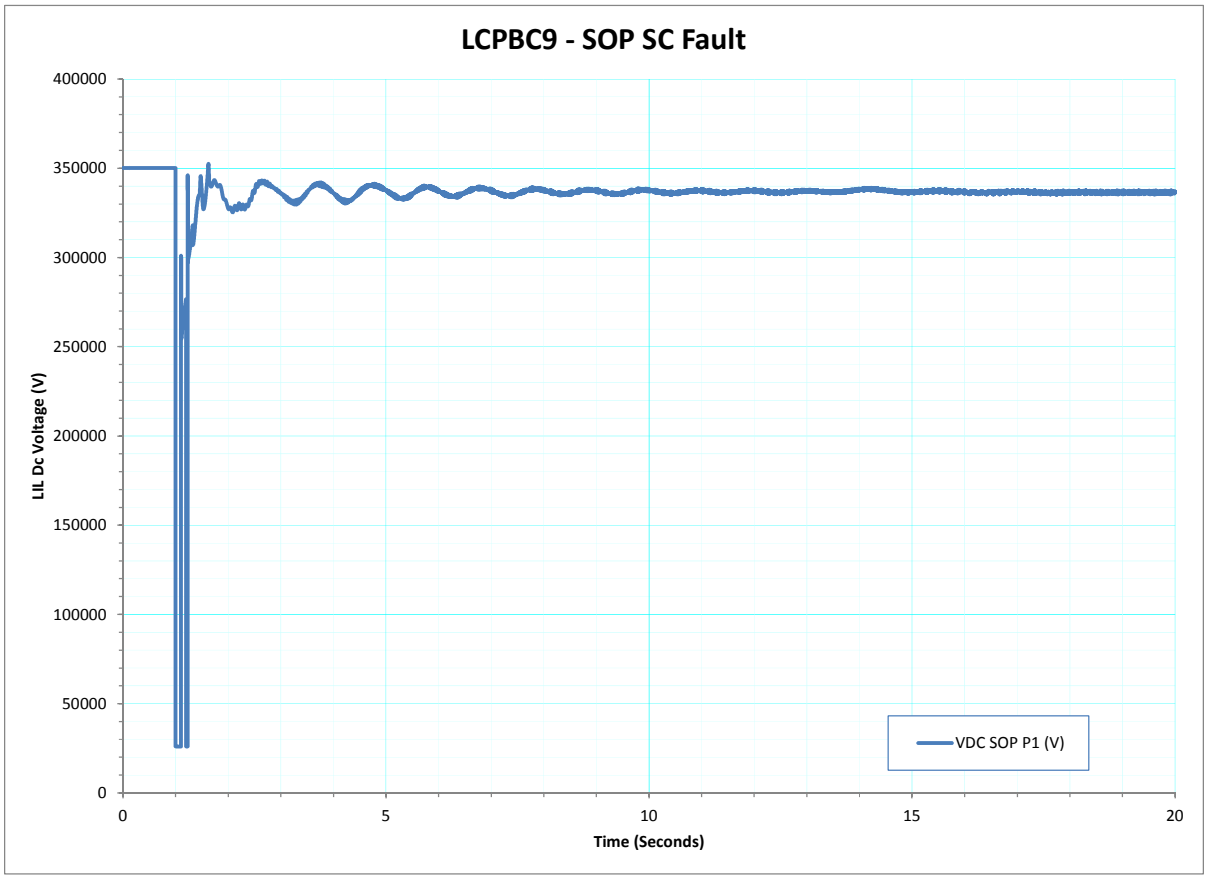

Figure 66 - LCPBC9 - SOP SC Fault - LIL Dc Voltage (V)

Additional analysis was performed to investigate the impact of curtailing the ML in the event of the SOP fault. As indicated below, the commutation failure is eliminated if the export is reduced from 500 MW to 250 MW.

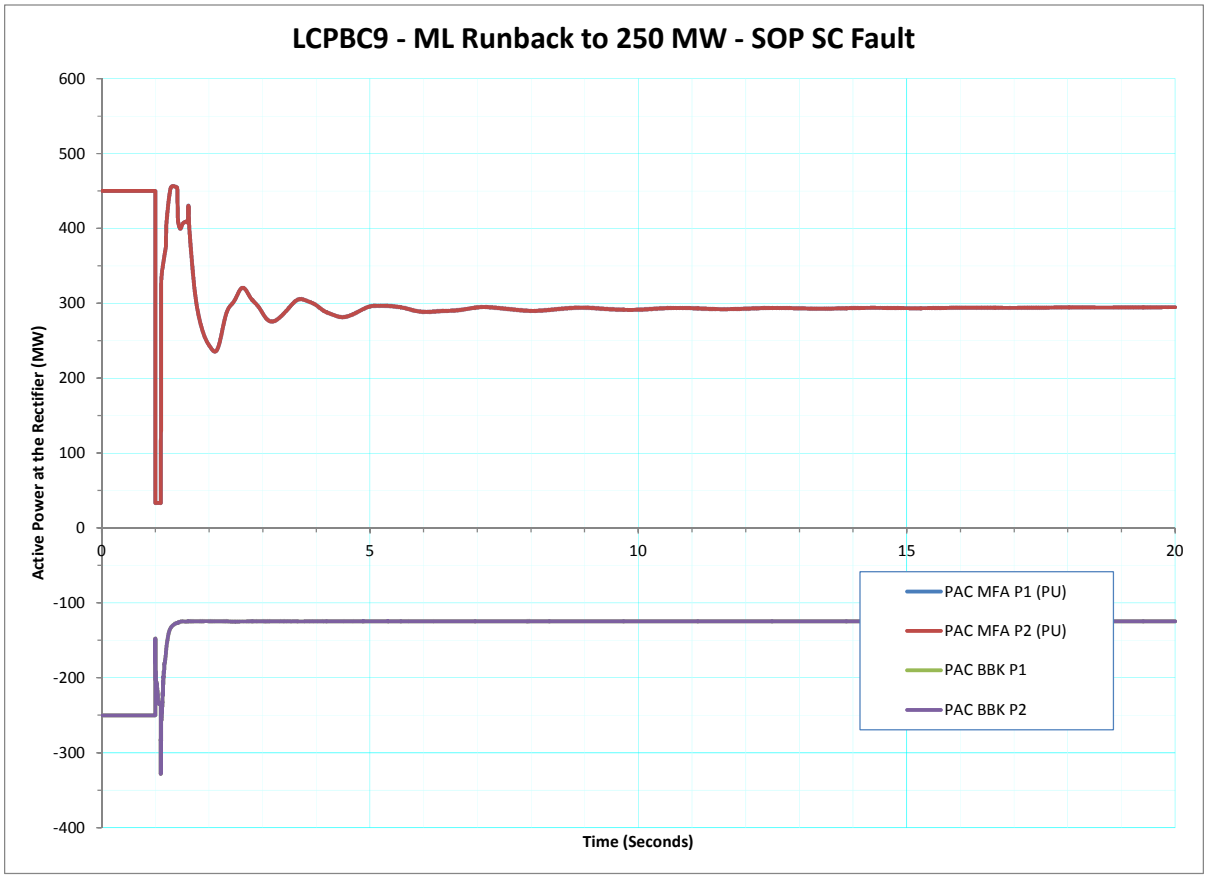

Figure 67 - LCPBC9 - ML Runback to 250 MW - SOP SC Fault - Active Power at the Rectifier (MW)

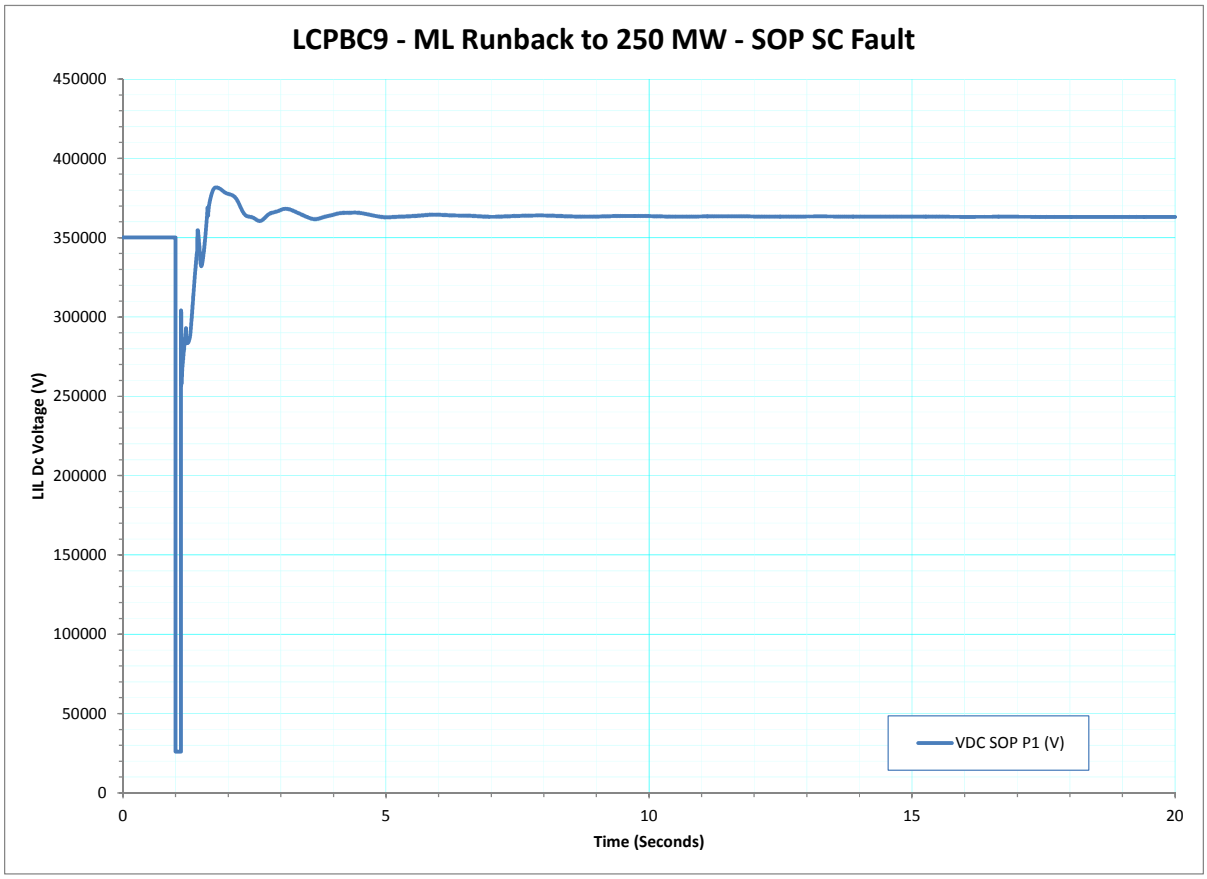

Figure 68 - LCPBC9 - ML Runback to 250 MW - SOP SC Fault - LIL Dc Voltage (V)

As discussed in Section 5.3, the BC9 case represents an extreme operating scenario where both the LIL and ML are operating at rated capacity while minimal generation is dispatched within the Interconnected Island System. Rather than curtailing ML exports for all three-phase faults at Soldiers Pond, a more practical solution would be to specify operating limitation for the system. Such limitations would ensure that extreme operating conditions are avoided and that system performance is acceptable.

6. CONCLUSIONS

A transient stability analysis was performed to identify unacceptable conditions arising from disturbances within the Island Interconnected System. Recommendations for these conditions are listed in Table 9.

Table 9 – Summary of Transient Stability Analysis

Contingency	Required Remedial Action
Faults at Bay d'Espoir	No Action Accepted as "Exceptional Contingency"
Faults at Bottom Brook, Buchans, Granite Canal, Massey Drive, Stony Brook, and Upper Salmon	Curtailment of ML Export to 250 MW.
LIL Temporary Bipole Faults	Curtailment of ML Export to 250 MW.
LIL Permanent Pole Faults	Curtailment of ML Export to 250 MW or 0 MW[8].
LIL Faults While In Monopole Mode	Curtailment of ML Export to 0 MW.
Loss of Island Generation	Curtailment of ML Export to 250 MW or 0 MW[9].
Loss of a Synchronous Condenser at Soldiers Pond	Development of Operating Instruction to avoid unacceptable system condition.[10].

It should be noted that the analysis described in this report is preliminary. It is recommended that a more comprehensive analysis be performed with detailed HVdc system models in conjunction with the vendors during the final design stages and during operational studies. Such an analysis will help to ensure the acceptable performance of the transmission system following the interconnection of the LIL and the ML.

[8] Depending on initial value of ML export.

[9] Depending on initial value of ML export.

[10] Unacceptable conditions resulting from this contingency were only observed for Base Case 9.

APPENDIX A Base Case Load Flow Plots

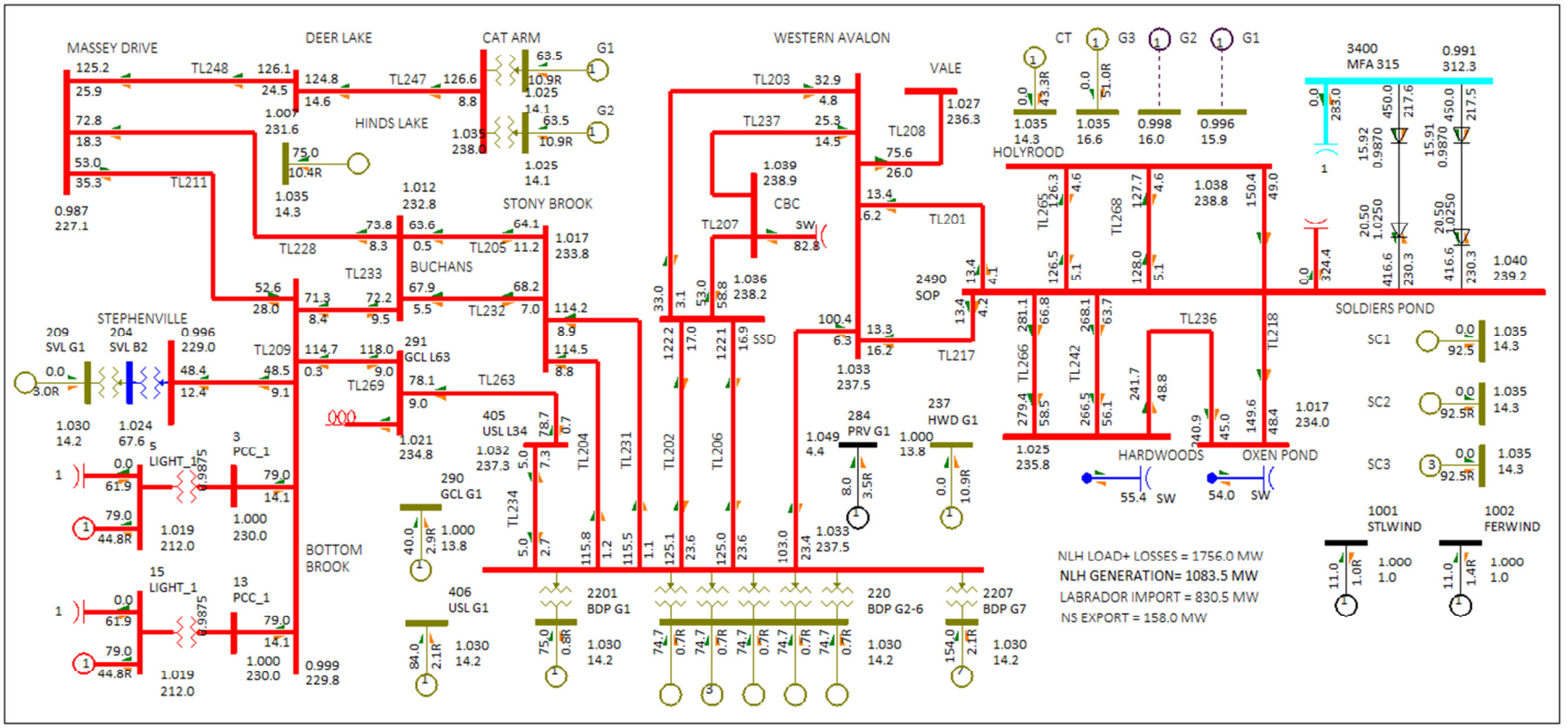

Figure 69 – Load Flow Plot – Base Case 1

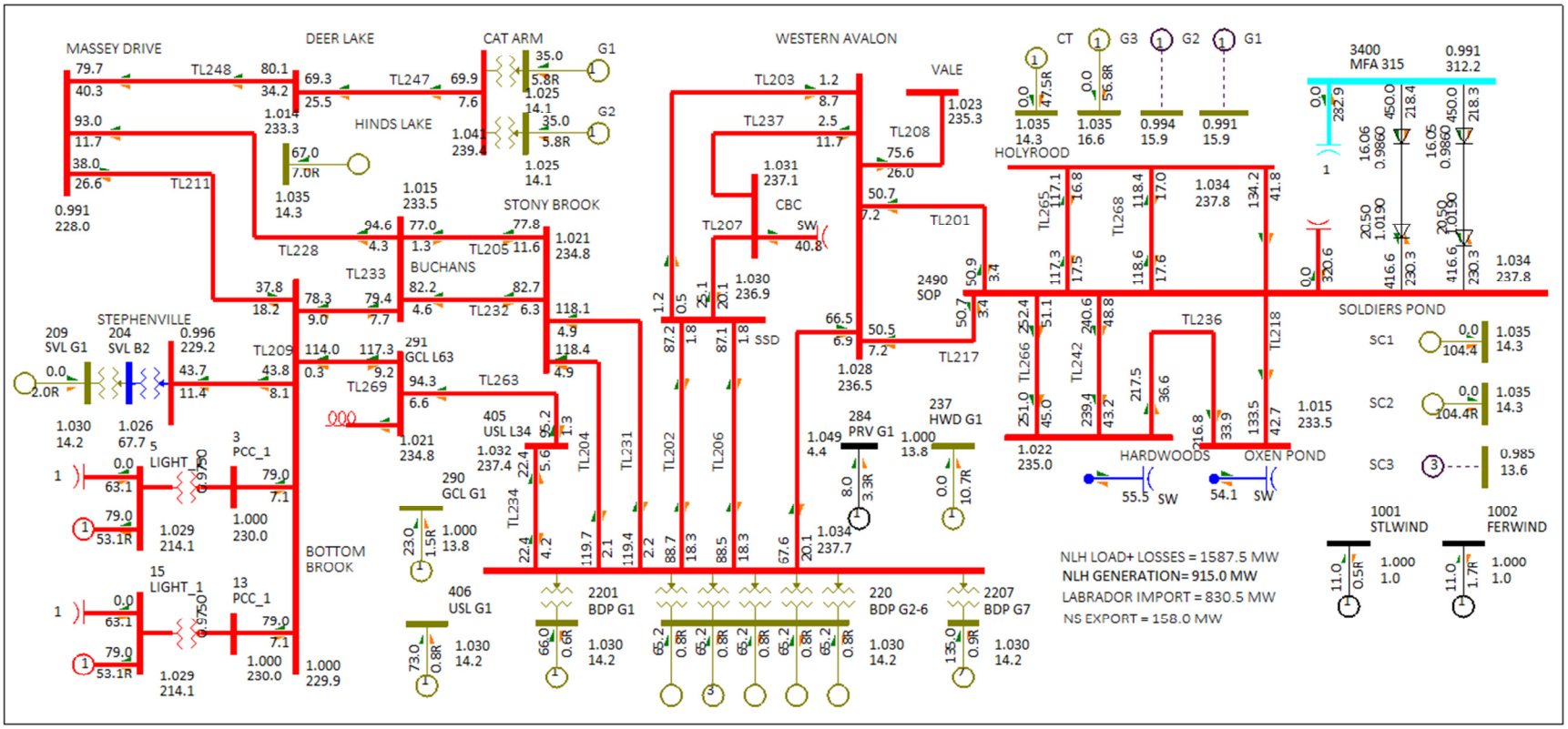

Figure 70 – Load Flow Plot – Base Case 2

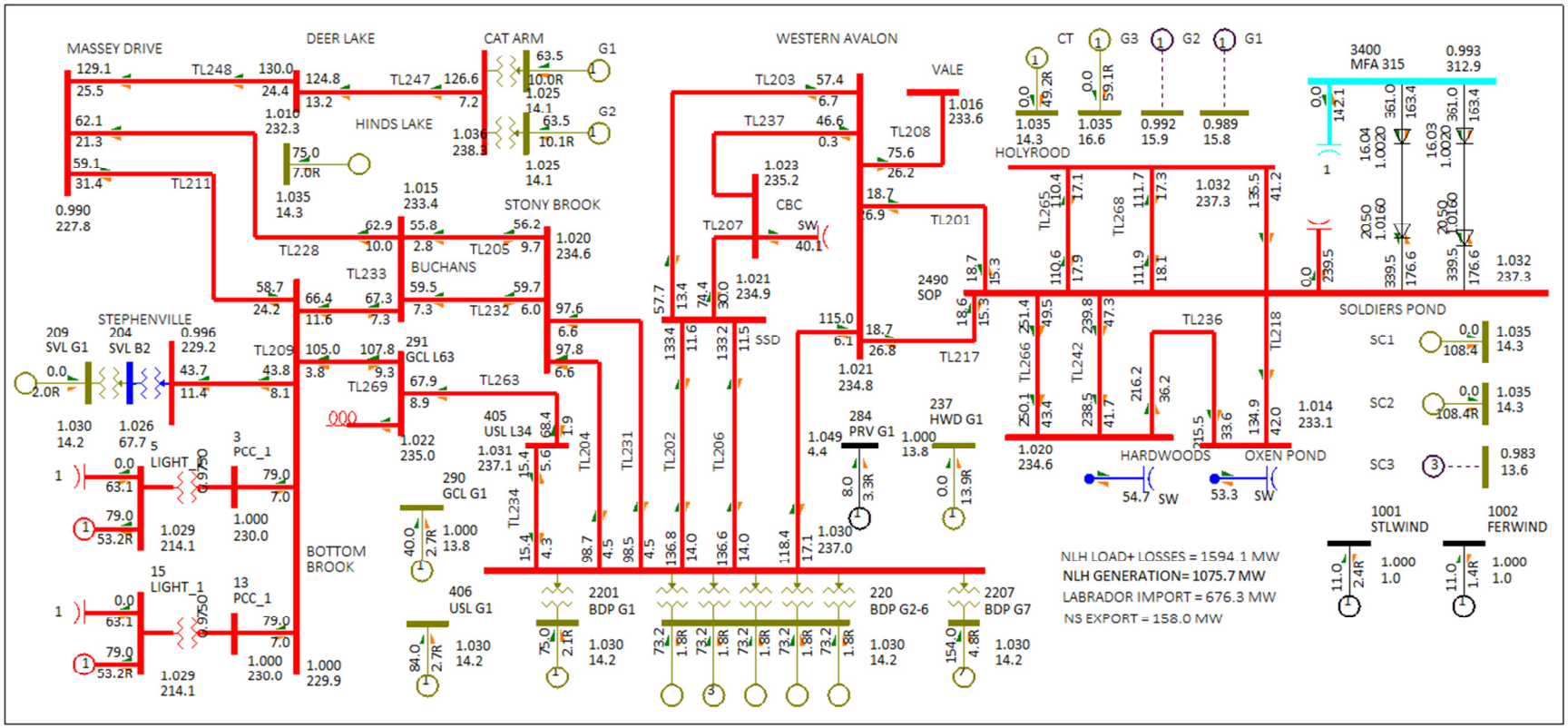

Figure 71 – Load Flow Plot – Base Case 3

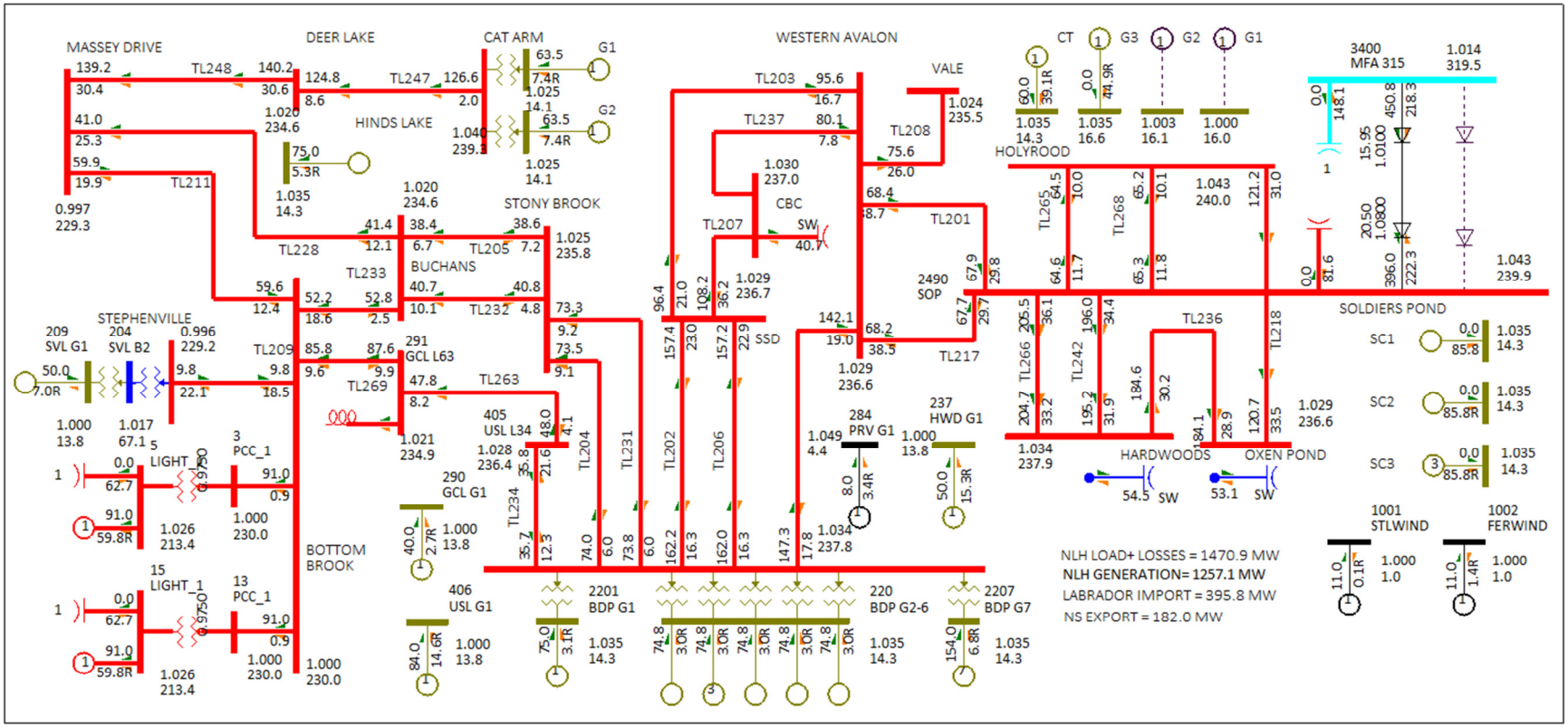

Figure 72 – Load Flow Plot – Base Case 4

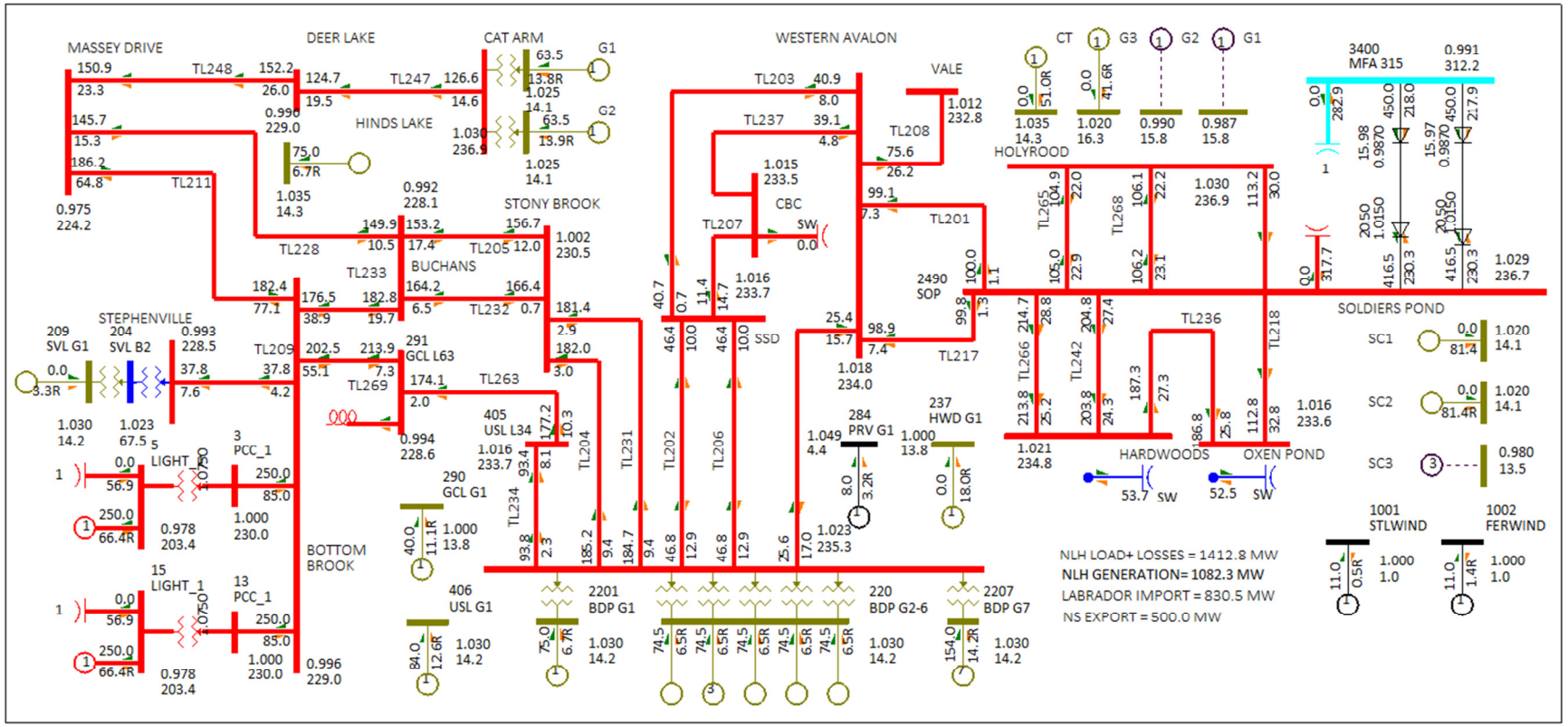

Figure 73 – Load Flow Plot – Base Case 6

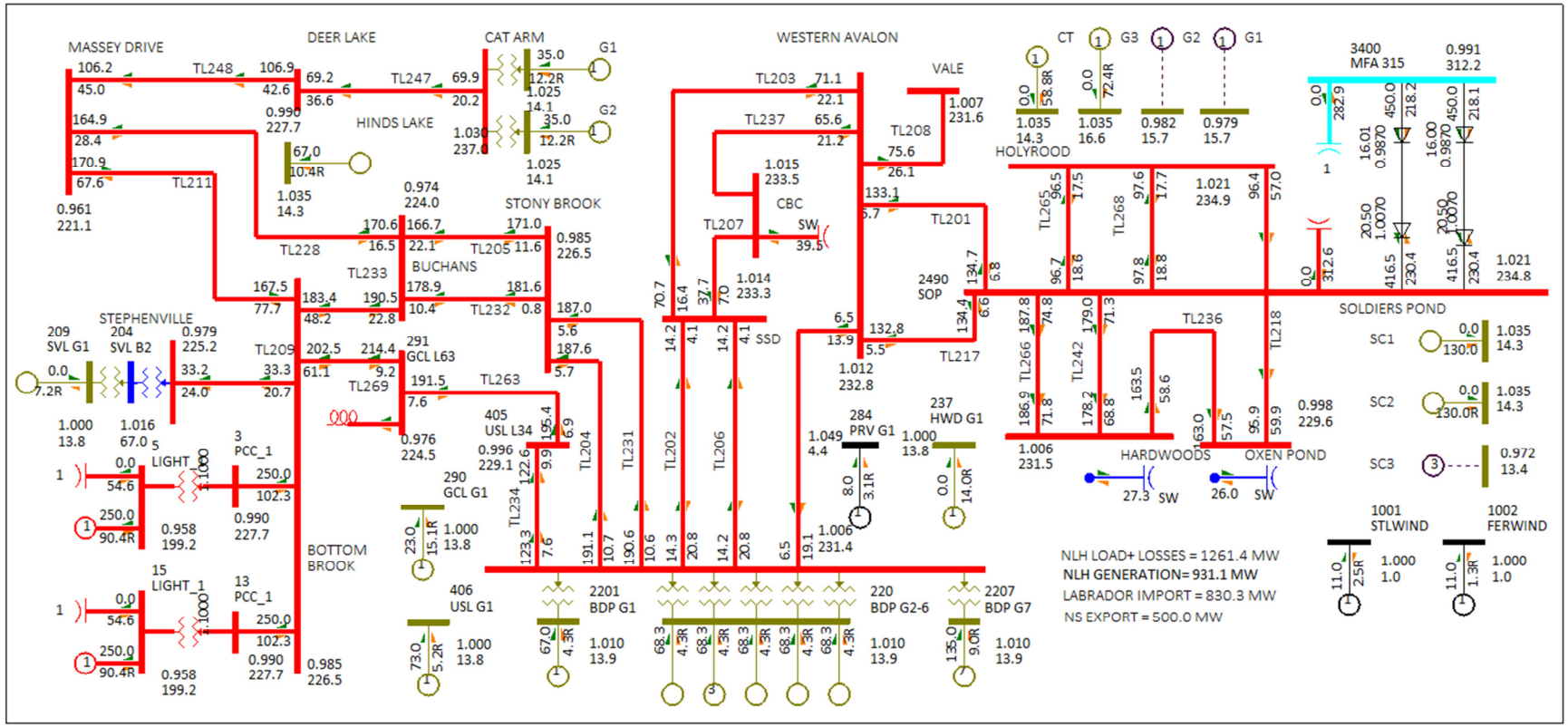

Figure 74 – Load Flow Plot – Base Case 7

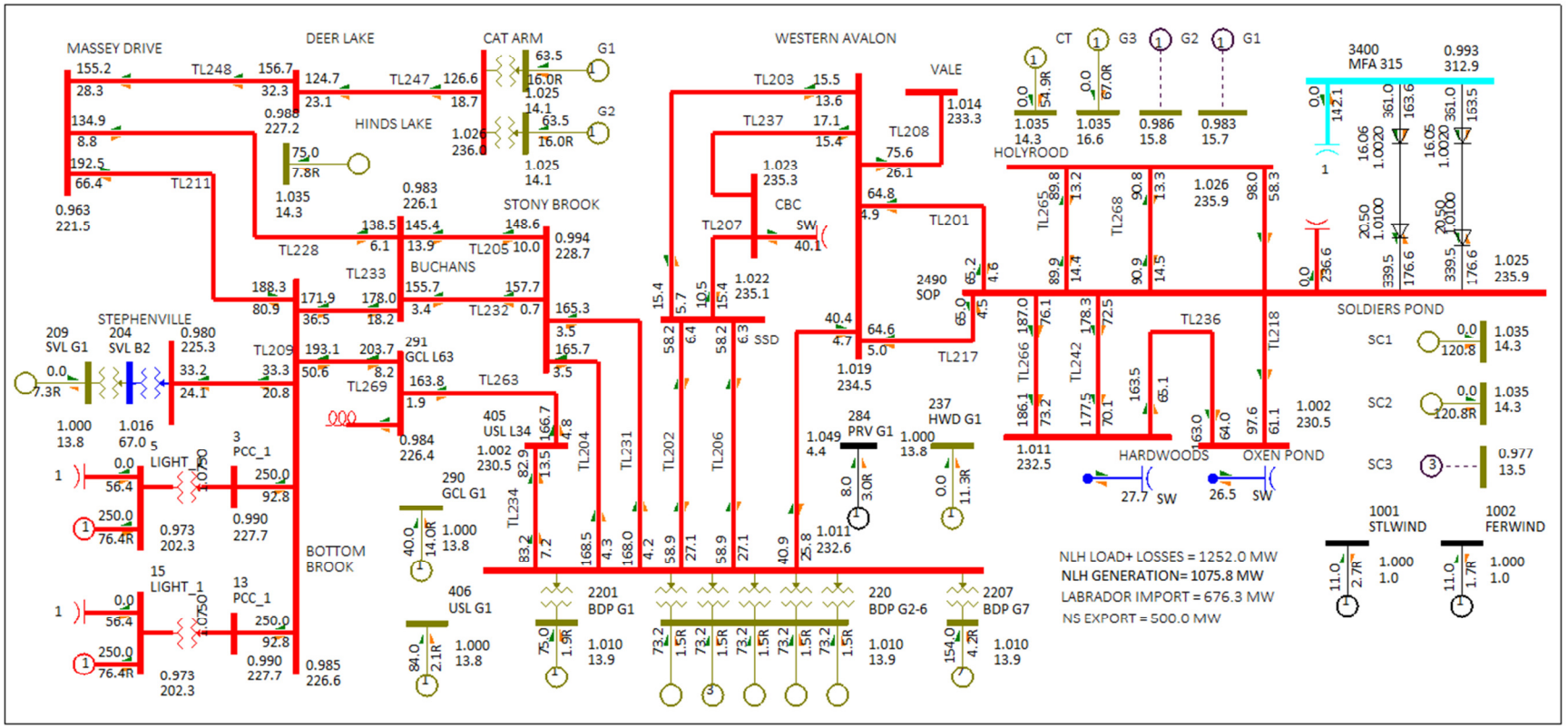

Figure 75 – Load Flow Plot – Base Case 8

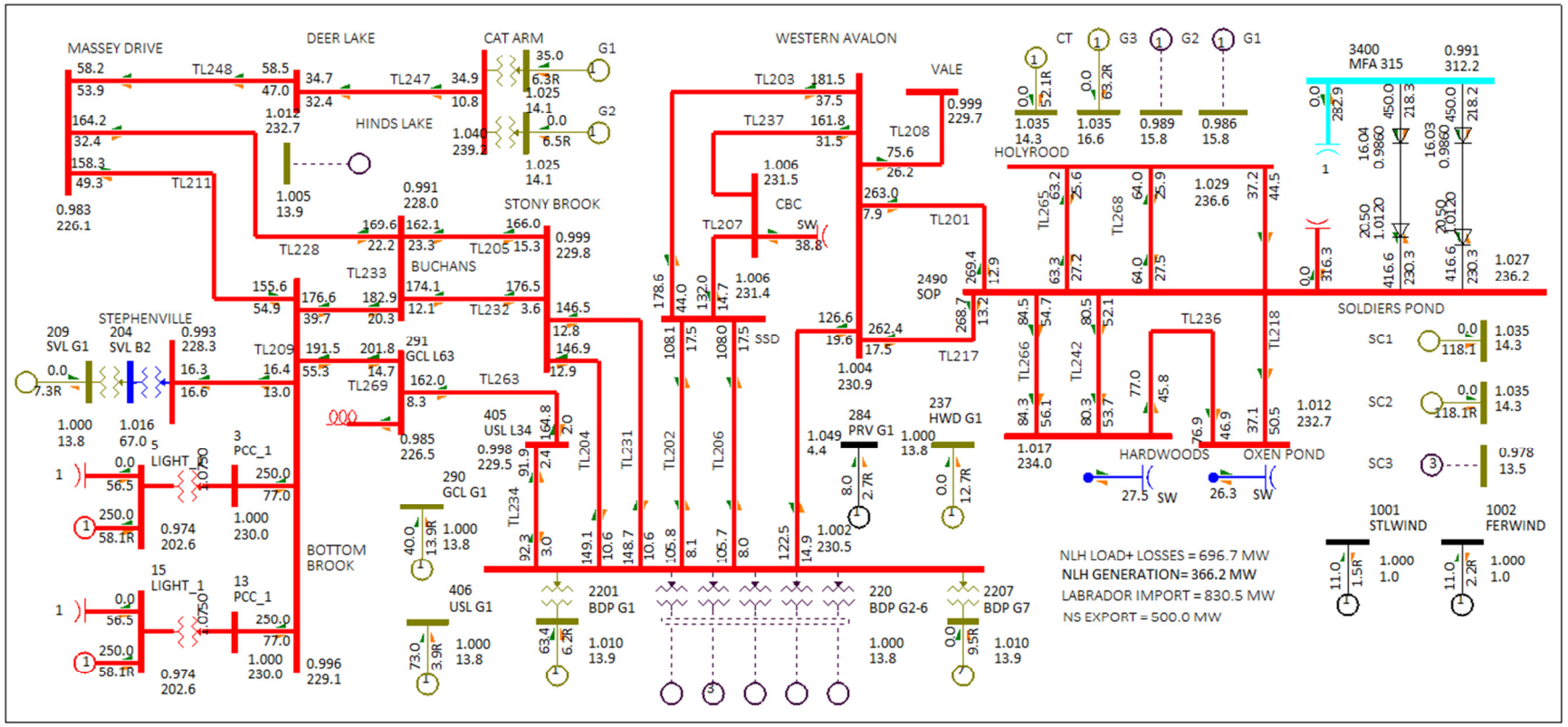

Figure 76 – Load Flow Plot – Base Case 9

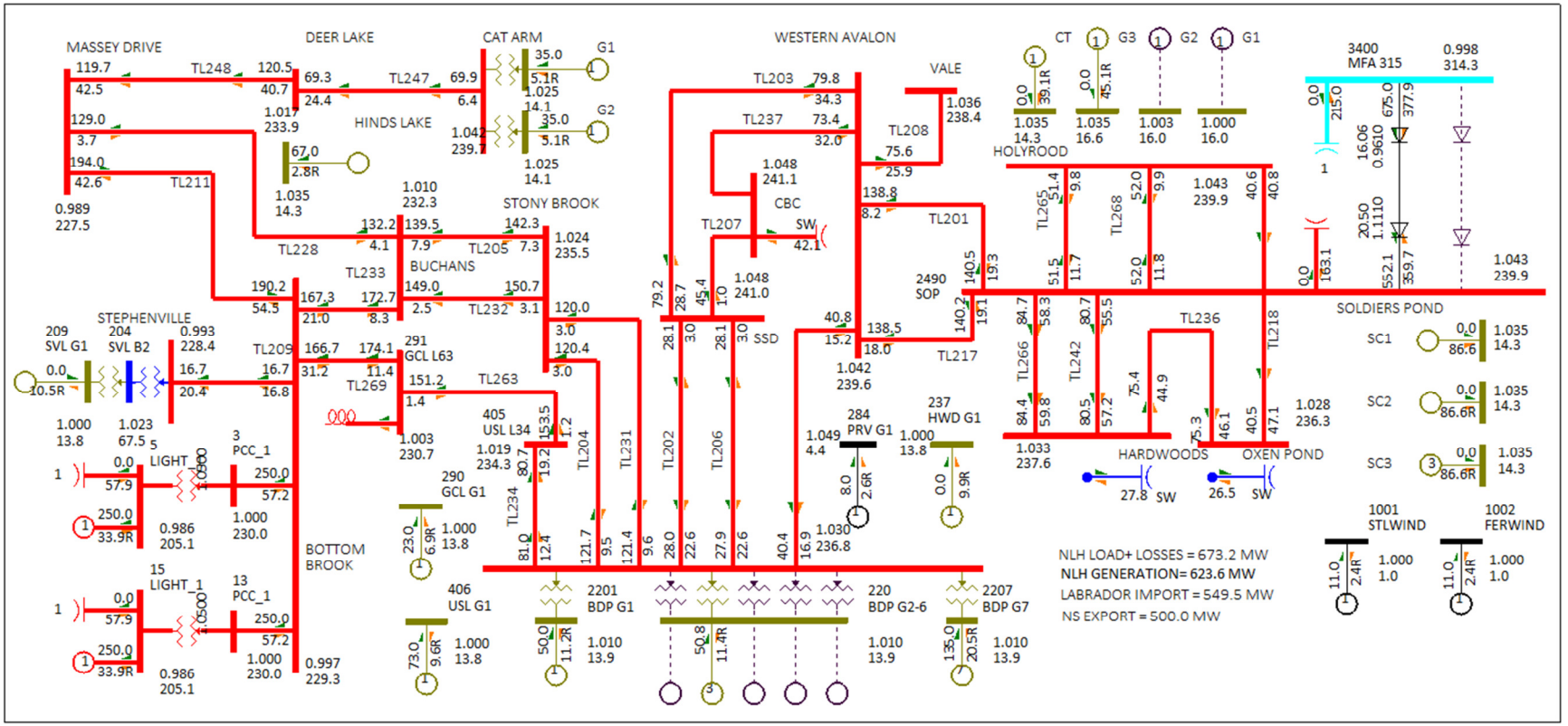

Figure 77 – Load Flow Plot – Base Case 10

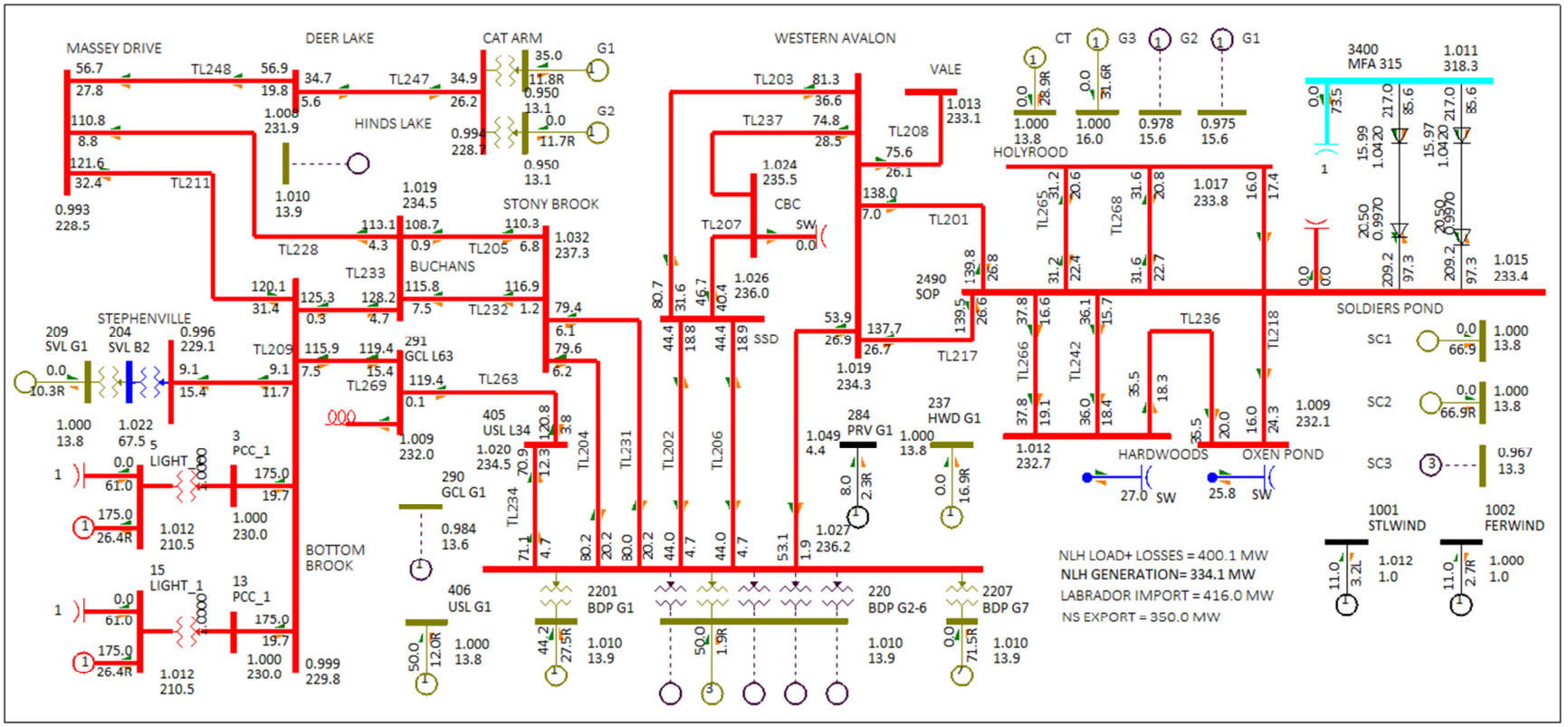

Figure 78 – Load Flow Plot – Base Case 11

APPENDIX B Contingency List

Table 10 – List of Contingencies for Dynamic Analysis

Contingency	Name	Description
CON1	Temporary Bipole Fault	LIL Bipole outage with full power restored after 300 ms.
CON2	Temporary Pole Fault[11]	LIL pole outage with full power restored after 300 ms.
CON3	Permanent Pole Fault	LIL Pole is tripped.
CON4	Three-phase fault at Soldiers Pond, followed by the tripping of a Synchronous Condenser	Synchronous condenser is tripped after 100 ms.
CON5	Three-phase fault at Soldiers Pond, followed by the tripping of TL217 to Western Avalon.	Line is tripped after 100 ms.
CON6	Three-phase fault at Soldiers Pond, followed by the tripping of TL266 to Hardwoods.	Line is tripped after 100 ms.
CON7	Three-phase fault at Western Avalon, Followed by the tripping of line to Bay d'Espoir.	Line is tripped after 100 ms.
CON8	Three-phase fault at Come-by-Chance, followed by the tripping of TL207 to Sunnyside.	Line is tripped after 100 ms.
CON9	Three-phase fault at Come-by-Chance, followed by the tripping of TL237 to Western Avalon.	Line is tripped after 100 ms.
CON10	Three-phase fault at Sunnyside, followed by the tripping of TL202 to Bay d'Espoir.	Line is tripped after 100 ms.
CON11	Three-phase fault at Sunnyside, followed by the tripping of TL203 to Western Avalon.	Line is tripped after 100 ms.
CON12	Three-phase fault at Sunnyside, followed by the tripping of TL207 to Come-by-Chance.	Line is tripped after 100 ms.
CON13	Three-phase fault at Bay d'Espoir, Followed by the tripping of TL202 to Sunnyside.	Line is tripped after 100 ms.

[11] This contingency is not considered for monopole cases as the results would be the same as CON1.

CON14	Three-phase fault at Bay d'Espoir, Followed by the tripping of TL204 to Stony Brook.	Line is tripped after 100 ms.
CON15	Three-phase fault at Bay d'Espoir, Followed by the tripping of TL234 to Upper Salmon.	Line is tripped after 100 ms.
CON16	Three-phase fault at Sunnyside, followed by the tripping of TL207 to Come-by-Chance.	Line is tripped after 100 ms.
CON17	Three-phase fault at Bay d'Espoir, Followed by the tripping of Unit.	Line is tripped after 100 ms.
CON18	Three-phase fault at Stony Brook, Followed by the tripping of TL232to Buchans.	Line is tripped after 100 ms.
CON19	Three-phase fault at Buchans, Followed by the tripping of TL233 to Bottom Brook.	Line is tripped after 100 ms.
CON20	Three-phase fault at Buchans, Followed by the tripping of TL228 to Massey Drive.	Line is tripped after 100 ms.
CON21	Three-phase fault at Massey Drive, Followed by the tripping of TL211 to Bottom Brook.	Line is tripped after 100 ms.
CON22	Three-phase fault at Massey Drive, Followed by the tripping of TL228 to Buchans.	Line is tripped after 100 ms.
CON23	Three-phase fault at Massey Drive, Followed by the tripping of TL248 to Buchans.	Line is tripped after 100 ms. TL247 is cross-tripped, isolating Cat Arm generation.
CON24	Three-phase fault at Bottom Brook Drive, followed by the tripping of TL269 to Granite Canal.	Line is tripped after 100 ms.
CON25	Three-phase fault at Bottom Brook Drive, followed by the tripping of TL209 to Stephenville.	Line is tripped after 100 ms.
CON26	Three-phase fault at Bottom Brook Drive, followed by the tripping of TL211 to Massey Drive.	Line is tripped after 100 ms.
CON27	Three-phase fault at Bottom Brook Drive, followed by the	Line is tripped after 100 ms.

	tripping of TL233 to Buchans.	
CON28	Three-phase fault at Bottom Brook, followed by the tripping of the Maritime Link	Link is tripped after 100 ms.
CON29	Three-phase fault at Stephenville, followed by the tripping of TL209 to Bottom Brook.	Line is tripped after 100 ms.
CON30	Three-phase fault at Upper Salmon, followed by tripping of unit.	Unit is tripped after 100 ms.
CON31	Three-phase fault at Upper Salmon, followed by the tripping of TL234 to Bay d'Espoir.	Line is tripped after 100 ms.
CON32	Three-phase fault at Upper Salmon, followed by the tripping of TL263 to Granite Canal.	Line is tripped after 100 ms.
CON33	Three-phase fault at Granite Canal, followed by the tripping of TL269 to Bottom Brook.	Line is tripped after 100 ms.
CON34	Three-phase fault at Granite Canal, followed by the tripping of TL263 to Upper Salmon.	Line is tripped after 100 ms.
CON35	SLG fault at Bay d'Espoir on TL202 to Sunnyside. Pole is successfully reclosed.	Bay d'Espoir circuit breaker pole recloses after 30 cycles, Sunnyside circuit breaker pole recloses after 40 ms.
CON36	SLG fault at Soldiers Pond on TL217 to Western Avalon. Pole is successfully reclosed.	Western Avalon pole recloses after 30 cycles, Soldiers Pond pole recloses after 40 ms.

APPENDIX C Remedial ML Curtailment for Ac Transmission Line Faults In Western Newfoundland

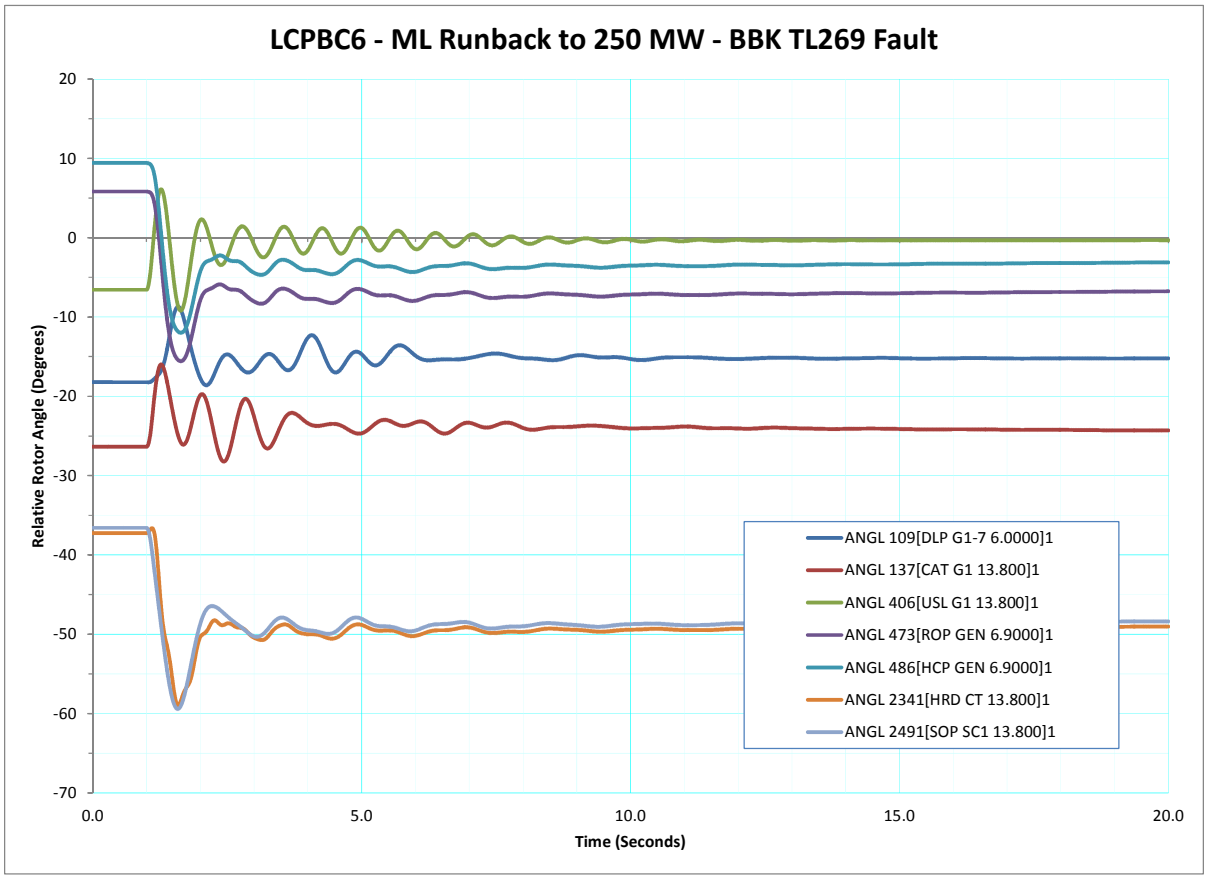

Figure 79 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - Relative Rotor Angle (Degrees)

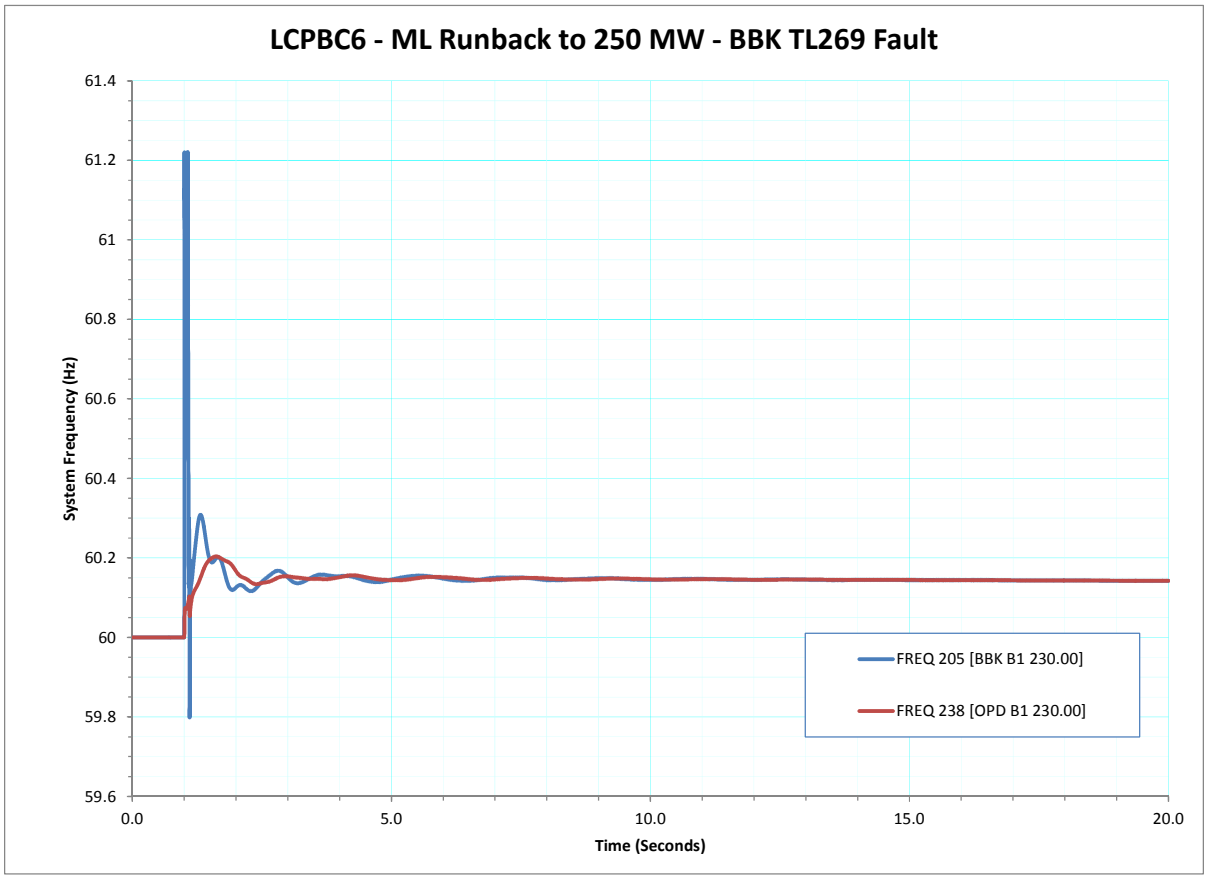

Figure 80 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - System Frequency (Hz)

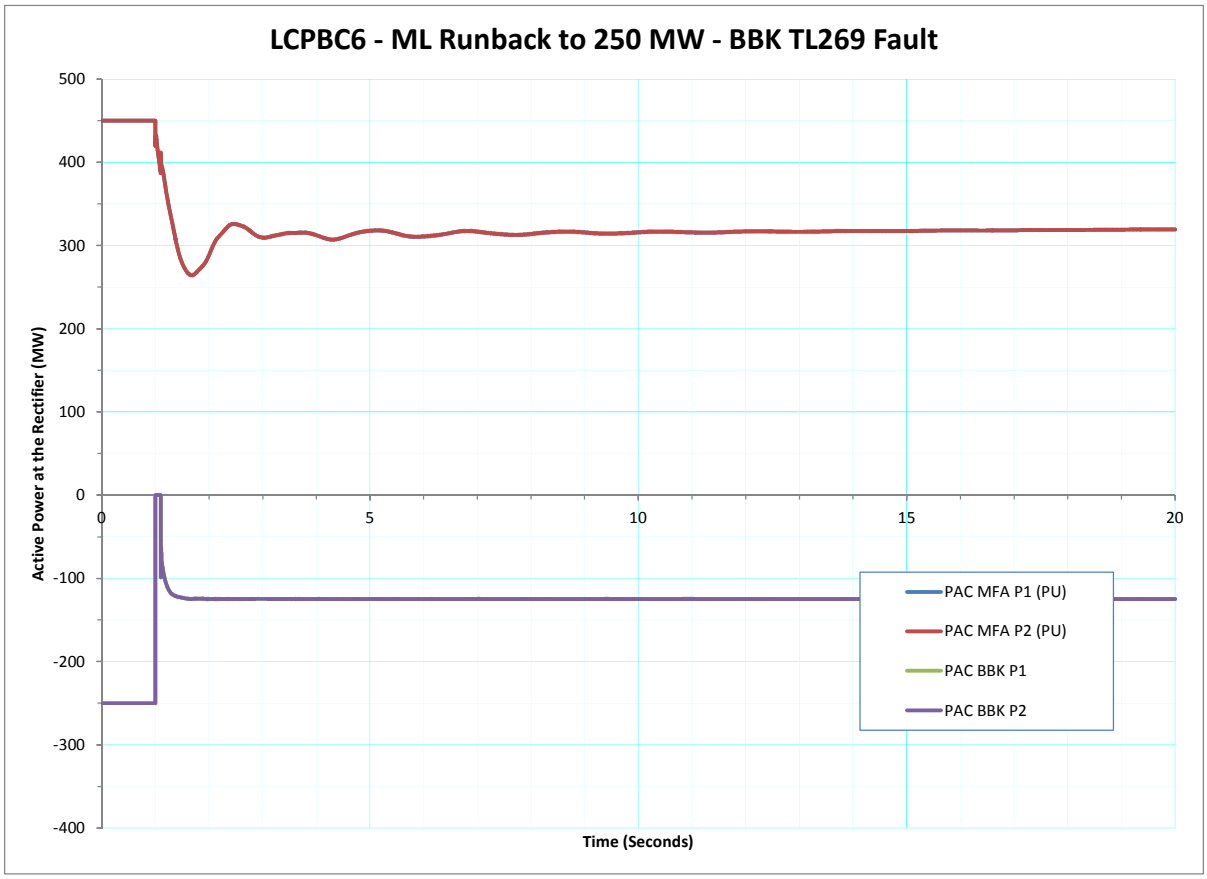

Figure 81 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - Active Power at the Rectifier (MW)

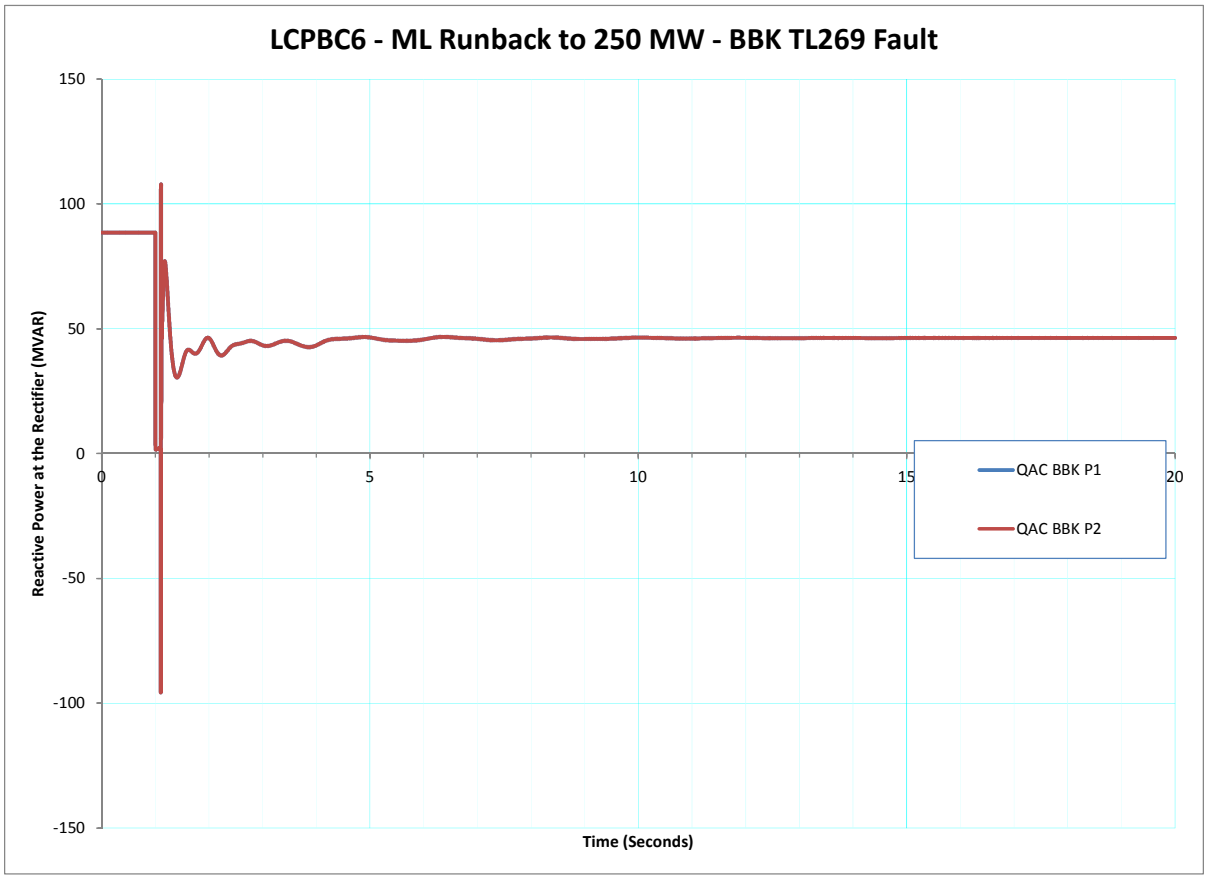

Figure 82 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - Reactive Power at the Rectifier (MVAR)

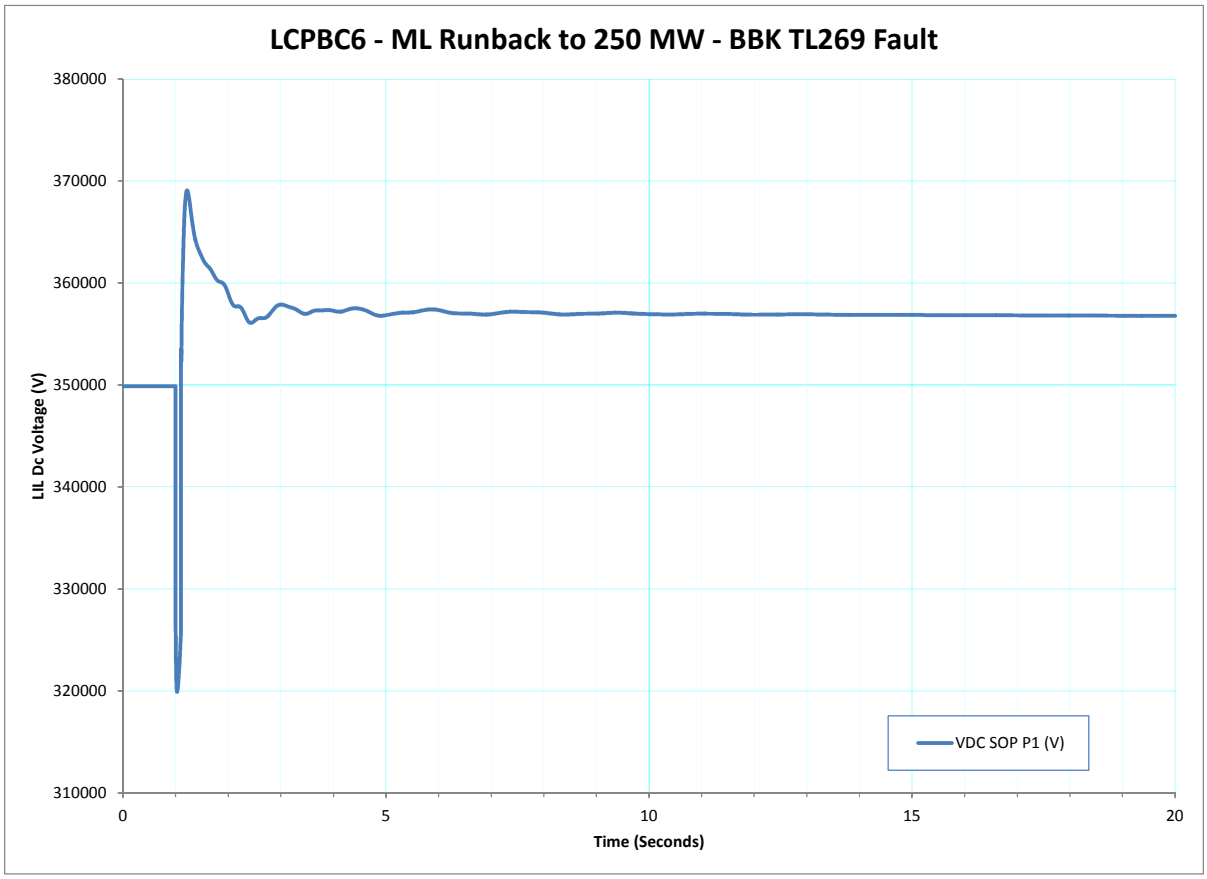

Figure 83 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - LIL Dc Voltage (V)

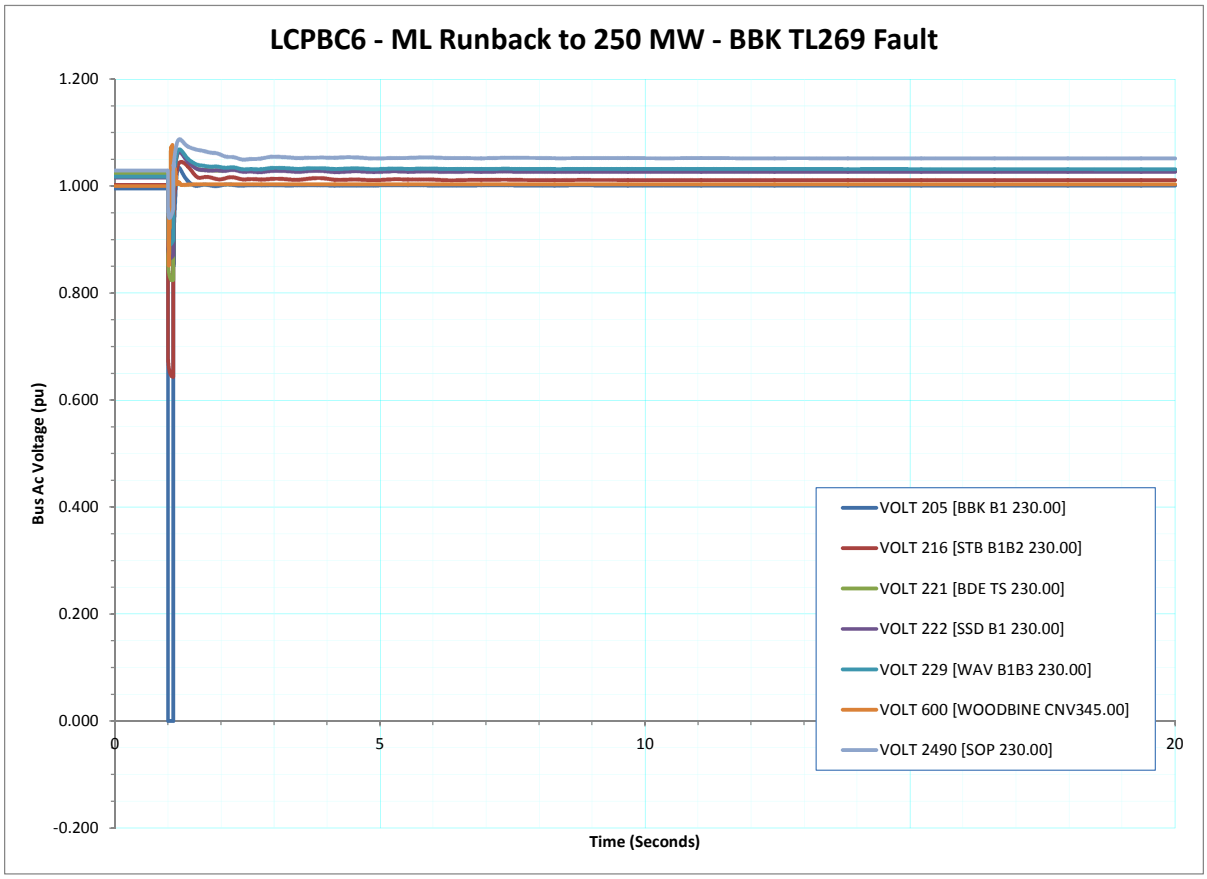

Figure 84 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - Bus Ac Voltage (pu)

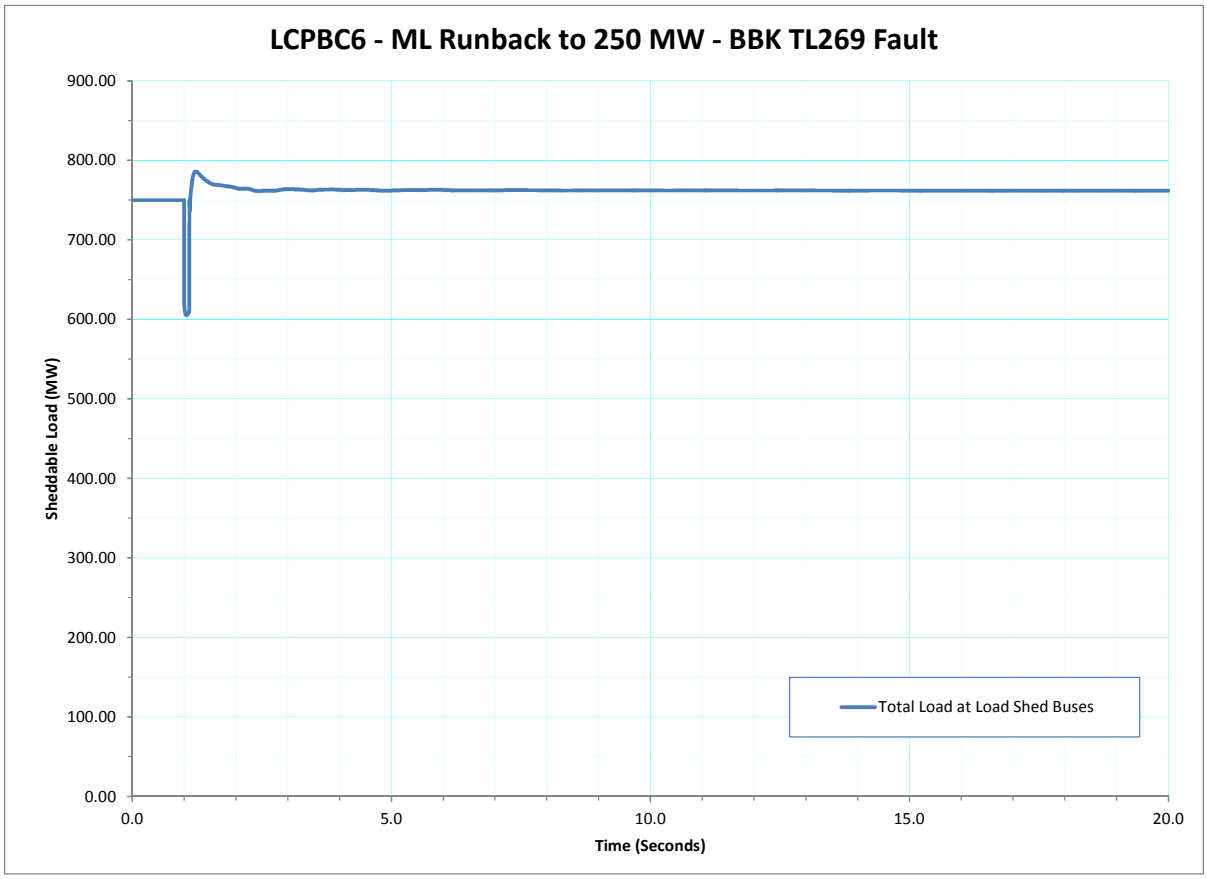

Figure 85 - LCPBC6 - ML Runback to 250 MW - BBK TL269 Fault - Sheddable Load (MW)

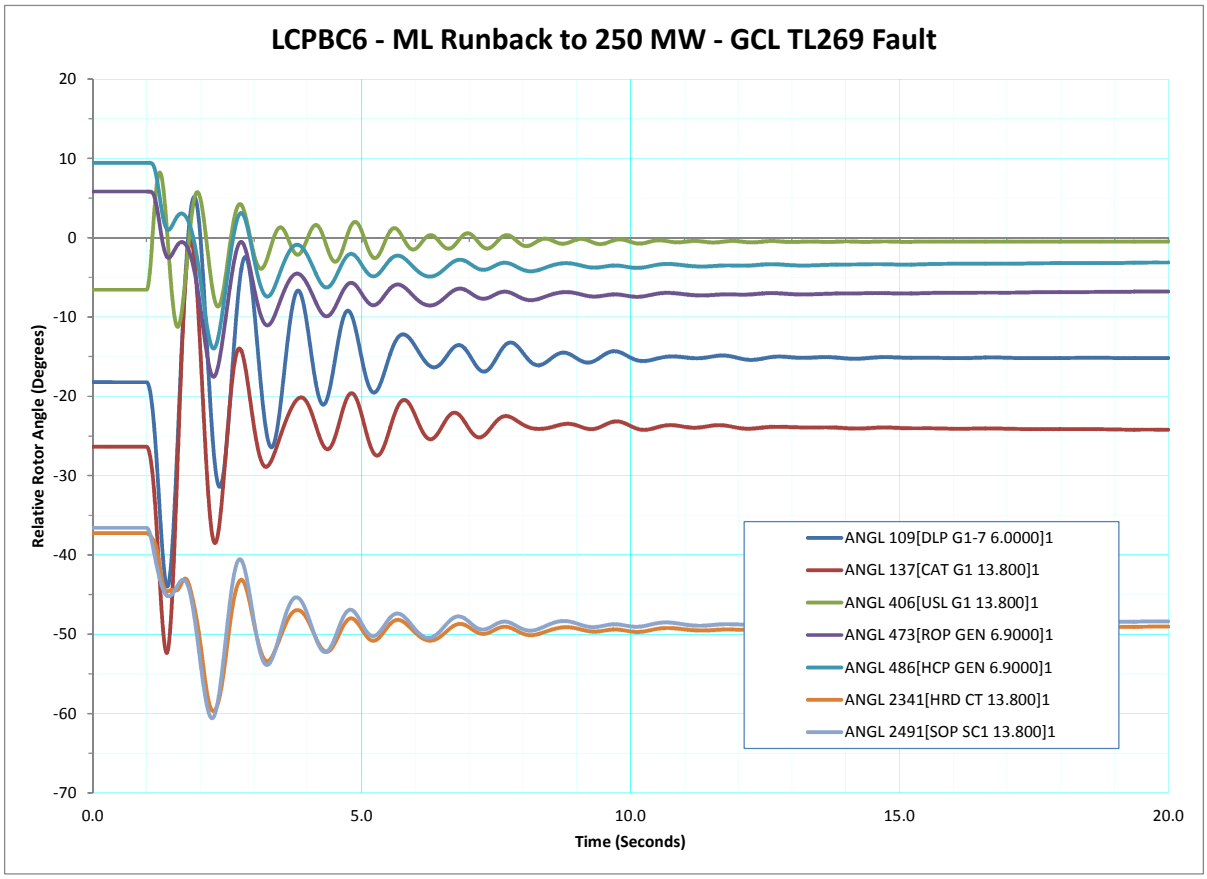

Figure 86 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - Relative Rotor Angle (Degrees)

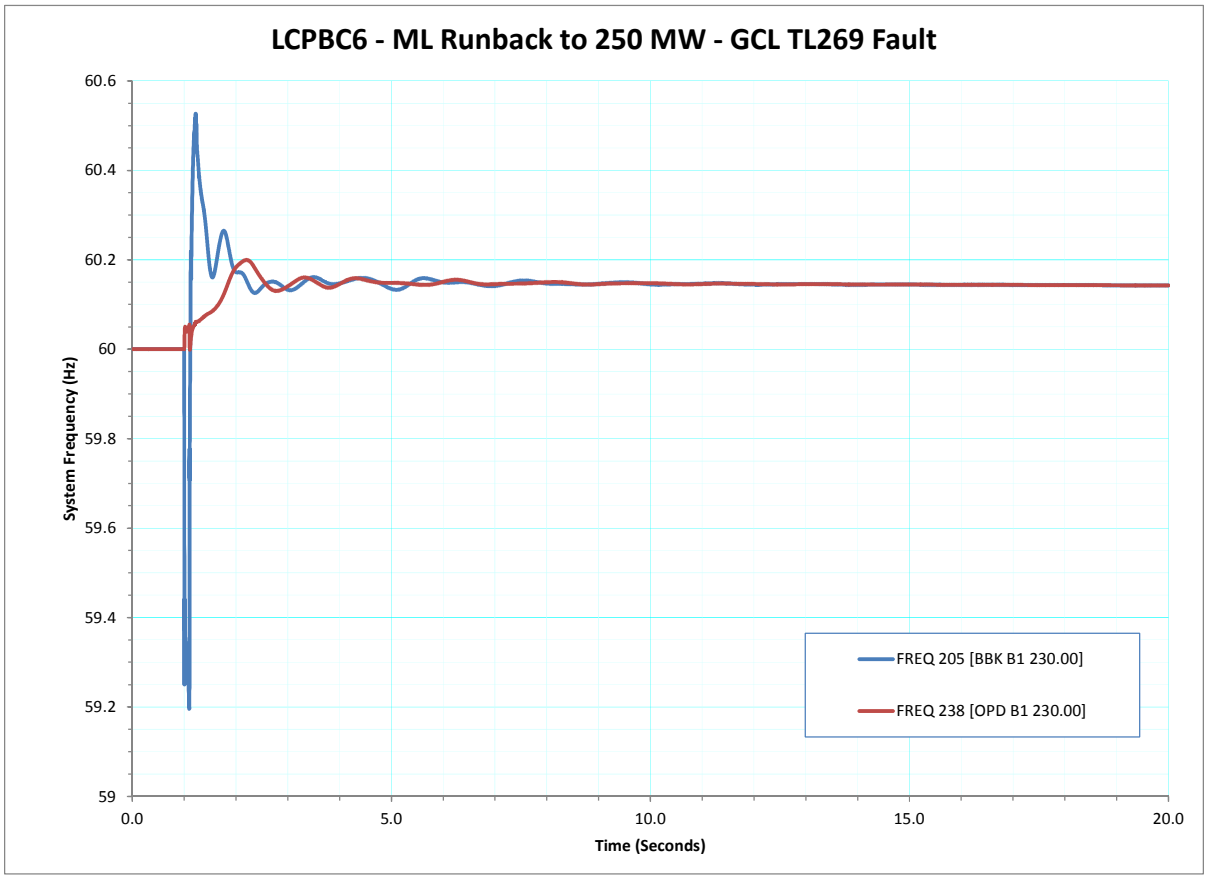

Figure 87 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - System Frequency (Hz)

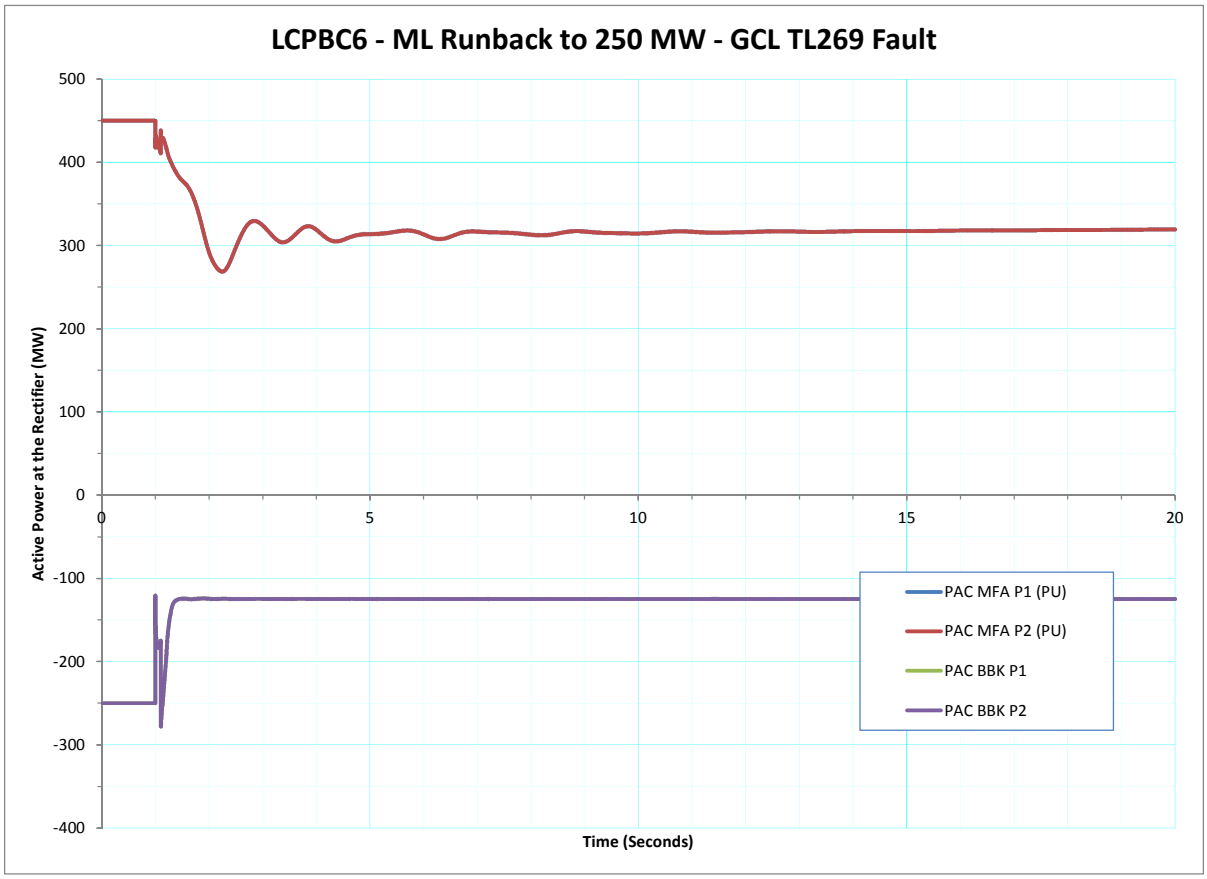

Figure 88 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - Active Power at the Rectifier (MW)

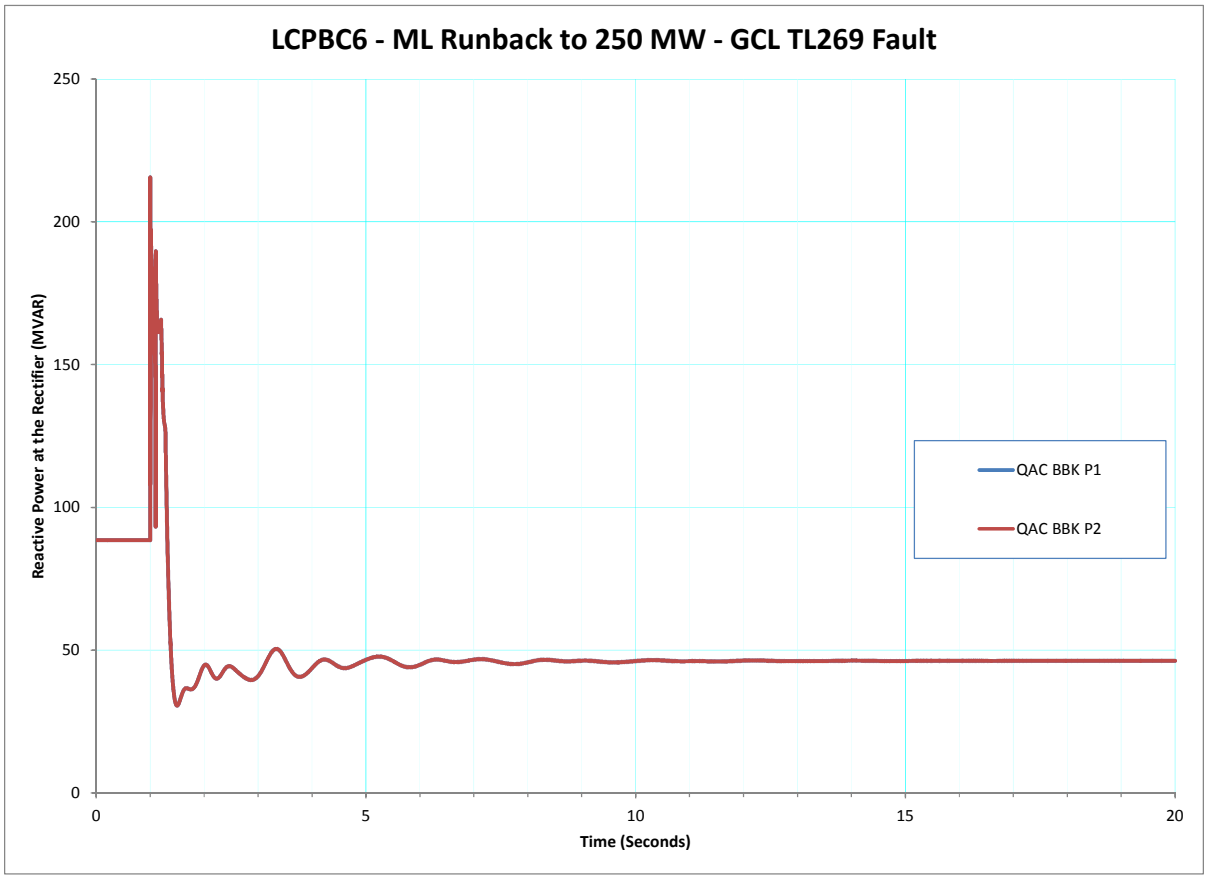

Figure 89 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - Reactive Power at the Rectifier (MVAR)

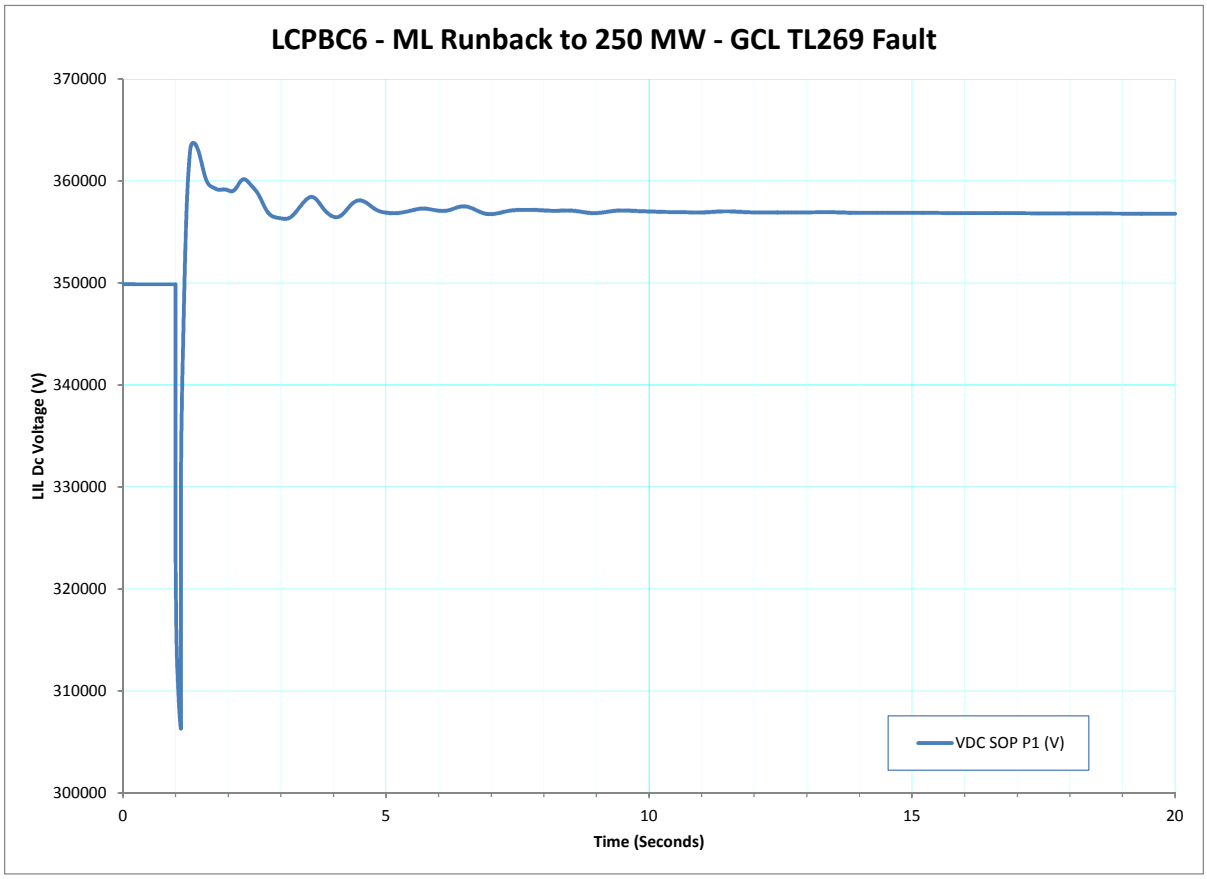

Figure 90 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - LIL Dc Voltage (V)

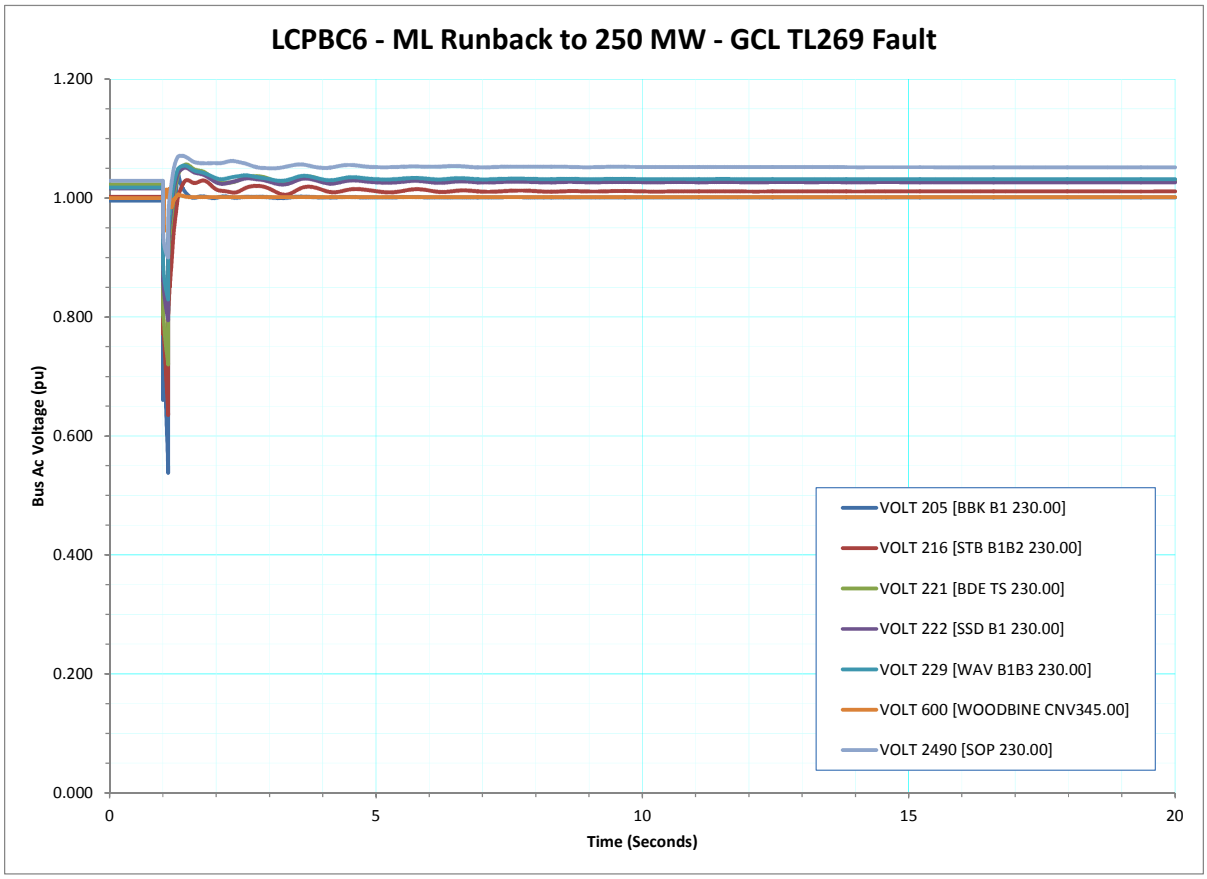

Figure 91 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - Bus Ac Voltage (pu)

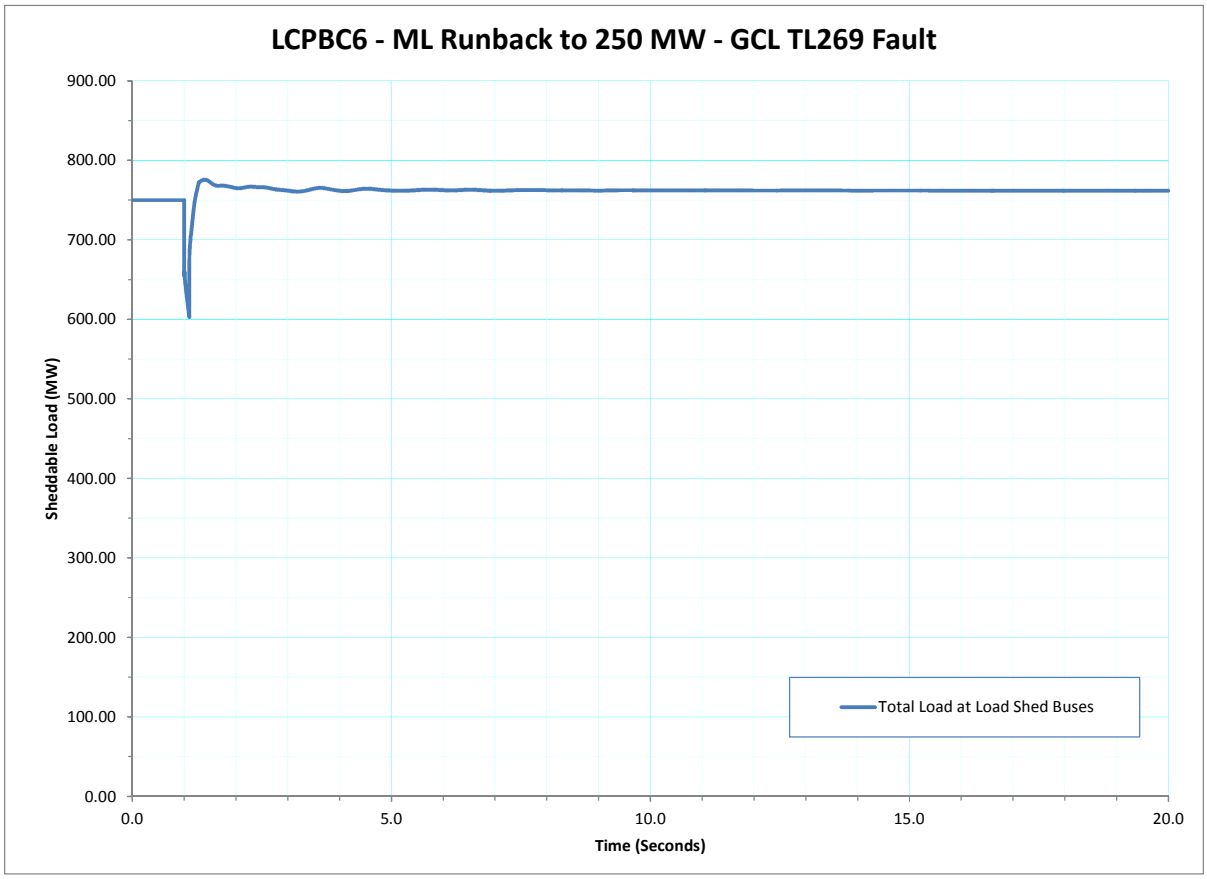

Figure 92 - LCPBC6 - ML Runback to 250 MW - GCL TL269 Fault - Sheddable Load (MW)

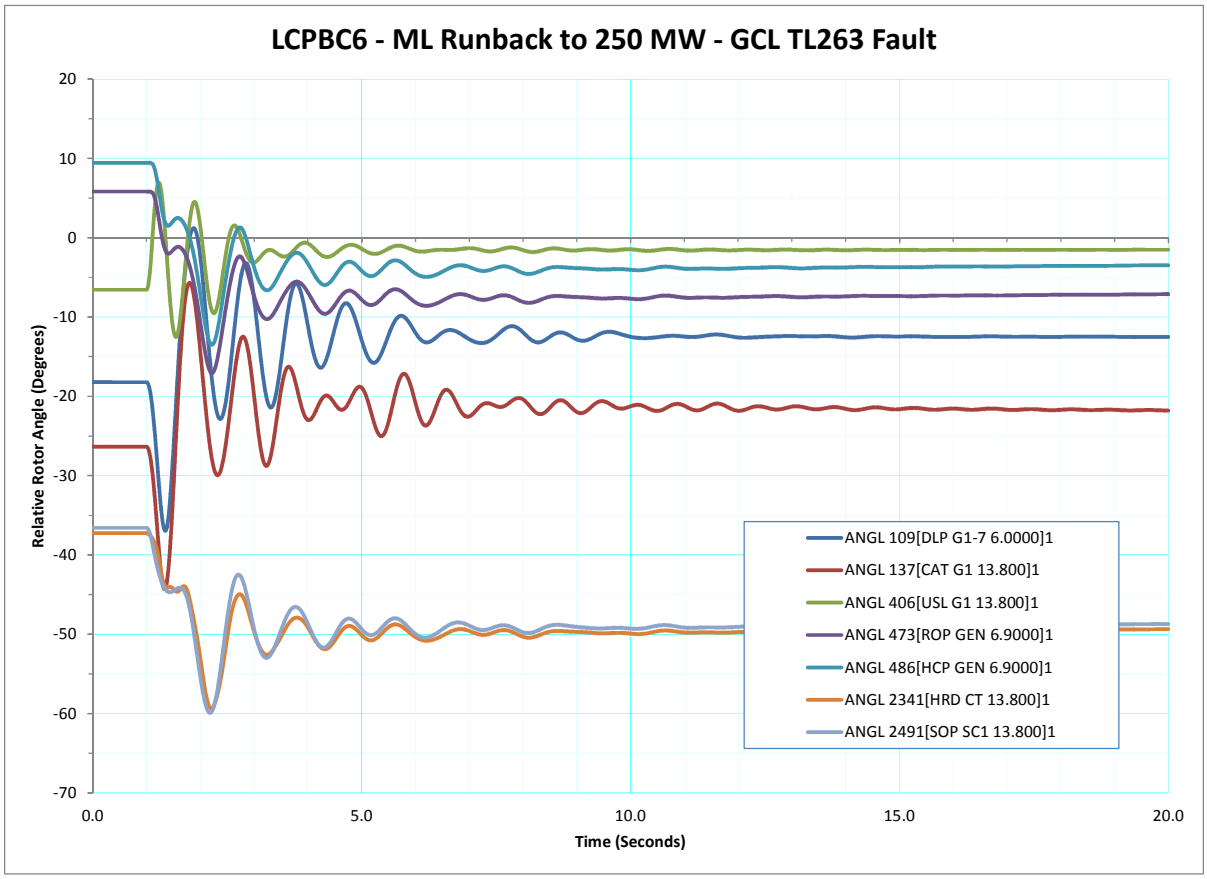

Figure 93 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - Relative Rotor Angle (Degrees)

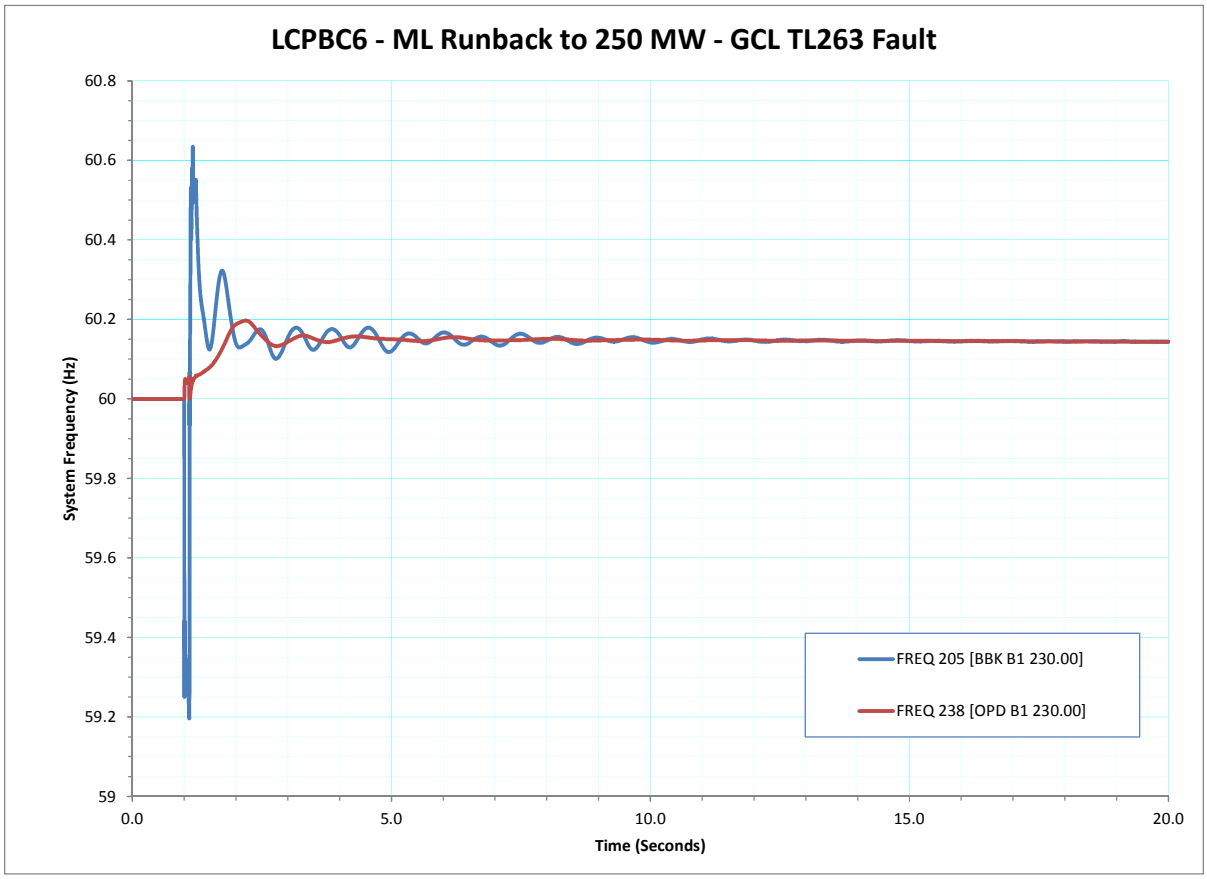

Figure 94 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - System Frequency (Hz)

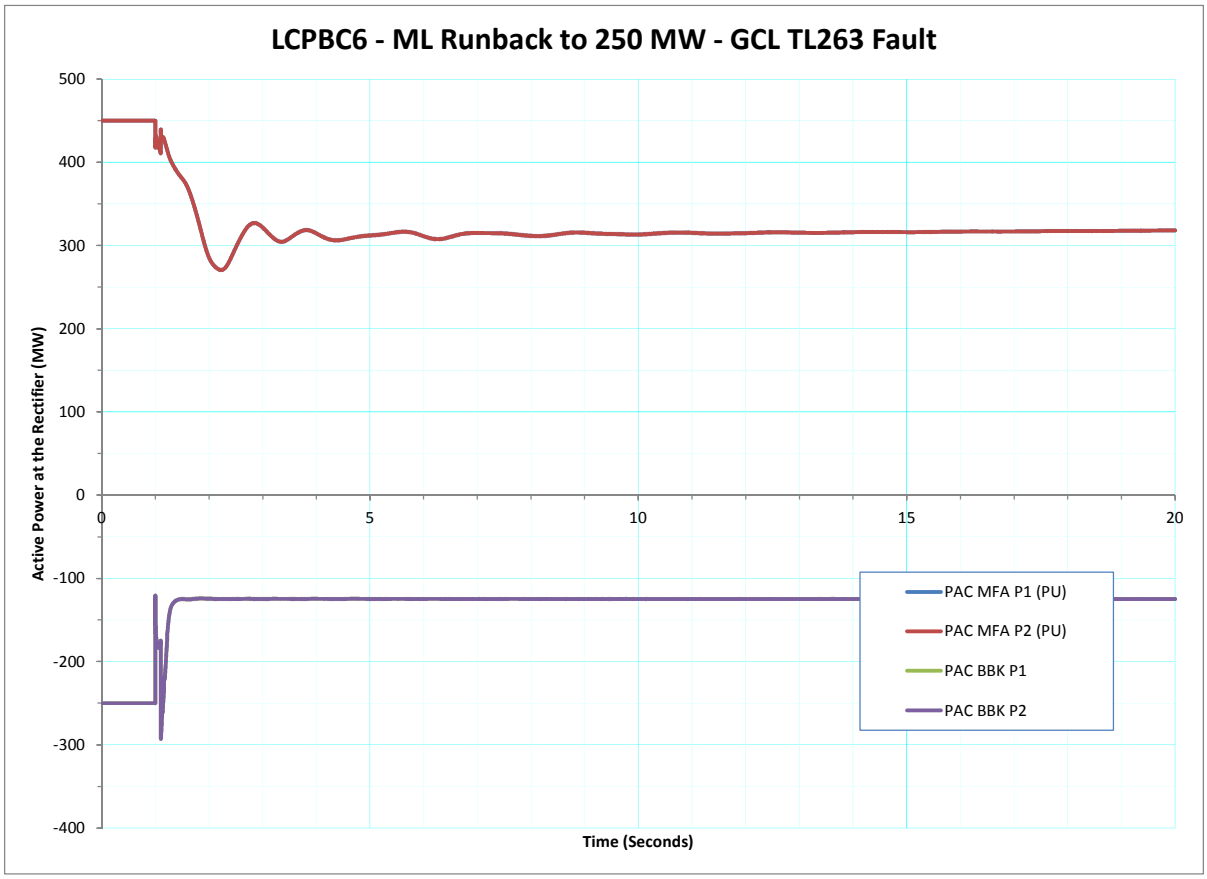

Figure 95 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - Active Power at the Rectifier (MW)

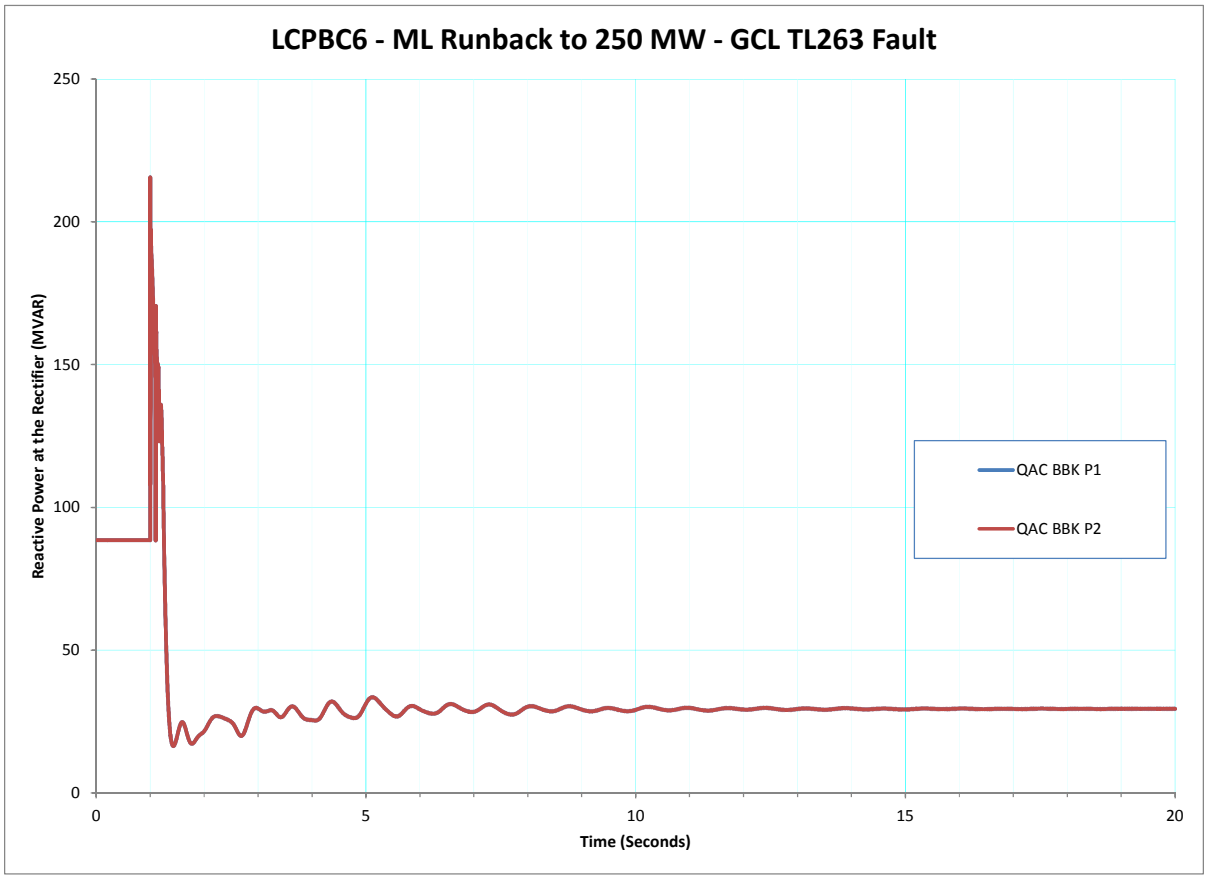

Figure 96 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - Reactive Power at the Rectifier (MVAR)

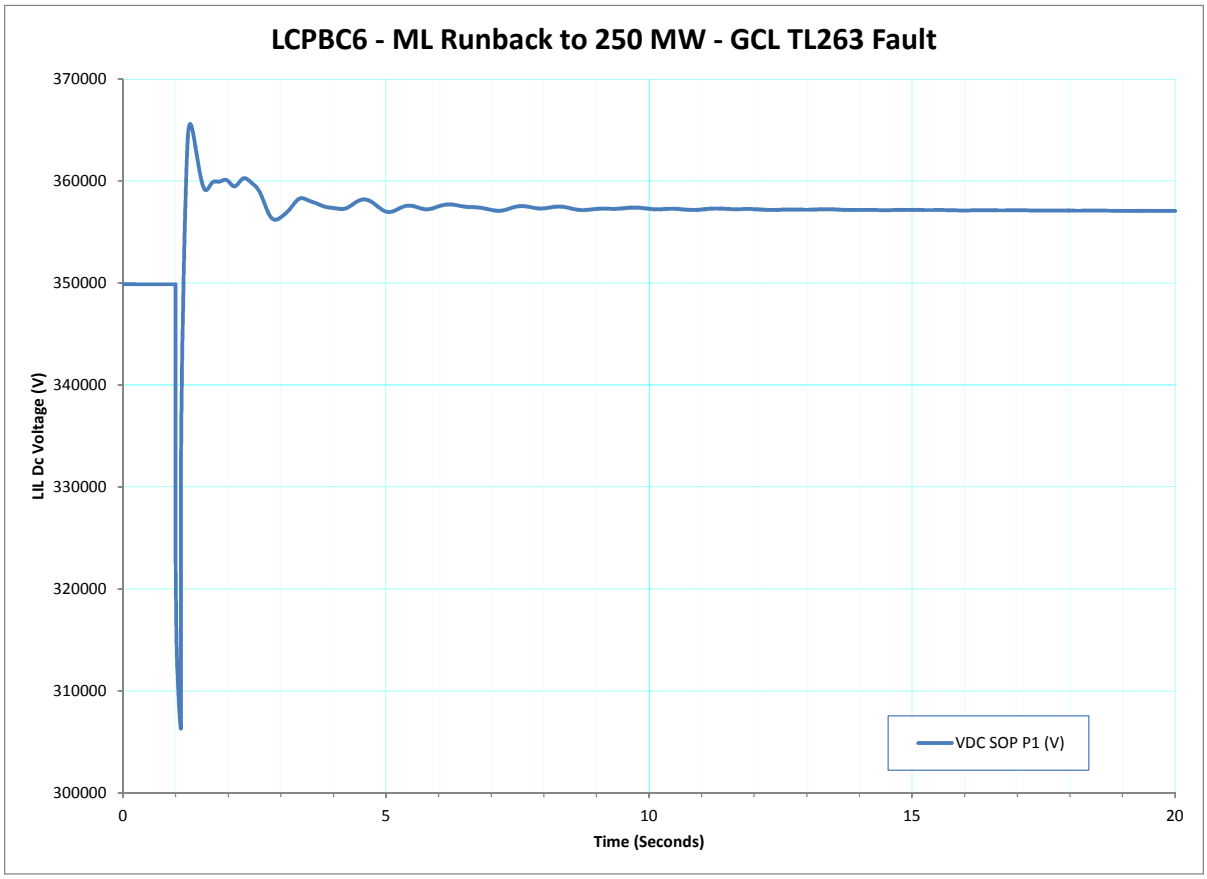

Figure 97 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - LIL Dc Voltage (V)

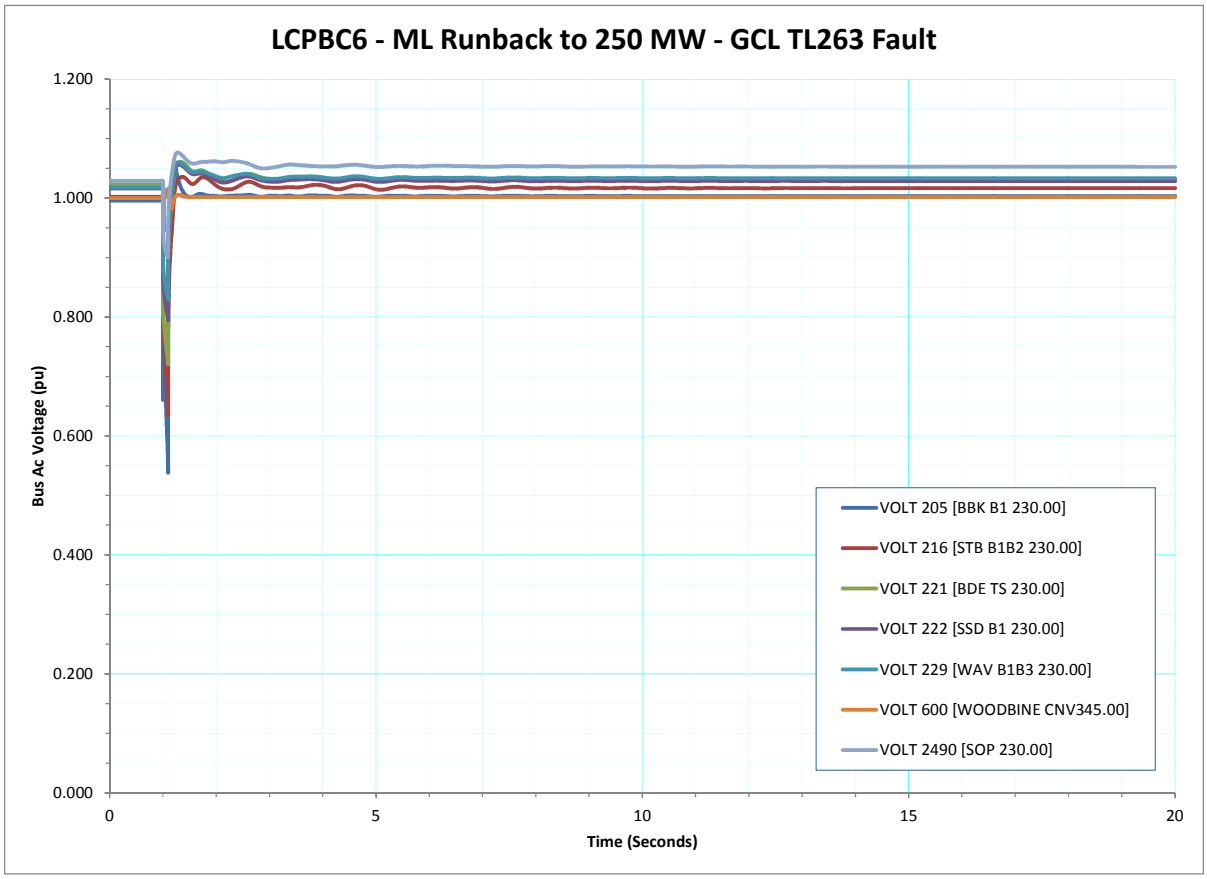

Figure 98 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - Bus Ac Voltage (pu)

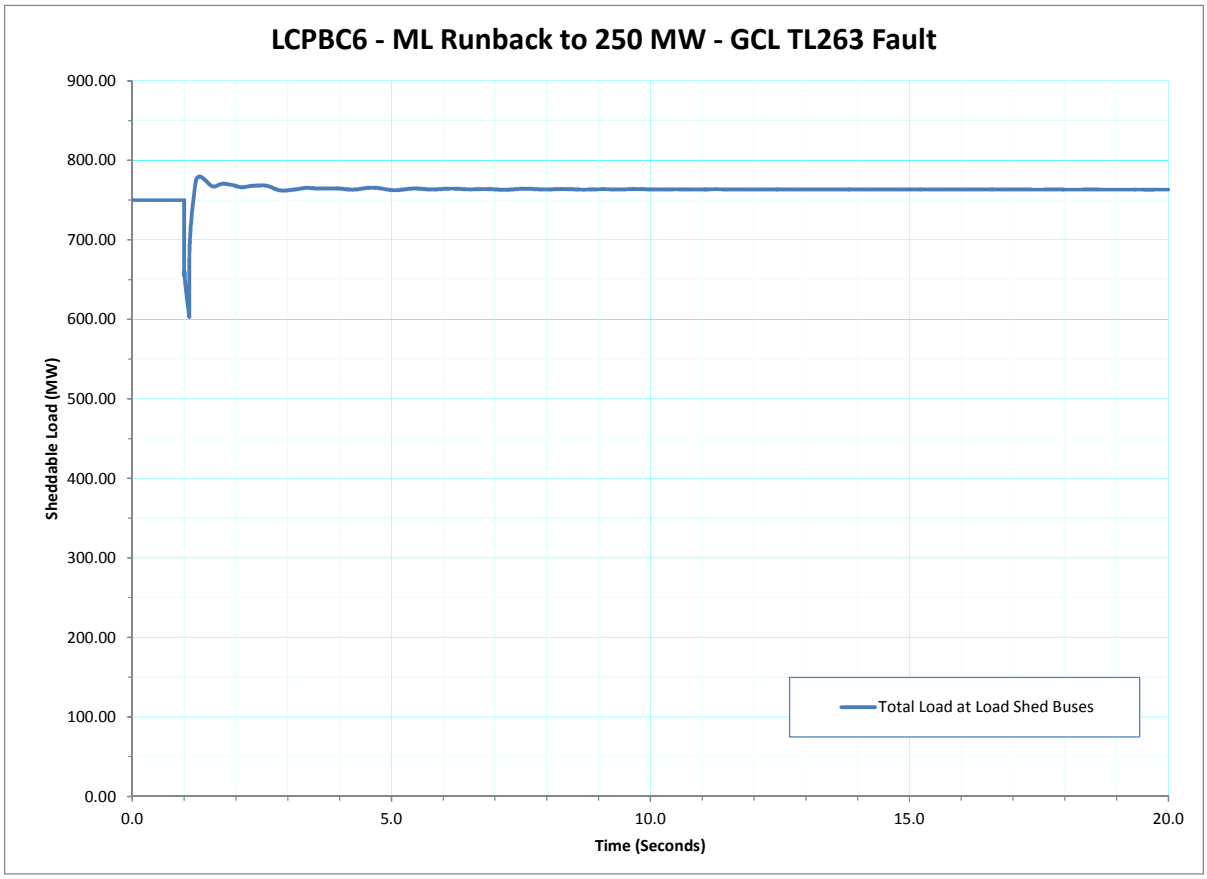

Figure 99 - LCPBC6 - ML Runback to 250 MW - GCL TL263 Fault - Sheddable Load (MW)

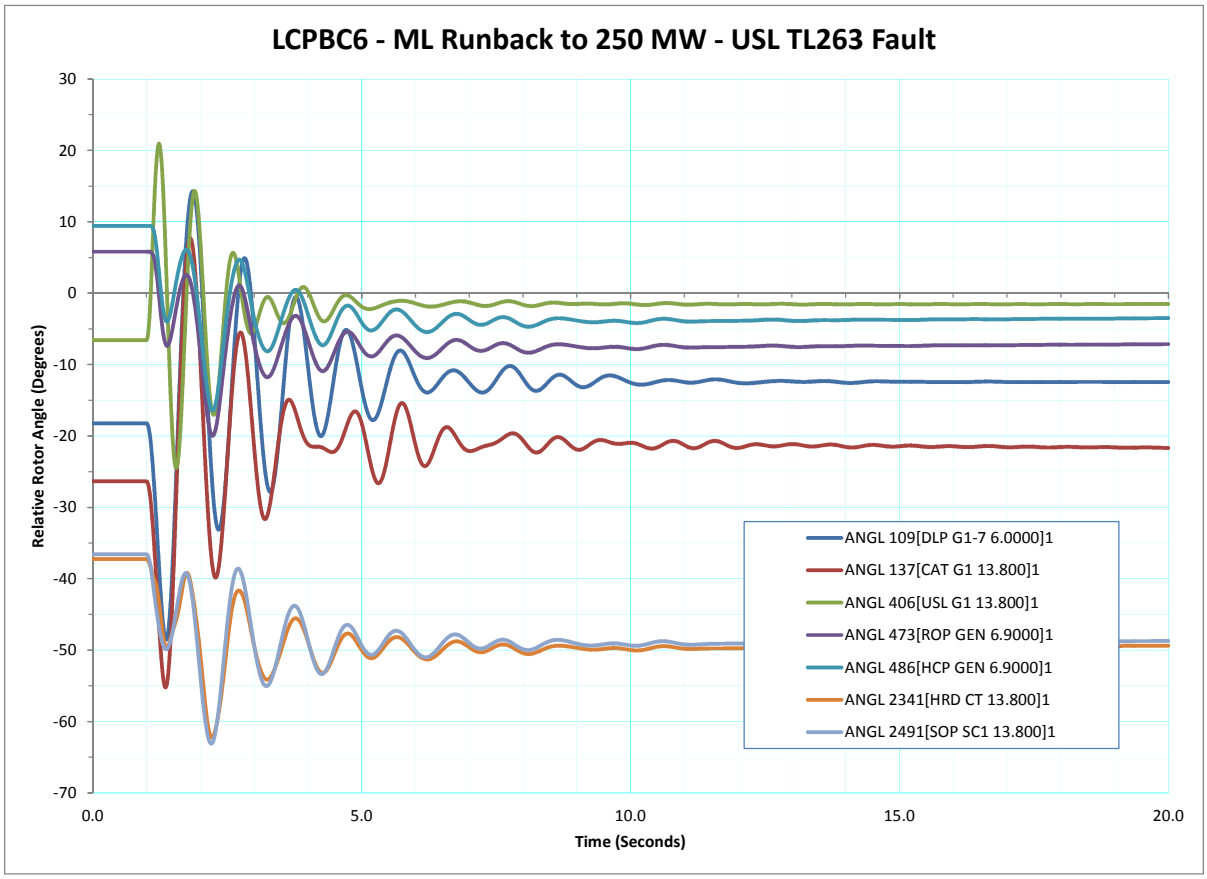

Figure 100 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - Relative Rotor Angle (Degrees)

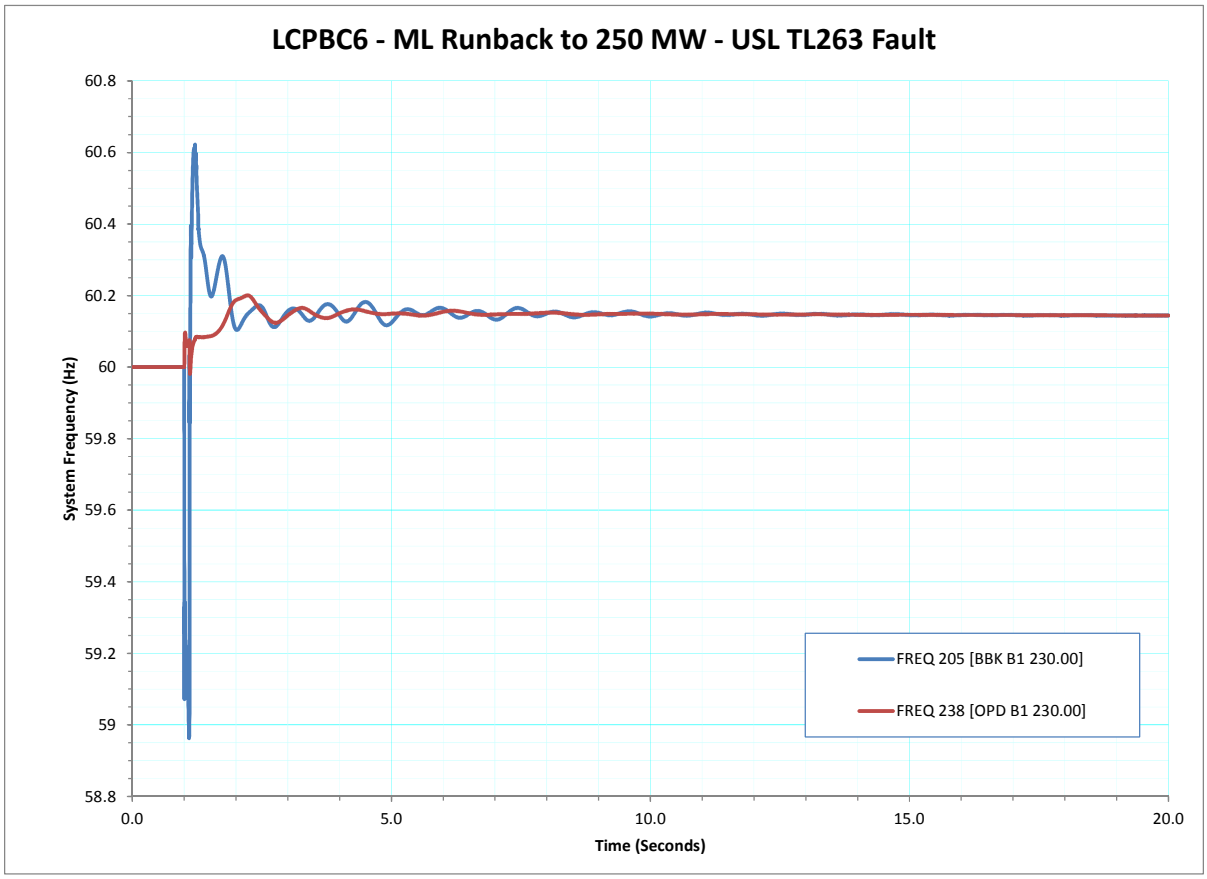

Figure 101 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - System Frequency (Hz)

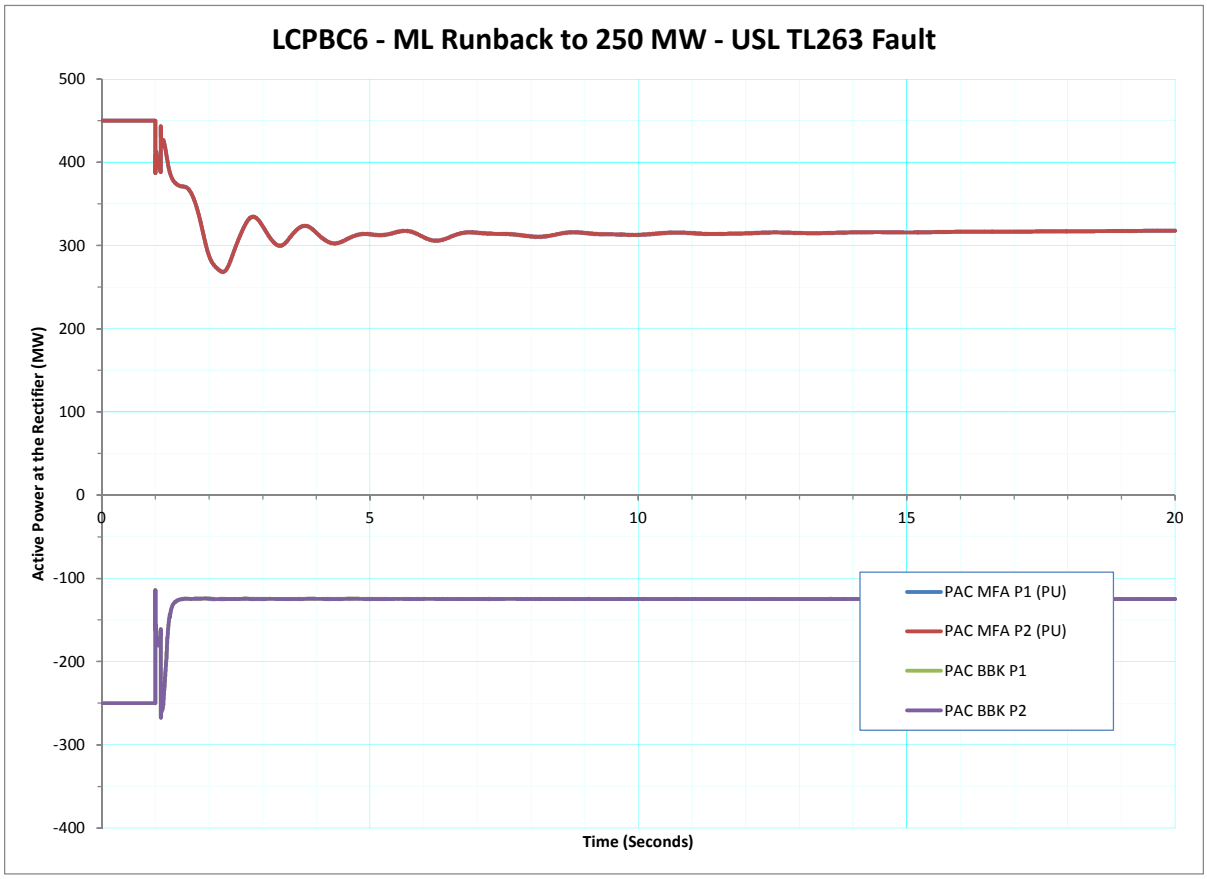

Figure 102 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - Active Power at the Rectifier (MW)

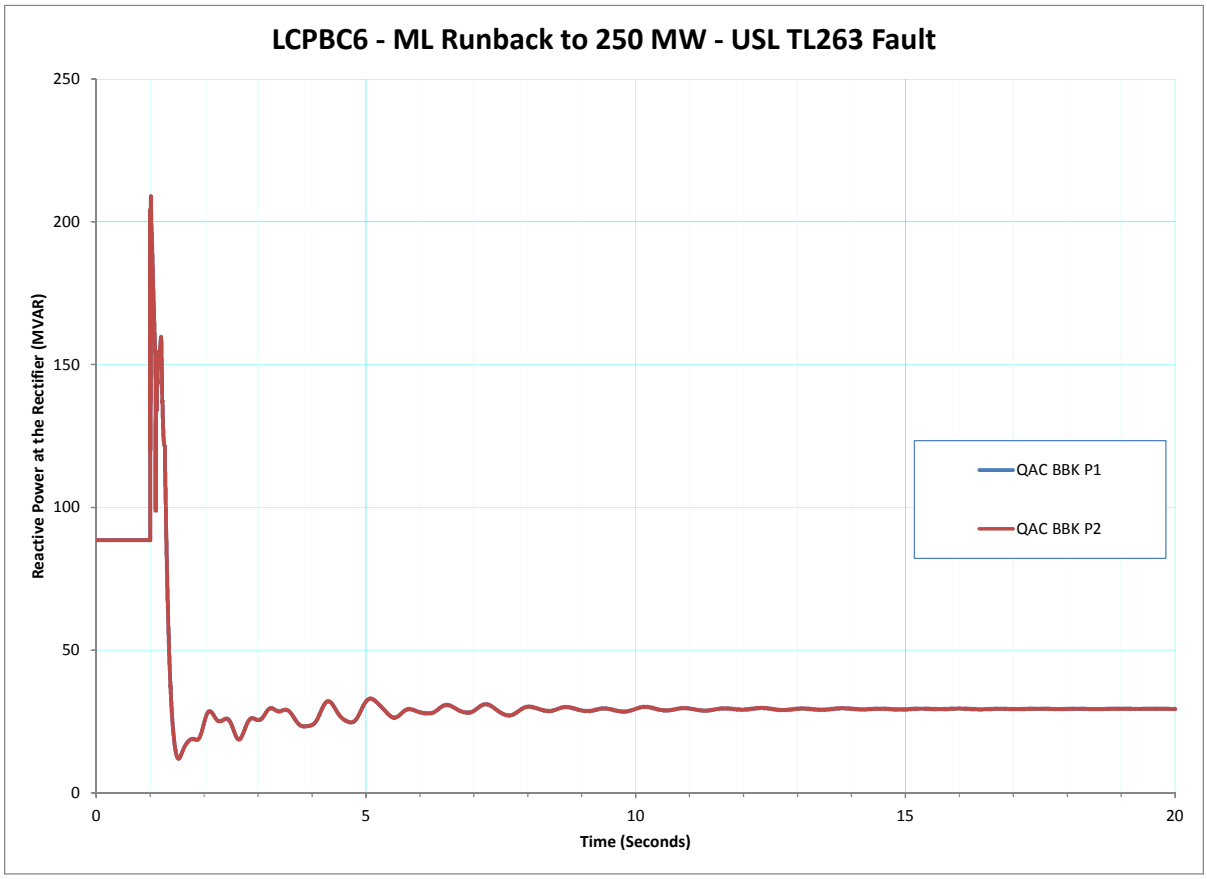

Figure 103 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - Reactive Power at the Rectifier (MVAR)

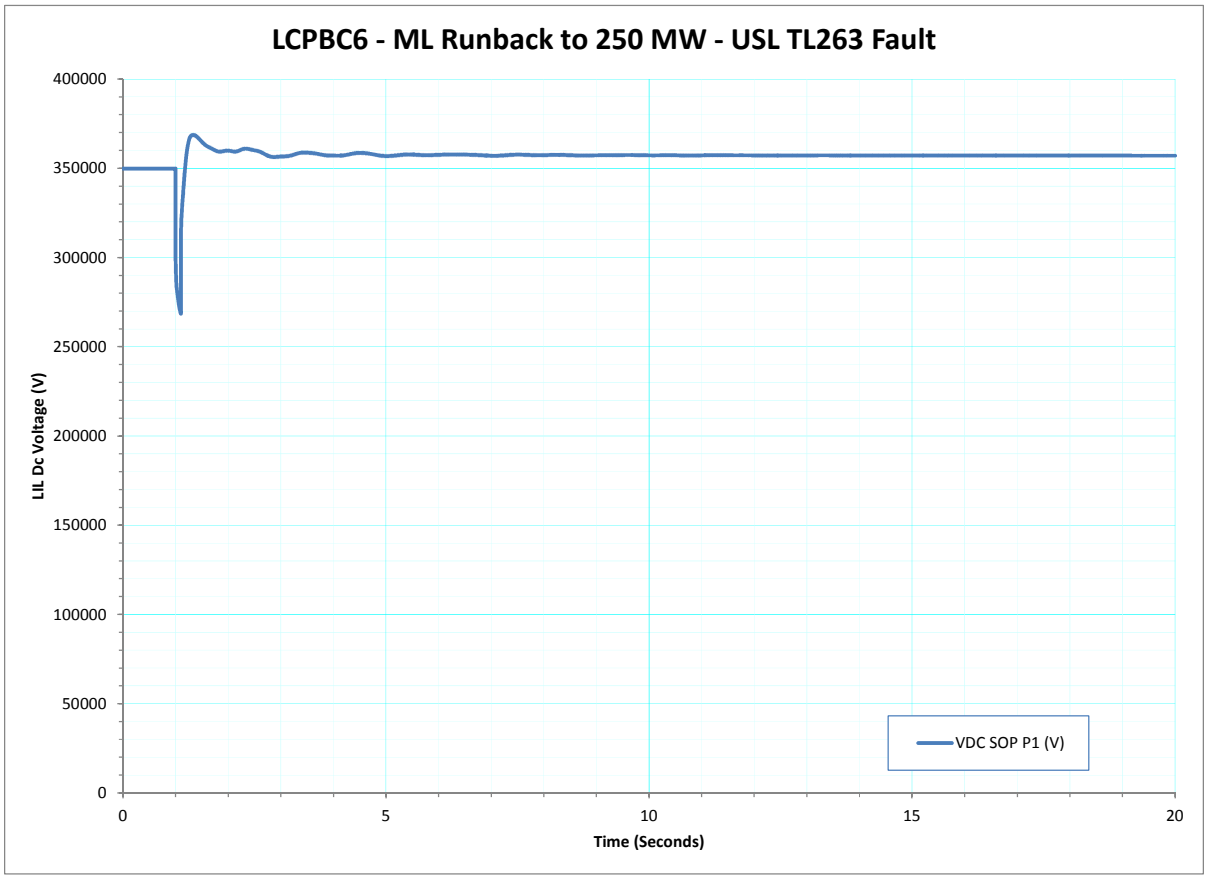

Figure 104 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - LIL Dc Voltage (V)

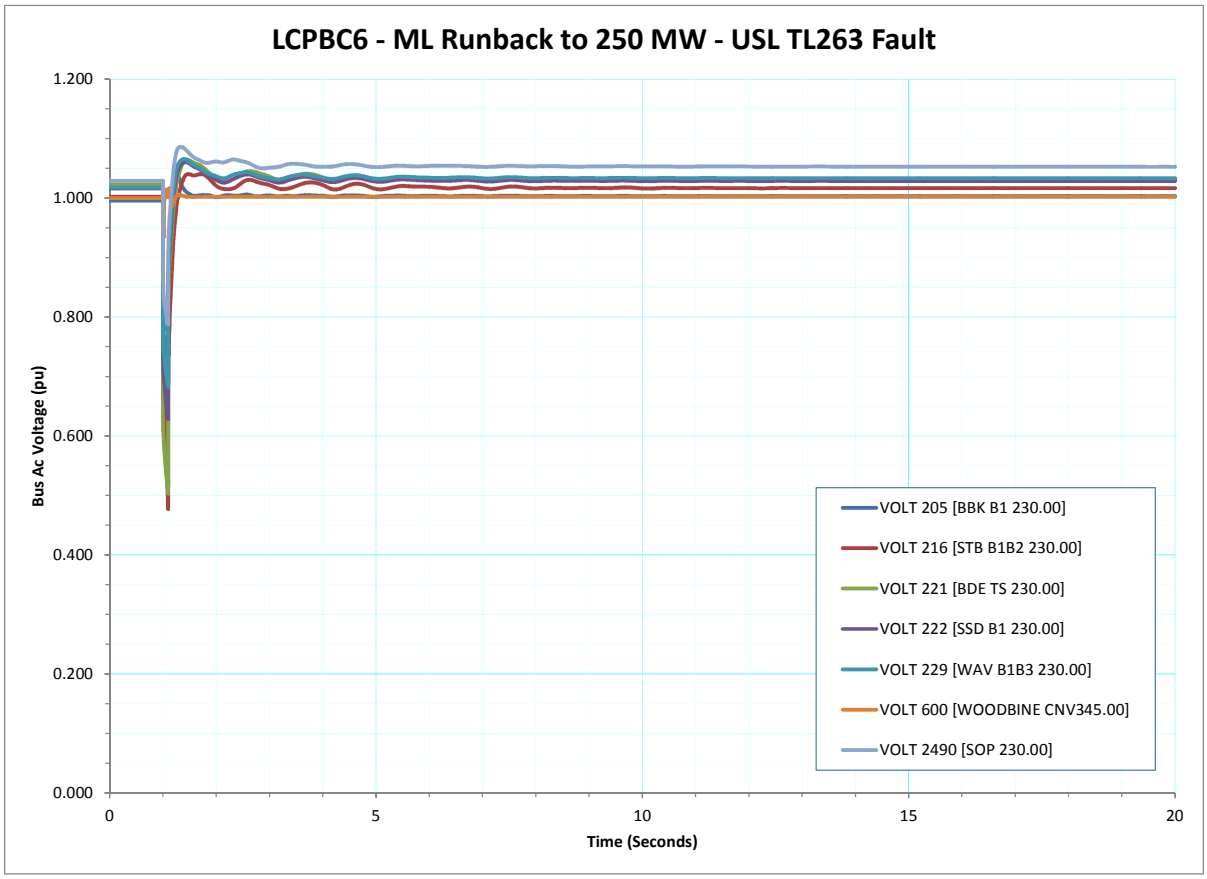

Figure 105 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - Bus Ac Voltage (pu)

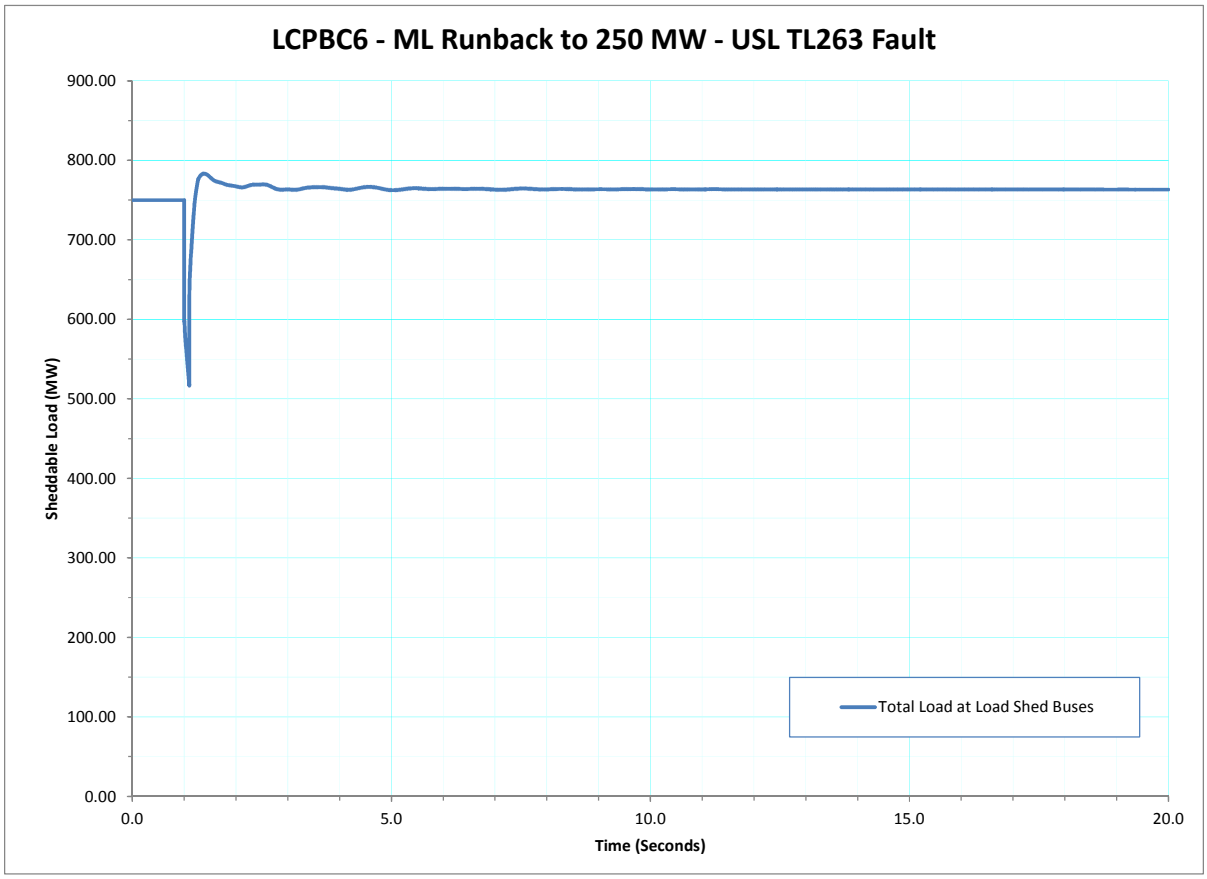

Figure 106 - LCPBC6 - ML Runback to 250 MW - USL TL263 Fault - Sheddable Load (MW)

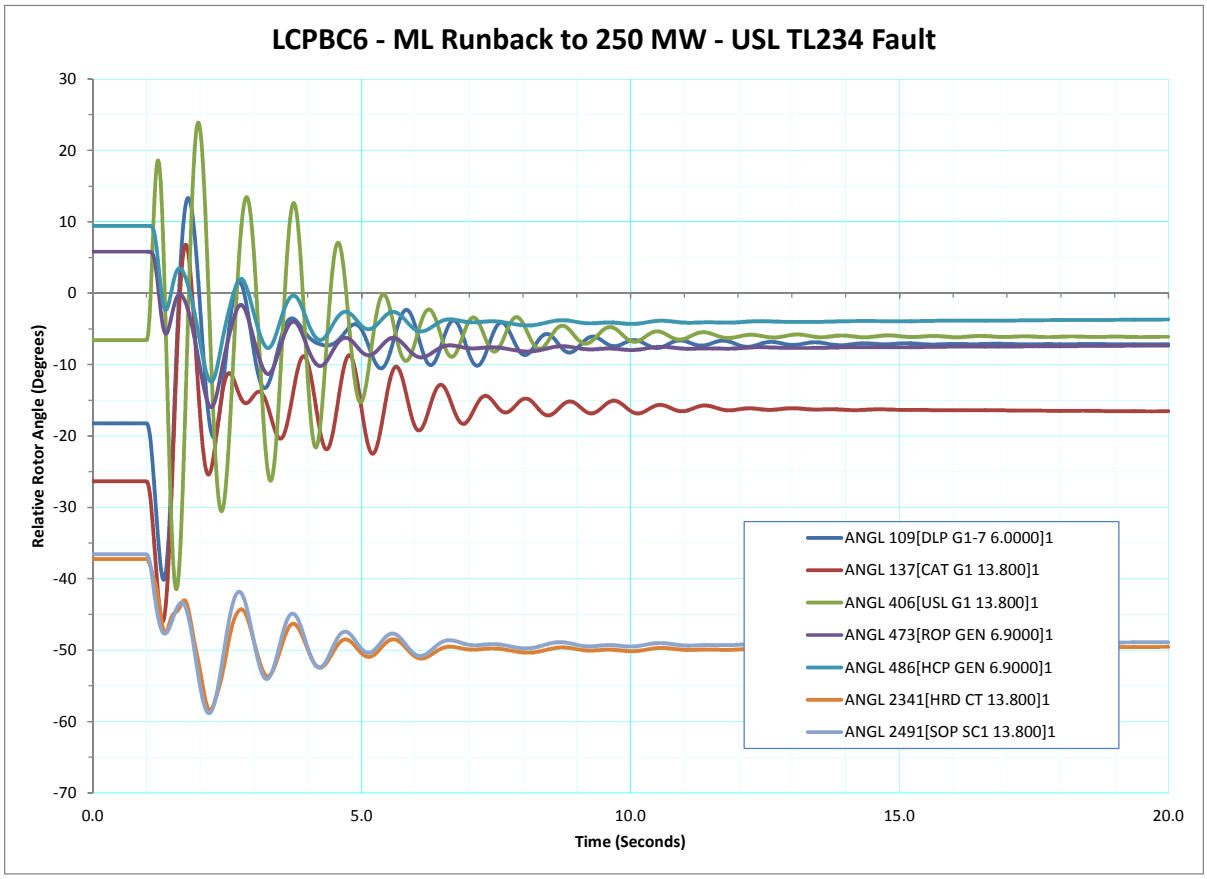

Figure 107 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - Relative Rotor Angle (Degrees)

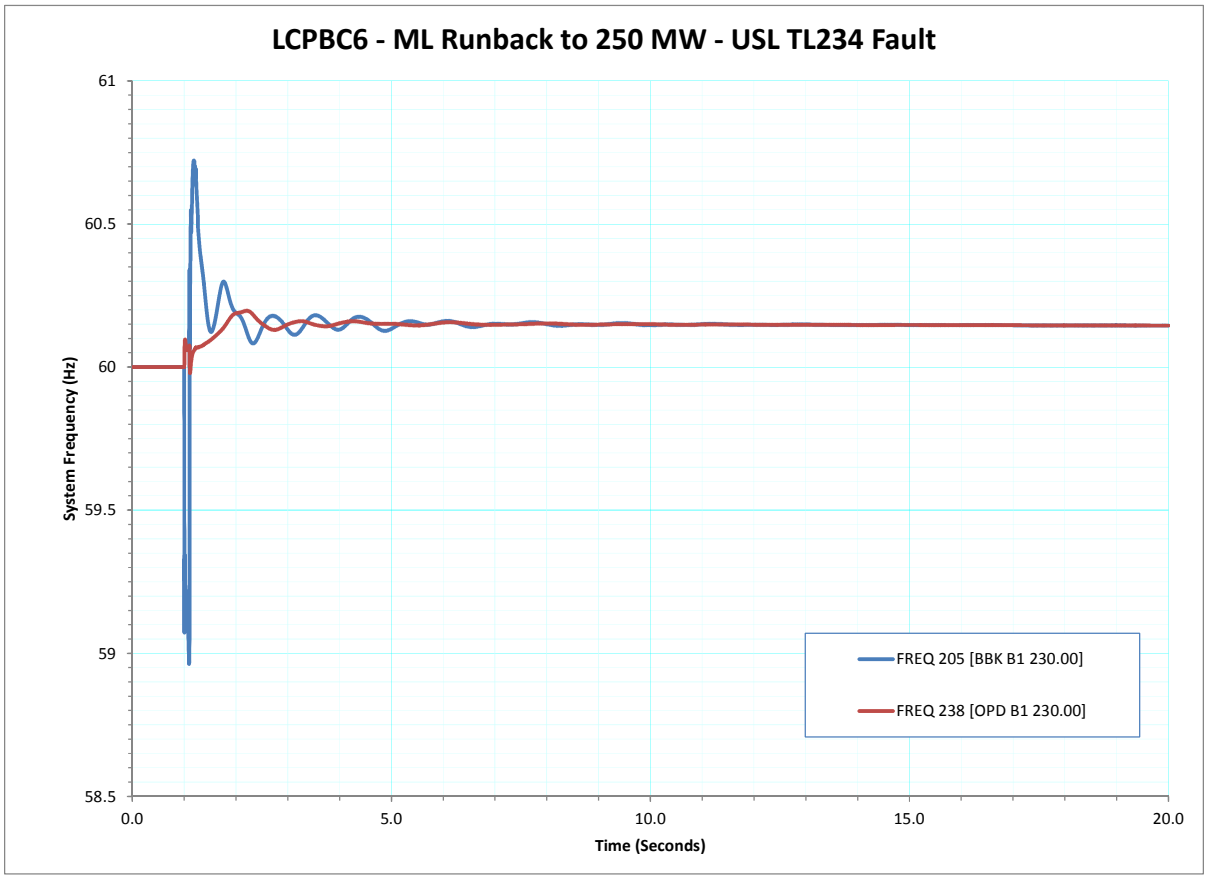

Figure 108 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - System Frequency (Hz)

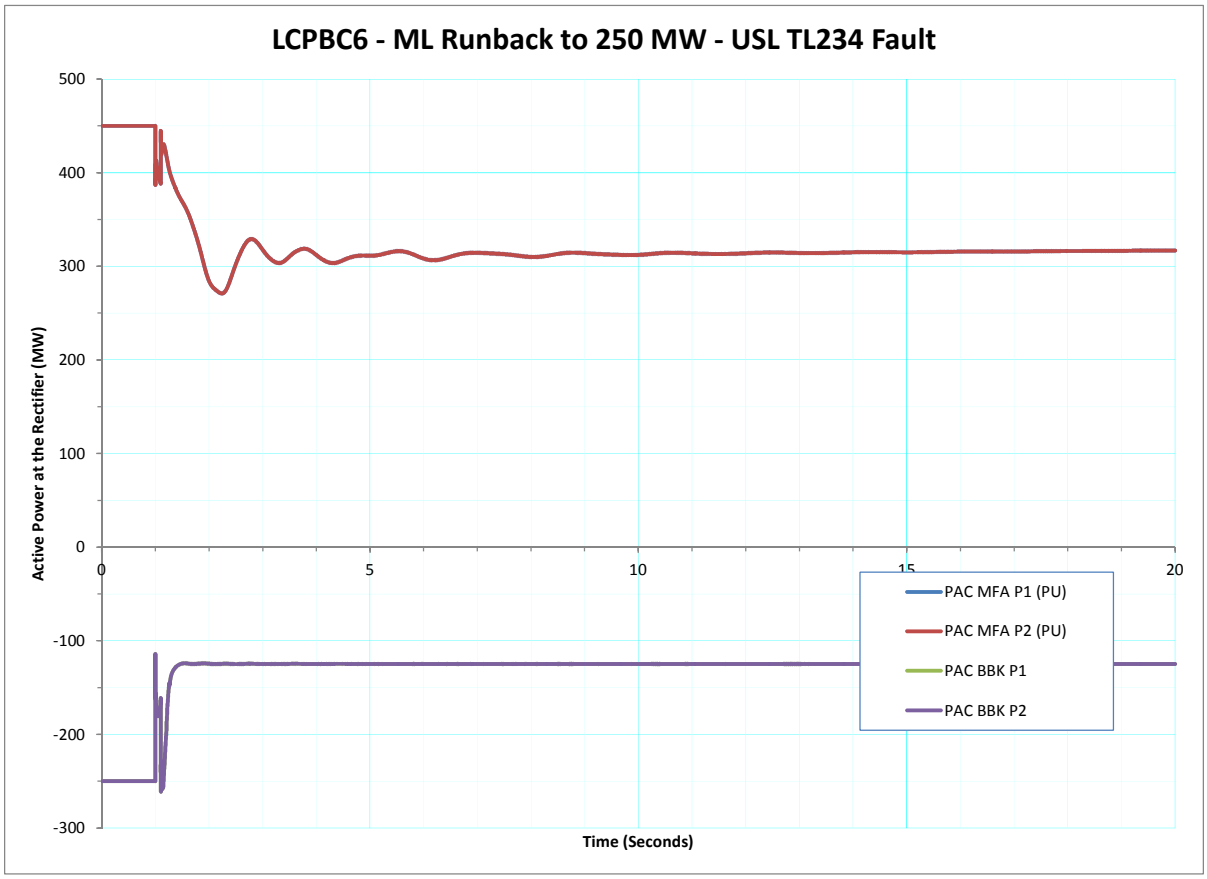

Figure 109 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - Active Power at the Rectifier (MW)

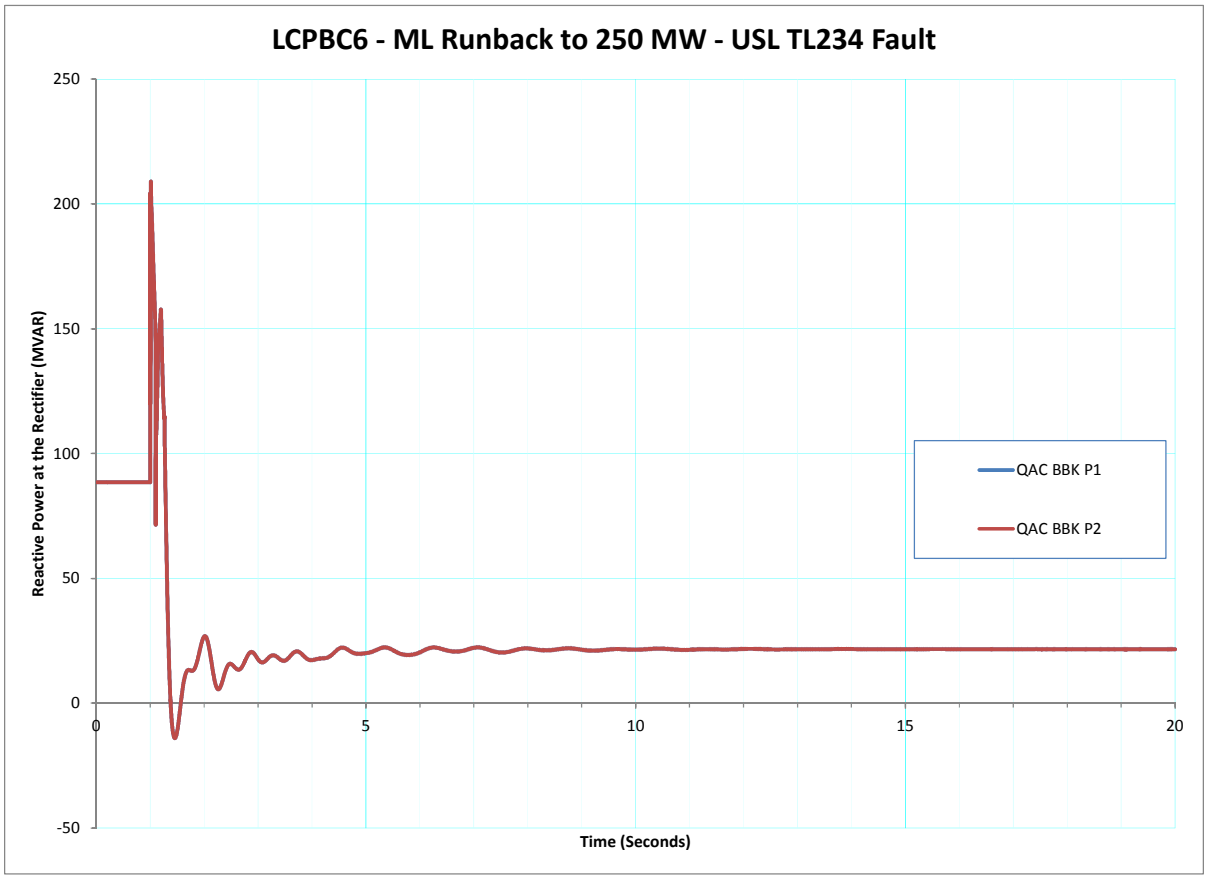

Figure 110 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - Reactive Power at the Rectifier (MVAR)

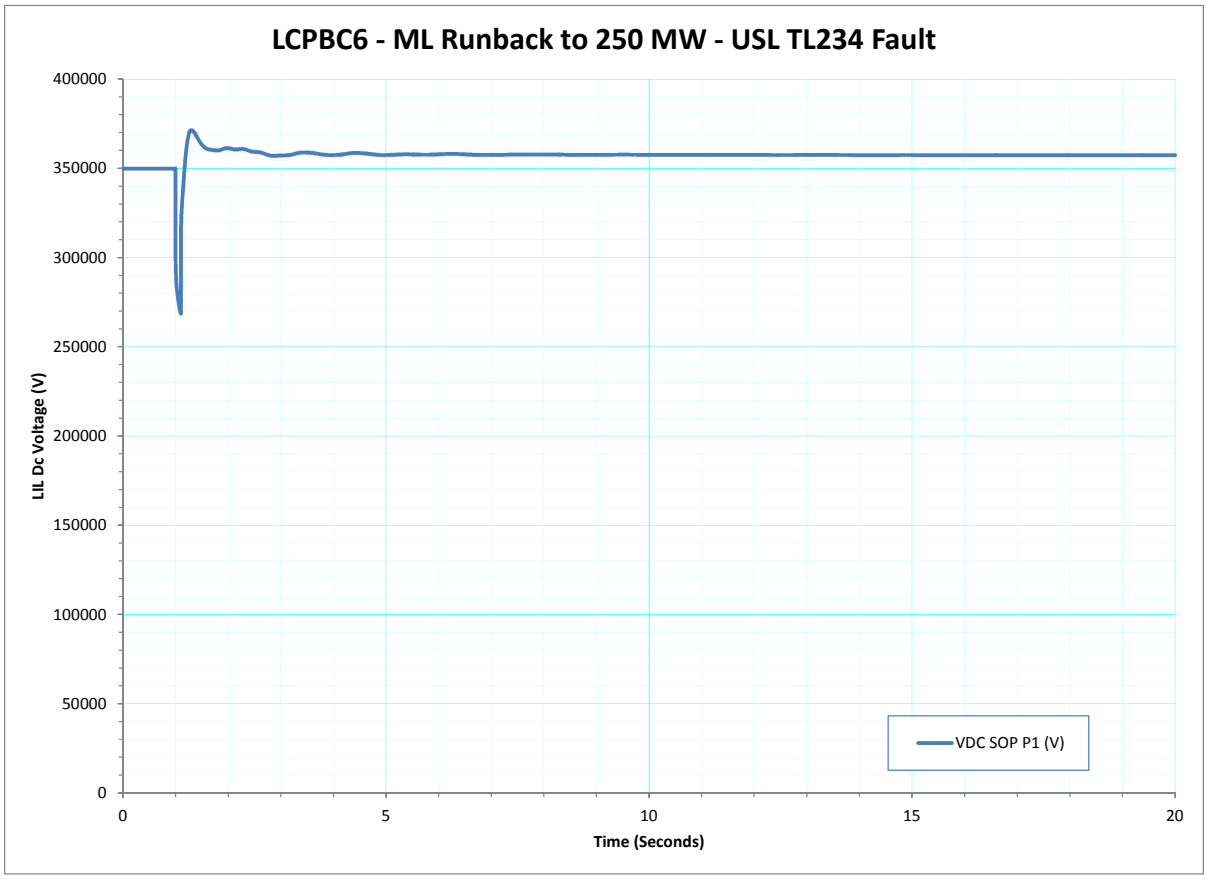

Figure 111 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - LIL Dc Voltage (V)

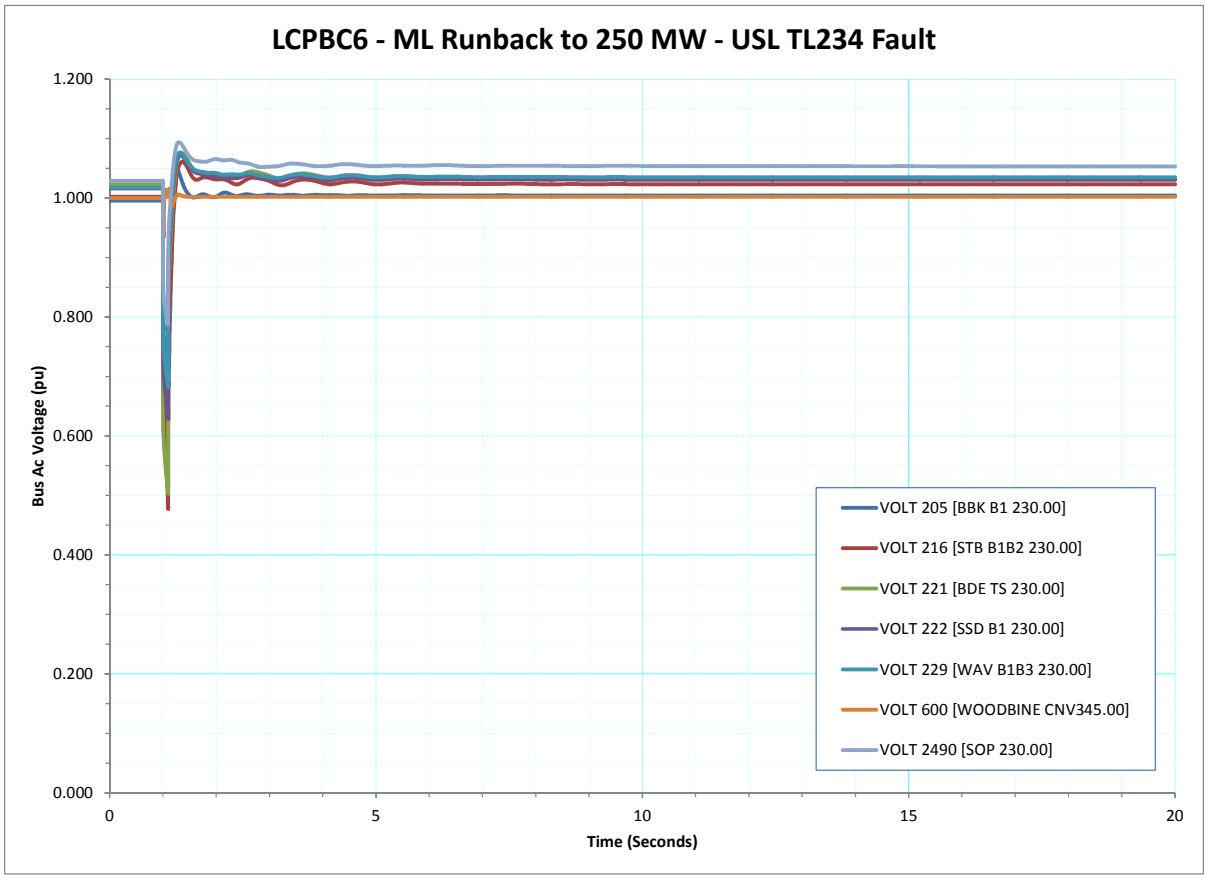

Figure 112 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - Bus Ac Voltage (pu)

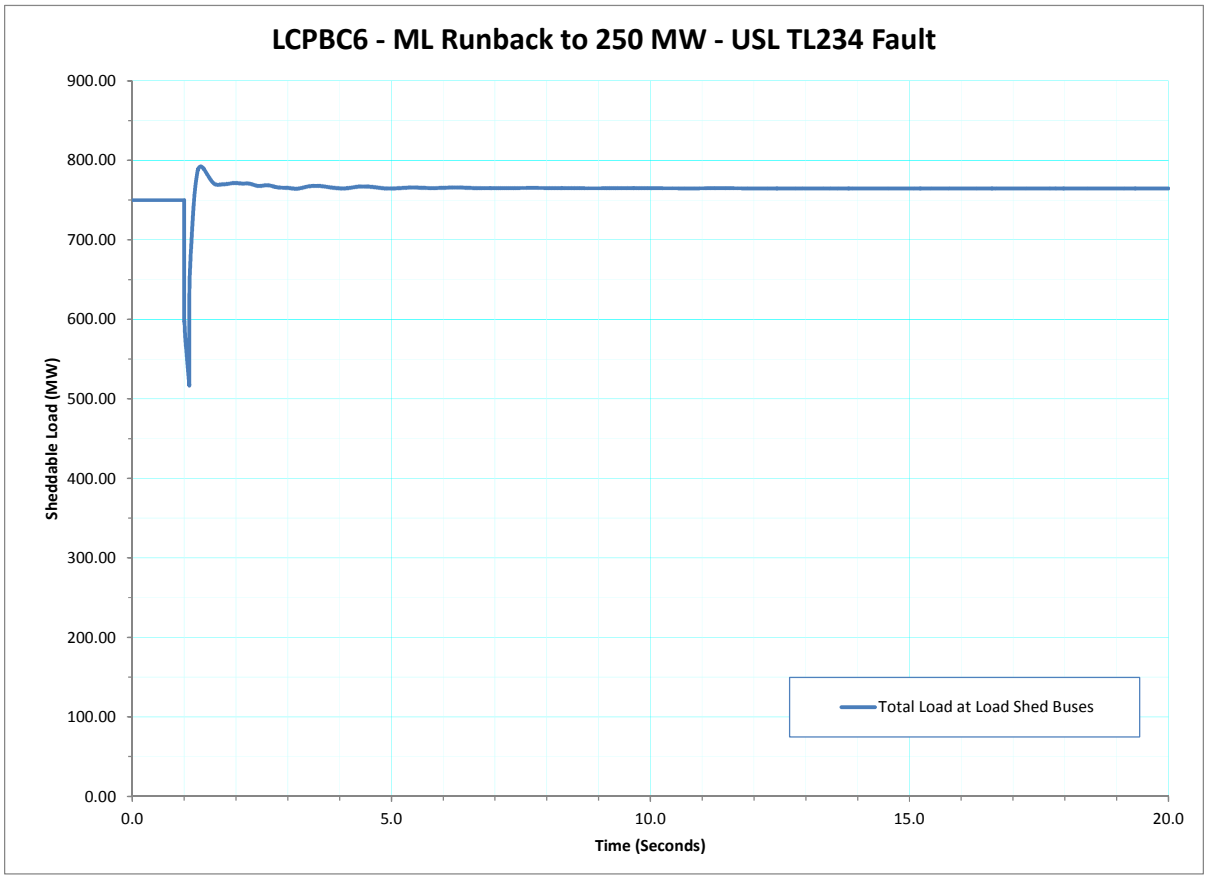

Figure 113 - LCPBC6 - ML Runback to 250 MW - USL TL234 Fault - Sheddable Load (MW)

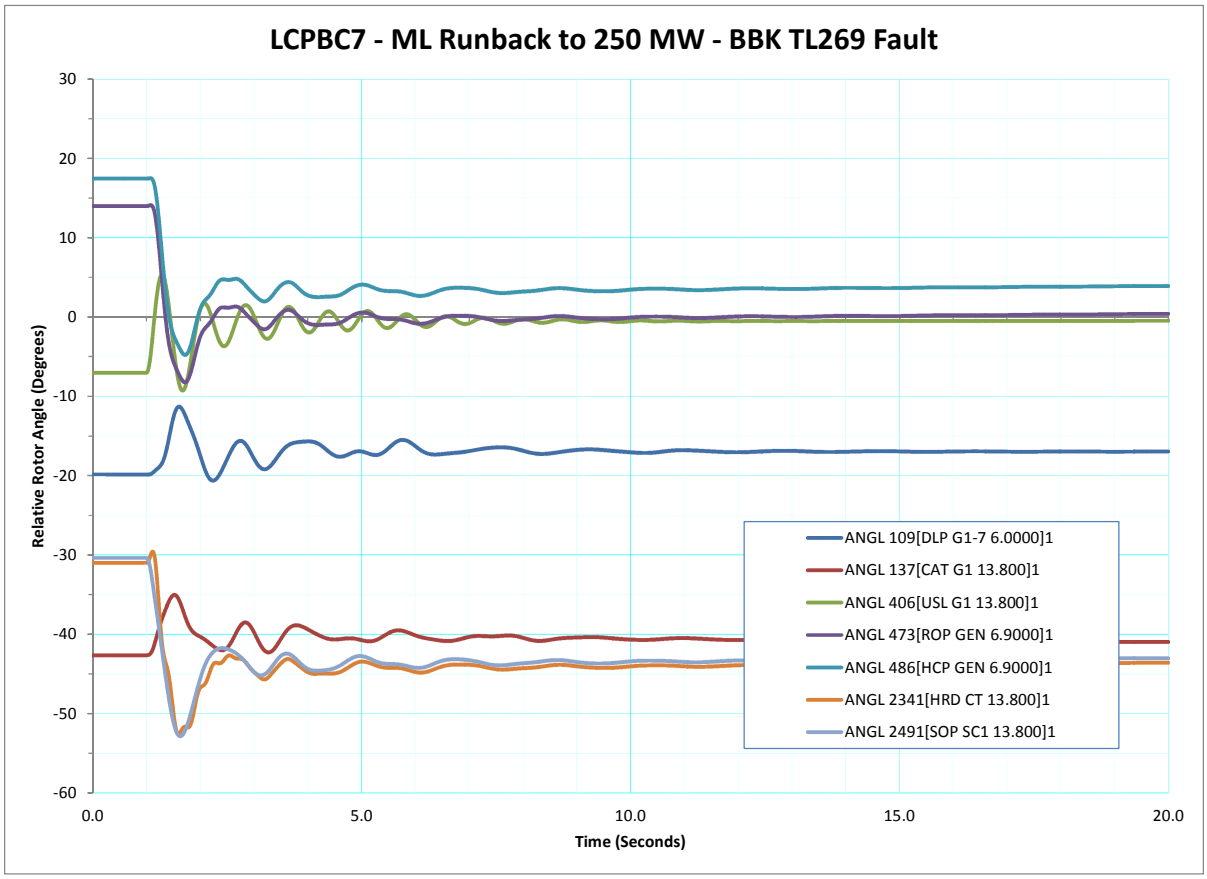

Figure 114 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - Relative Rotor Angle (Degrees)

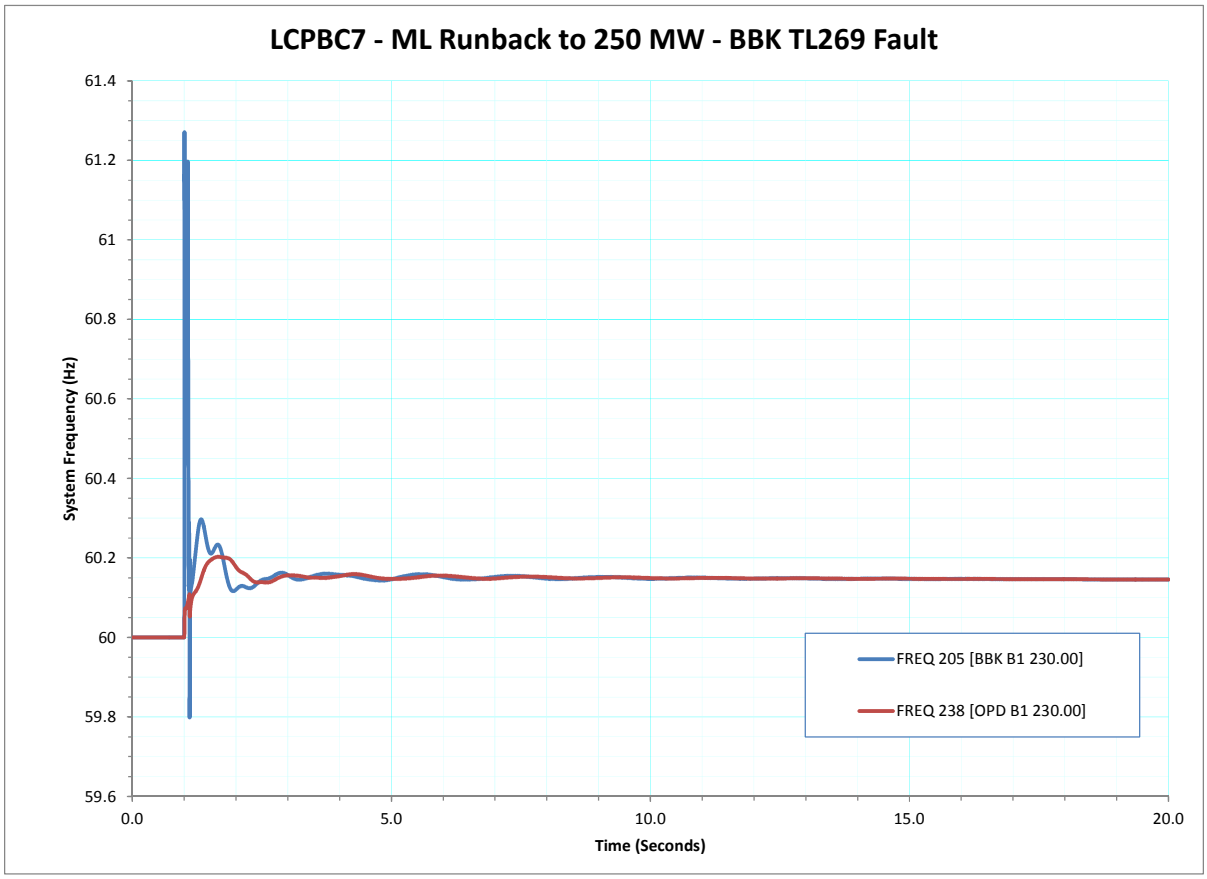

Figure 115 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - System Frequency (Hz)

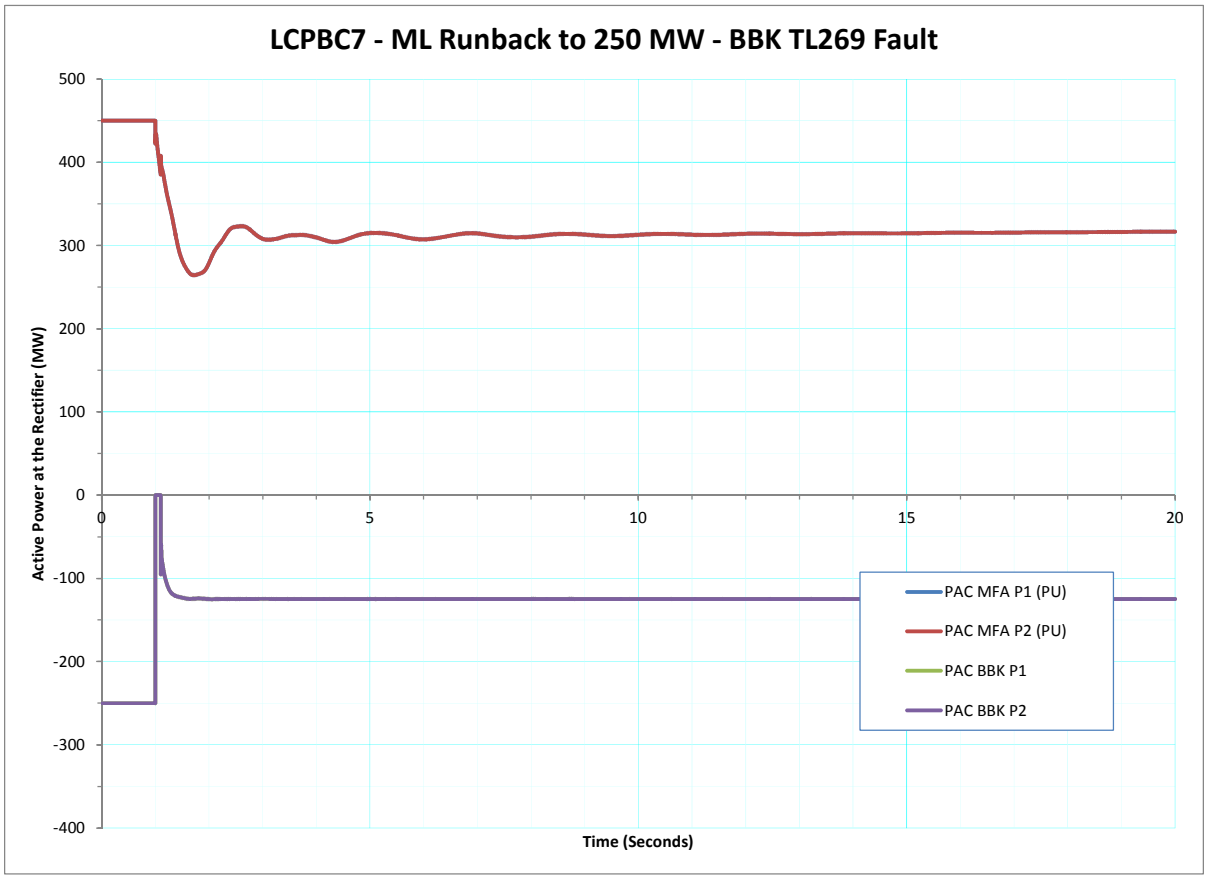

Figure 116 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - Active Power at the Rectifier (MW)

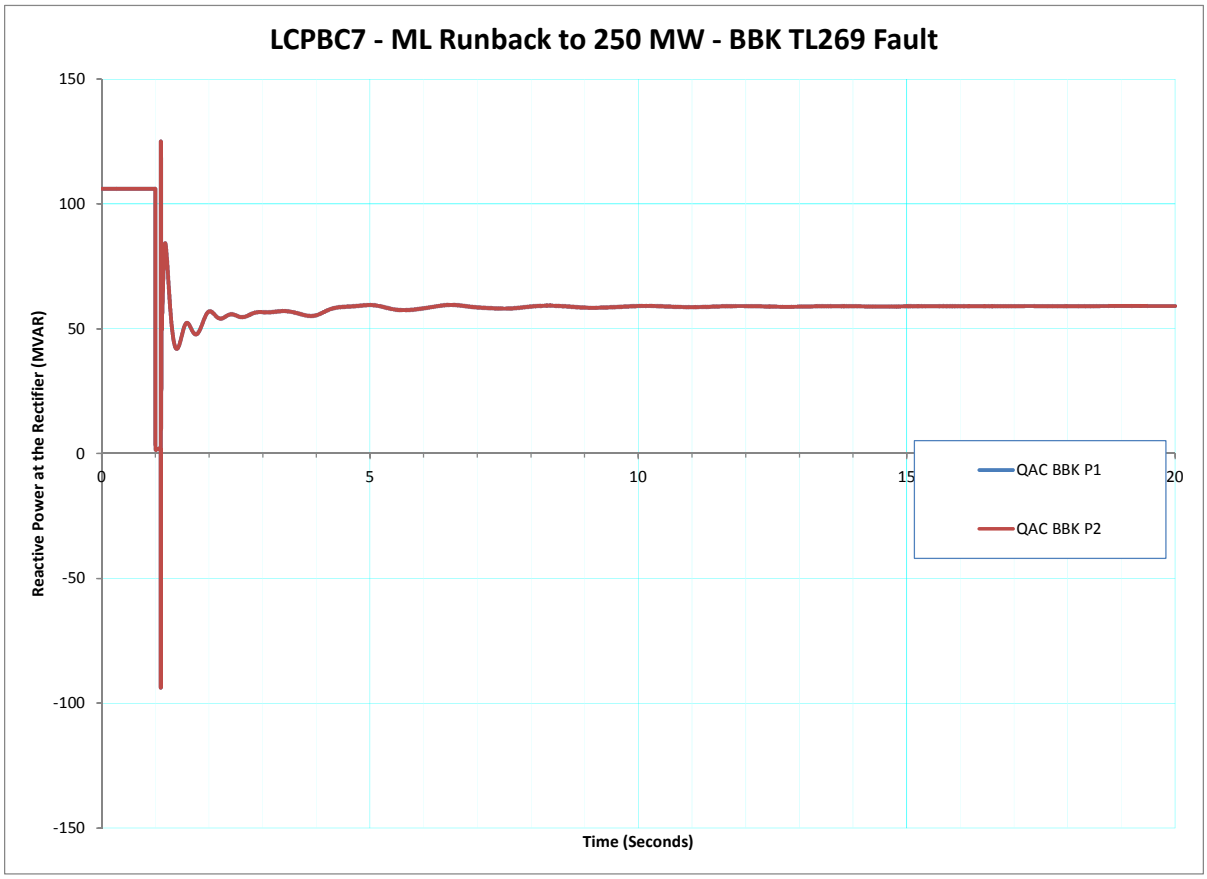

Figure 117 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - Reactive Power at the Rectifier (MVAR)

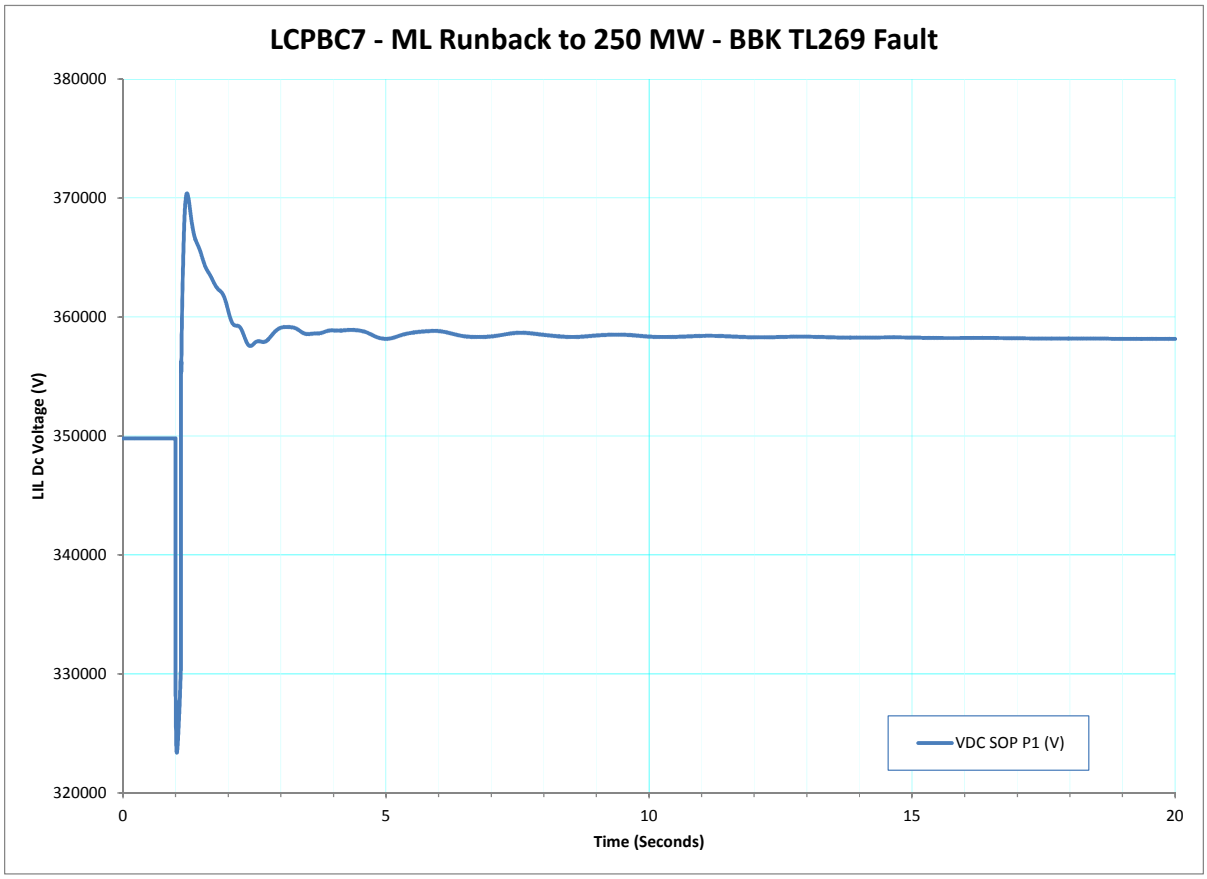

Figure 118 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - LIL Dc Voltage (V)

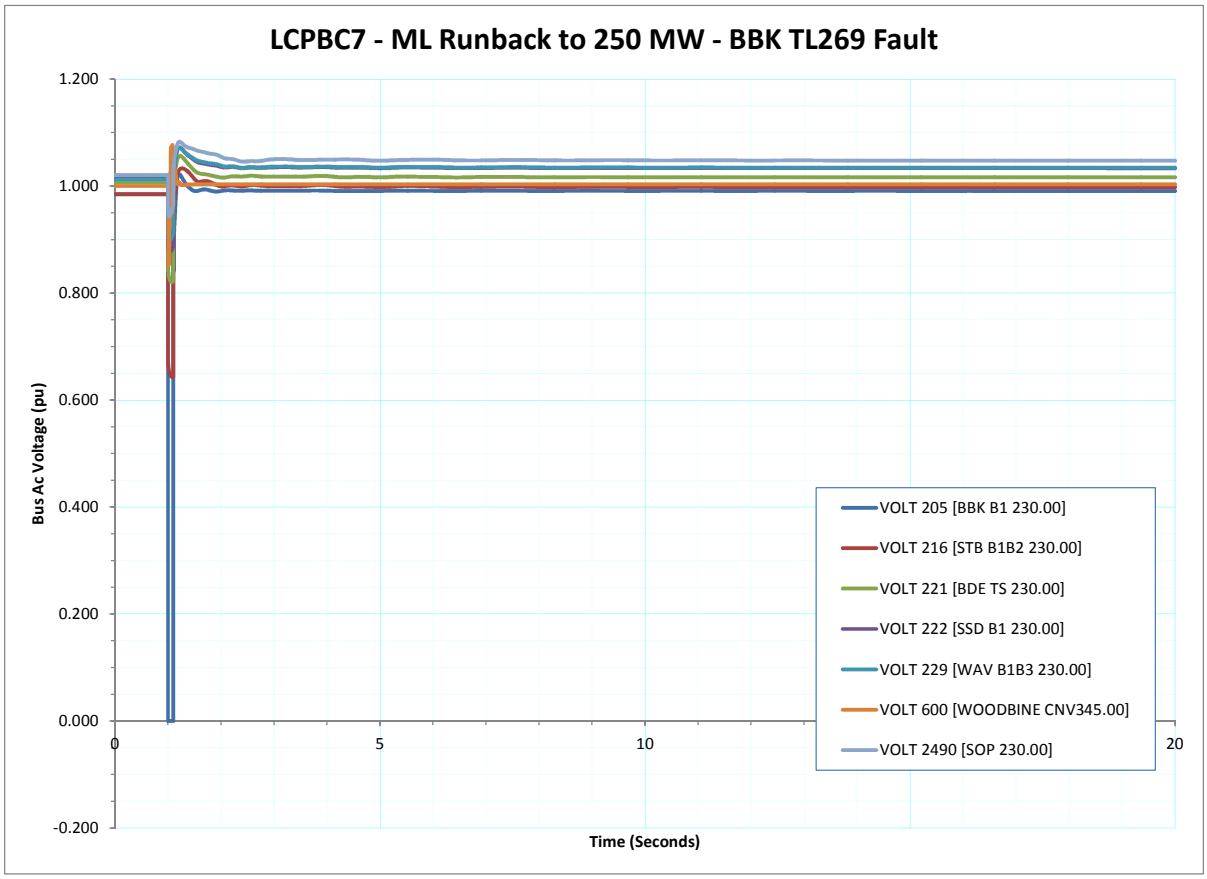

Figure 119 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - Bus Ac Voltage (pu)

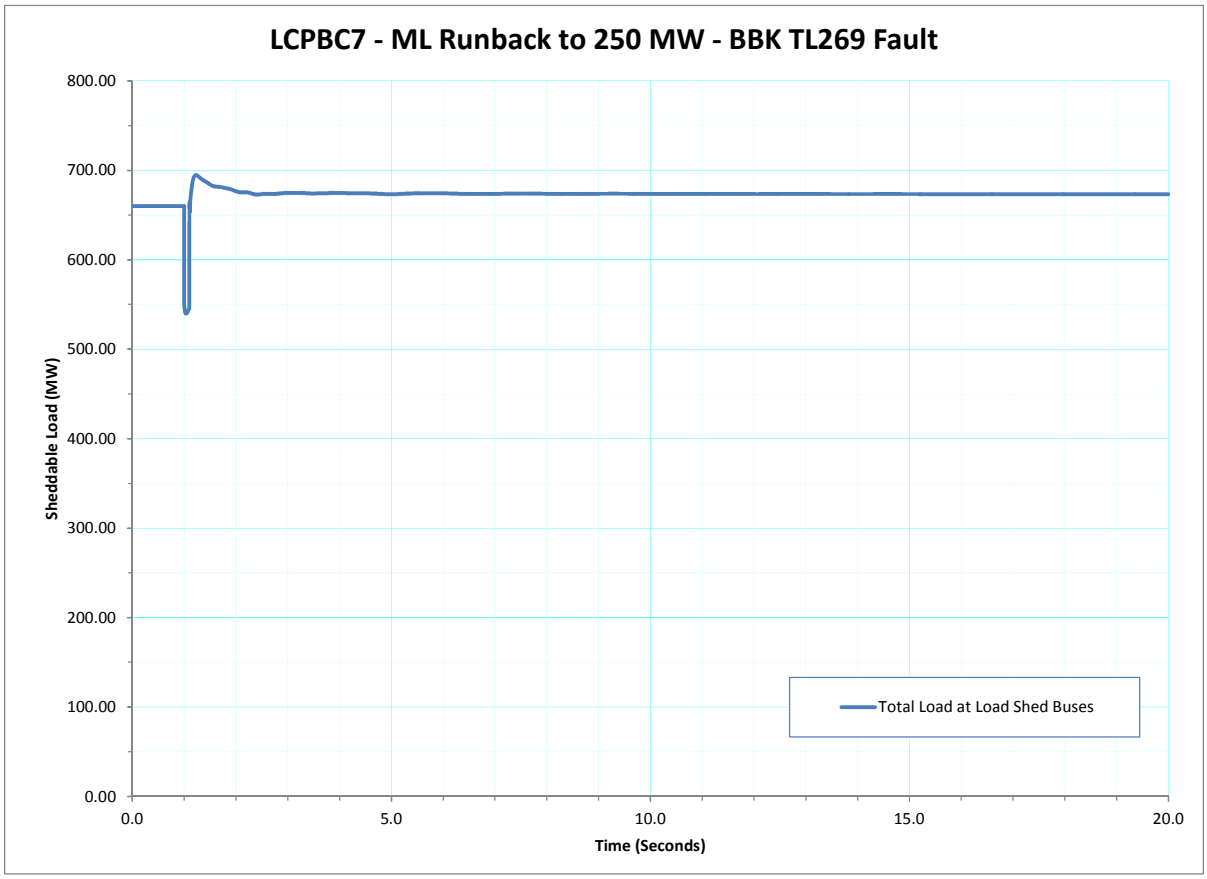
LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Sheddable Load (MW)
0.0
5.0
10.0
15.0
20.0
Time (Seconds)
Total Load at Load Shed Buses

Figure 120 - LCPBC7 - ML Runback to 250 MW - BBK TL269 Fault - Sheddable Load (MW)

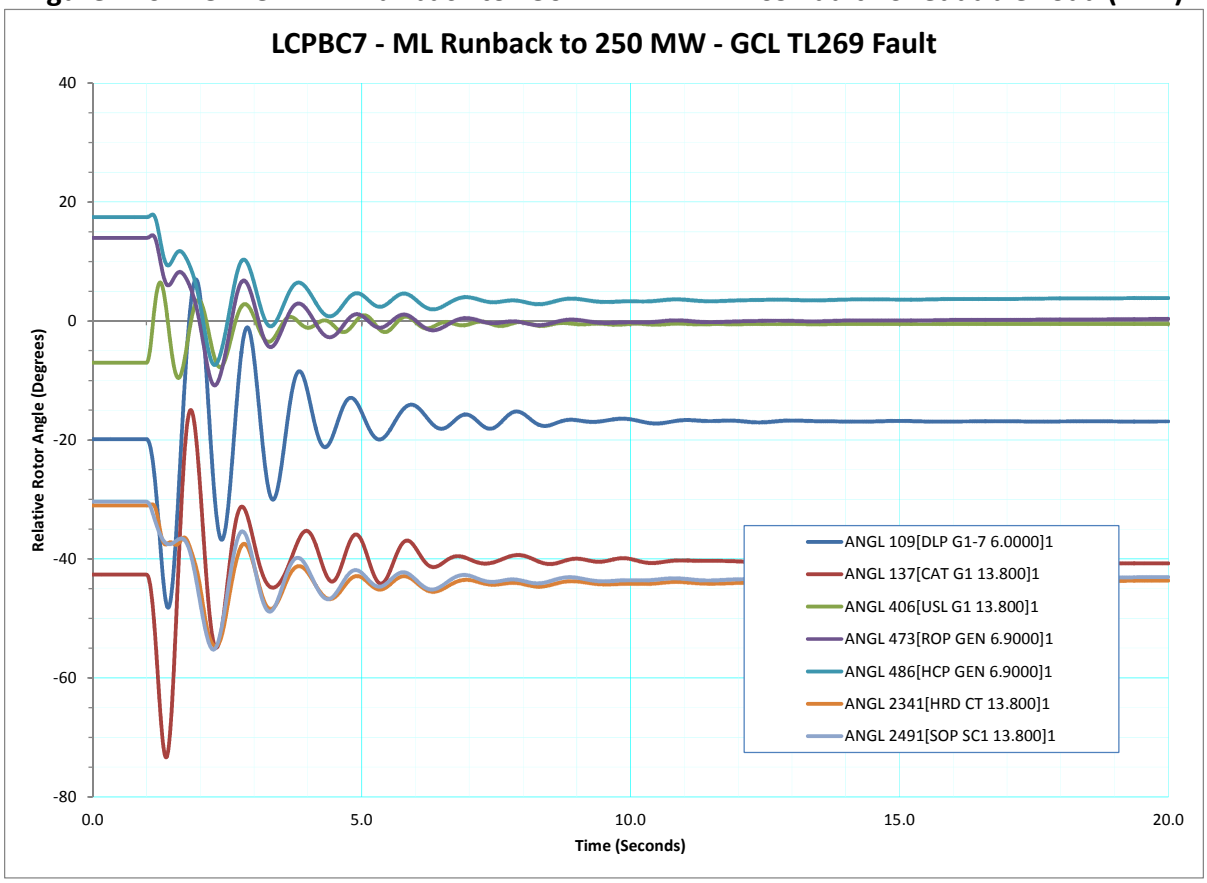

Figure 121 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - Relative Rotor Angle (Degrees)

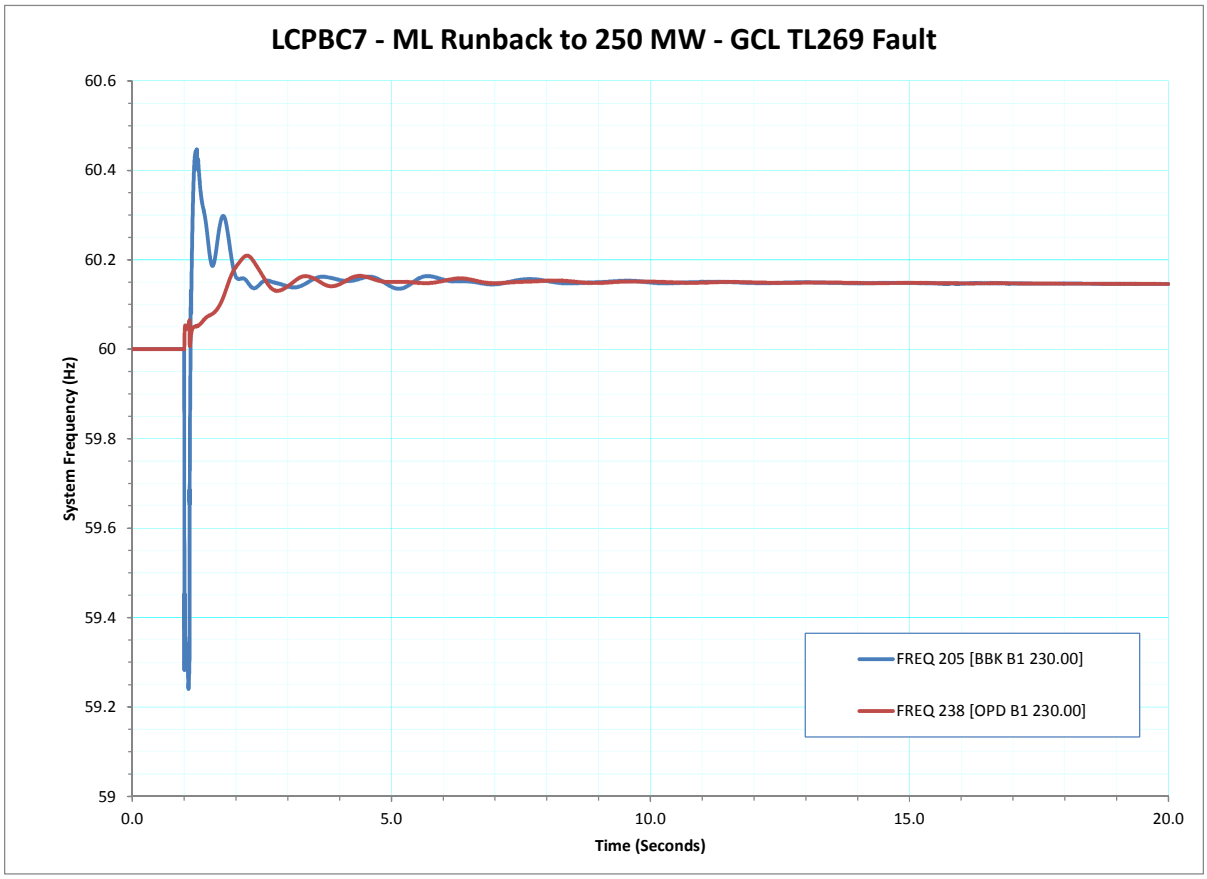

Figure 122 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - System Frequency (Hz)

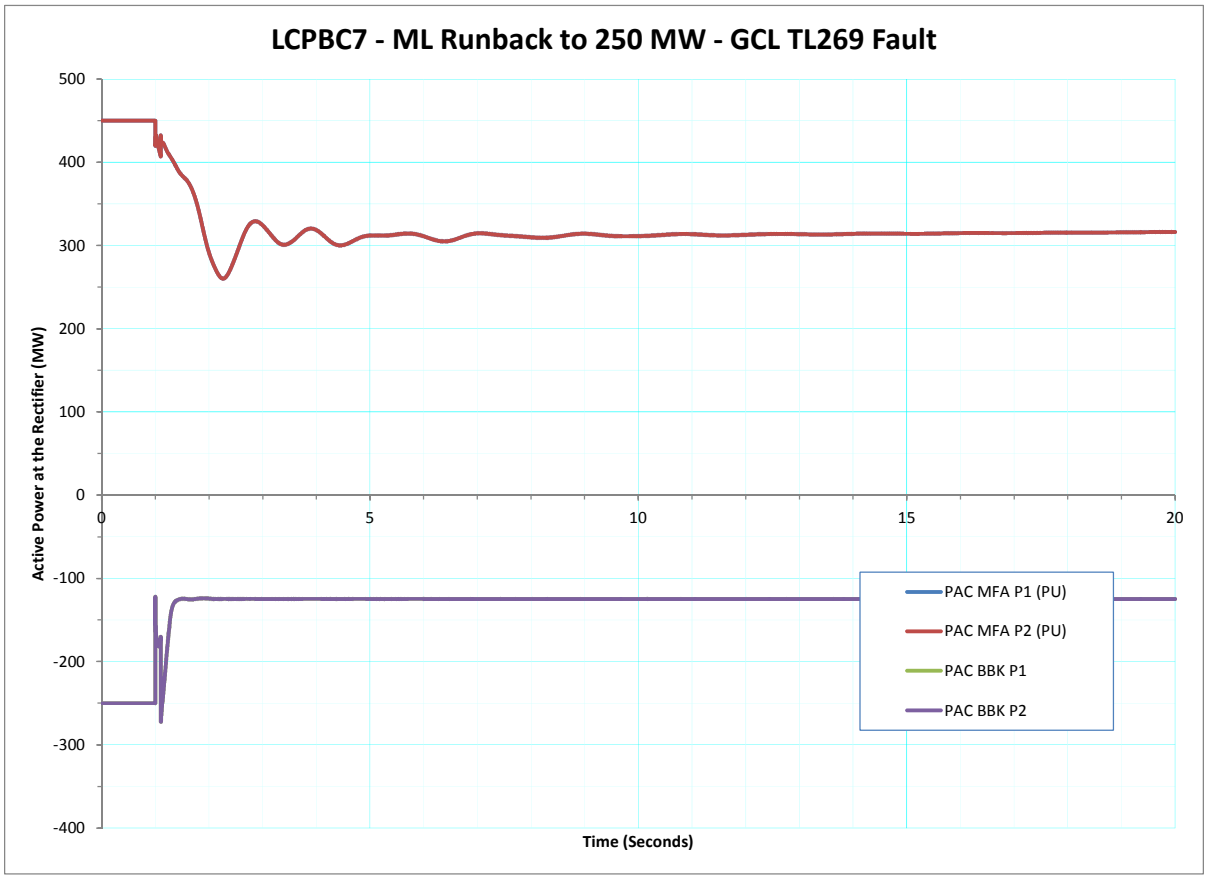

Figure 123 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - Active Power at the Rectifier (MW)

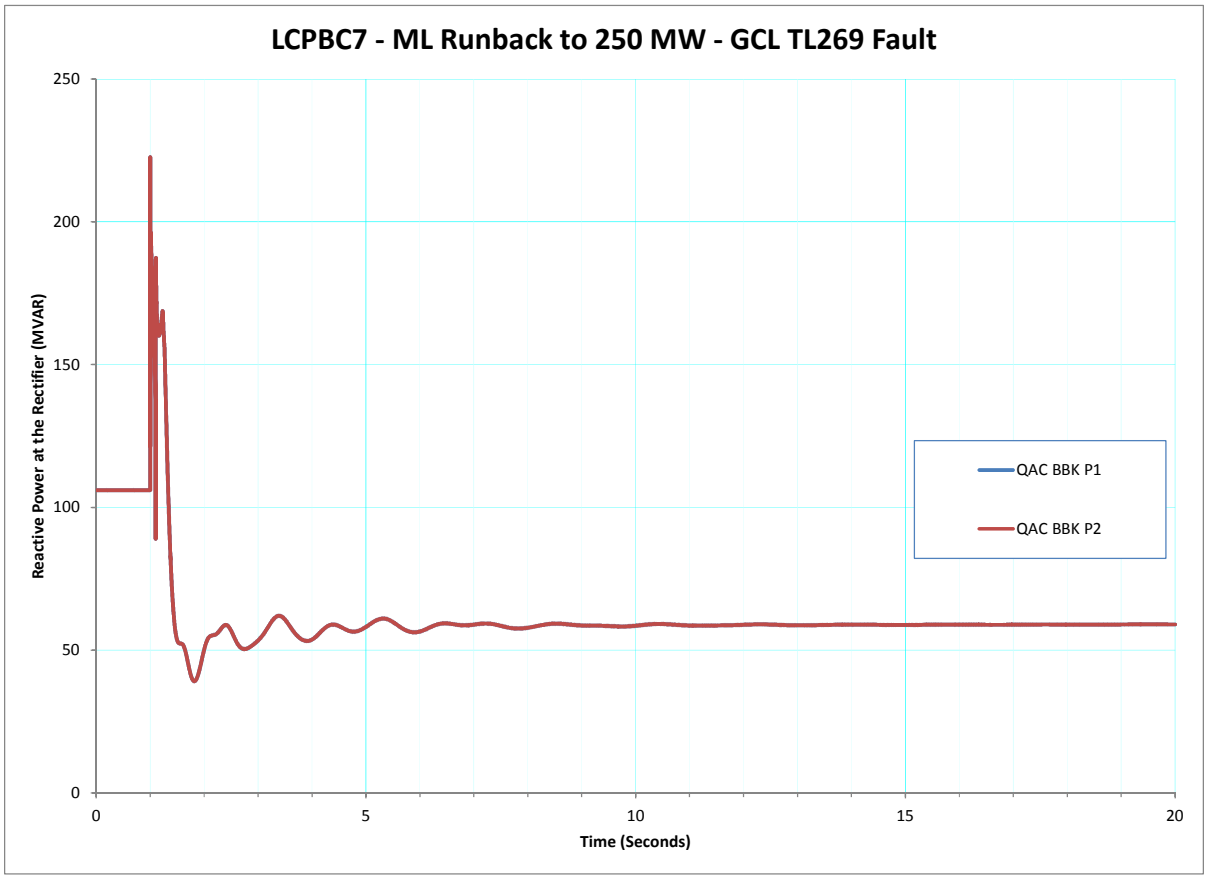

Figure 124 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - Reactive Power at the Rectifier (MVAR)

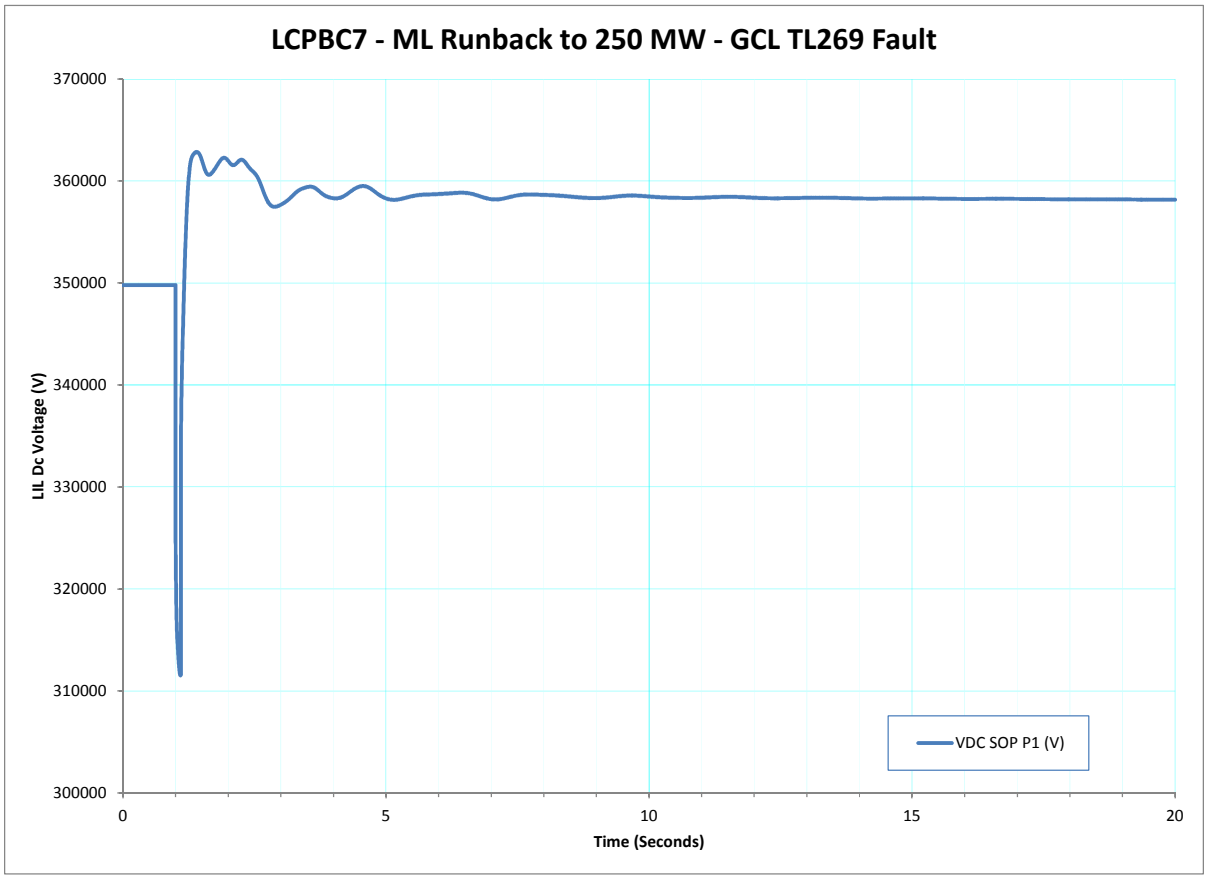

Figure 125 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - LIL Dc Voltage (V)

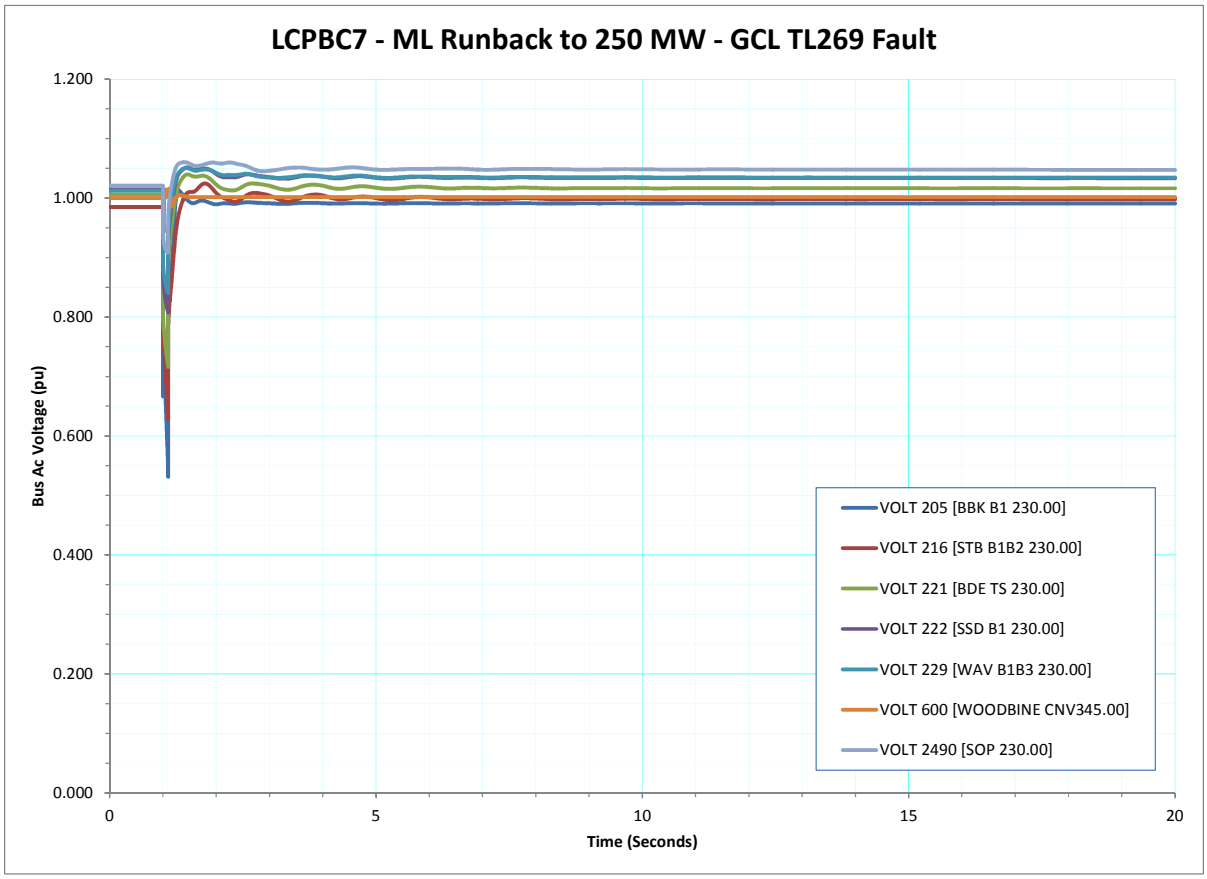

Figure 126 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - Bus Ac Voltage (pu)

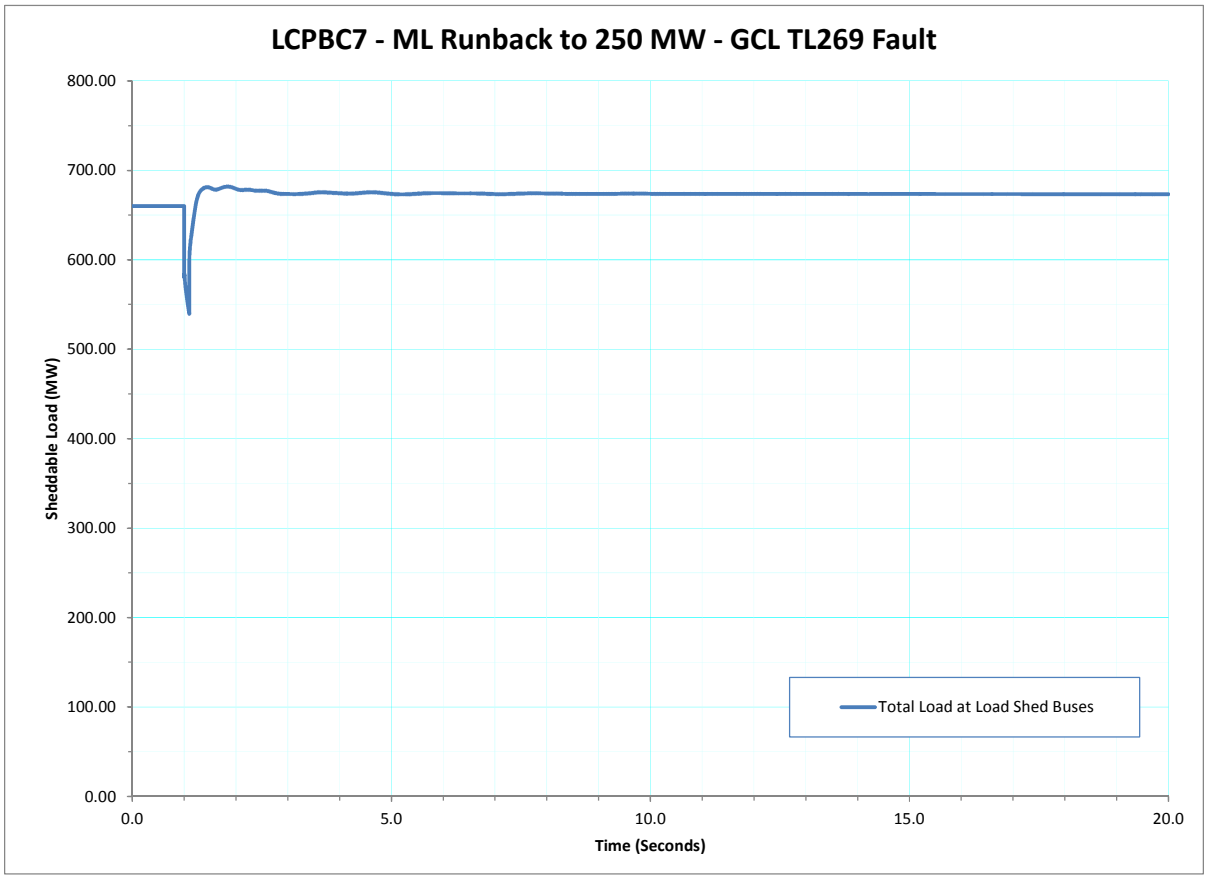

Figure 127 - LCPBC7 - ML Runback to 250 MW - GCL TL269 Fault - Sheddable Load (MW)

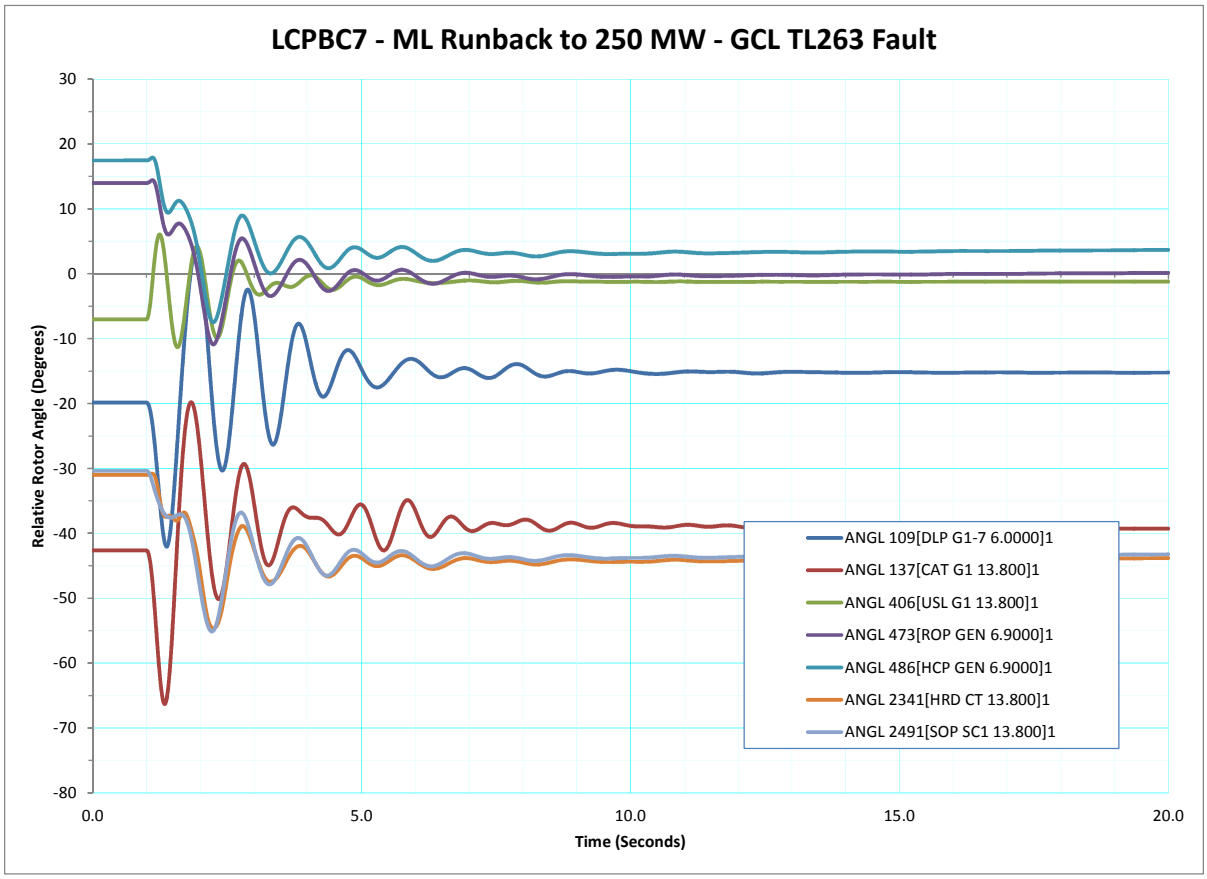

Figure 128 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - Relative Rotor Angle (Degrees)

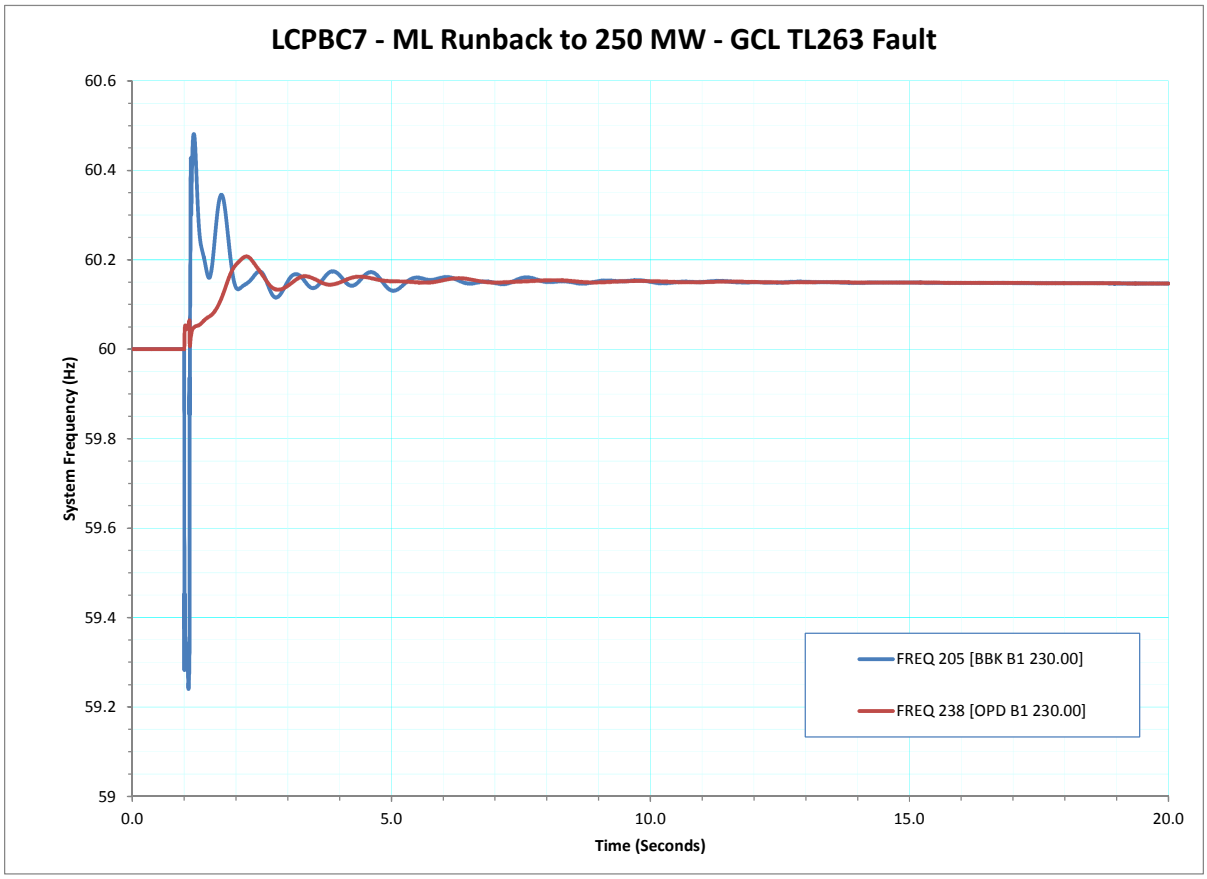

Figure 129 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - System Frequency (Hz)

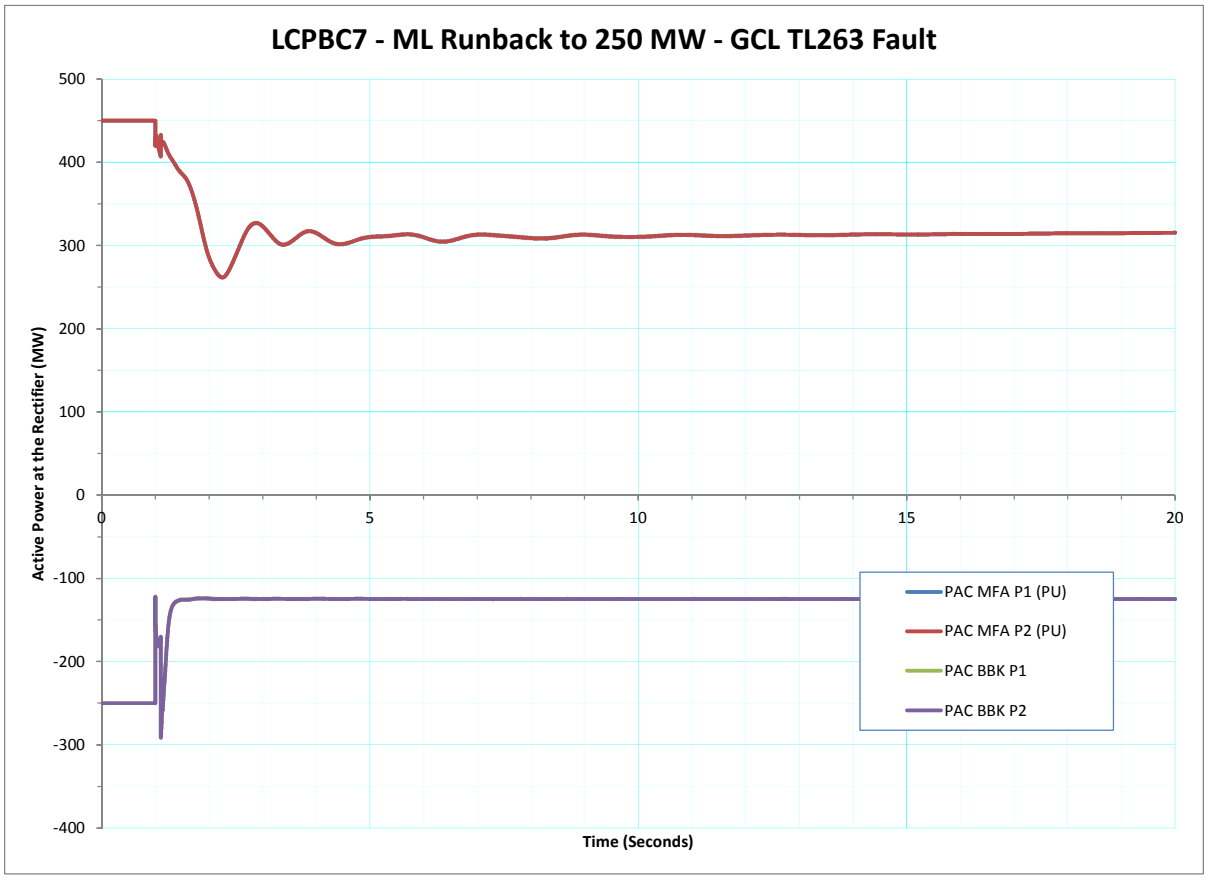

Figure 130 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - Active Power at the Rectifier (MW)

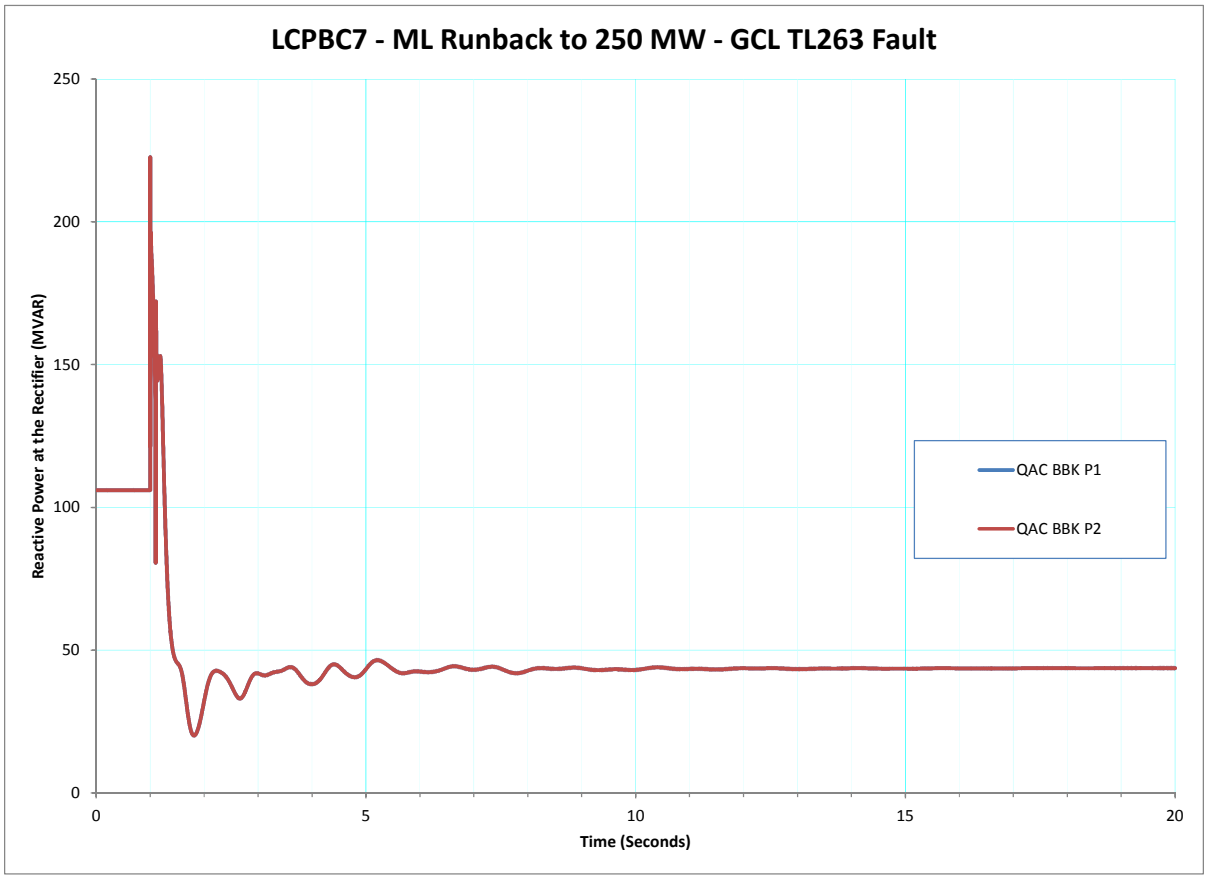

Figure 131 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - Reactive Power at the Rectifier (MVAR)

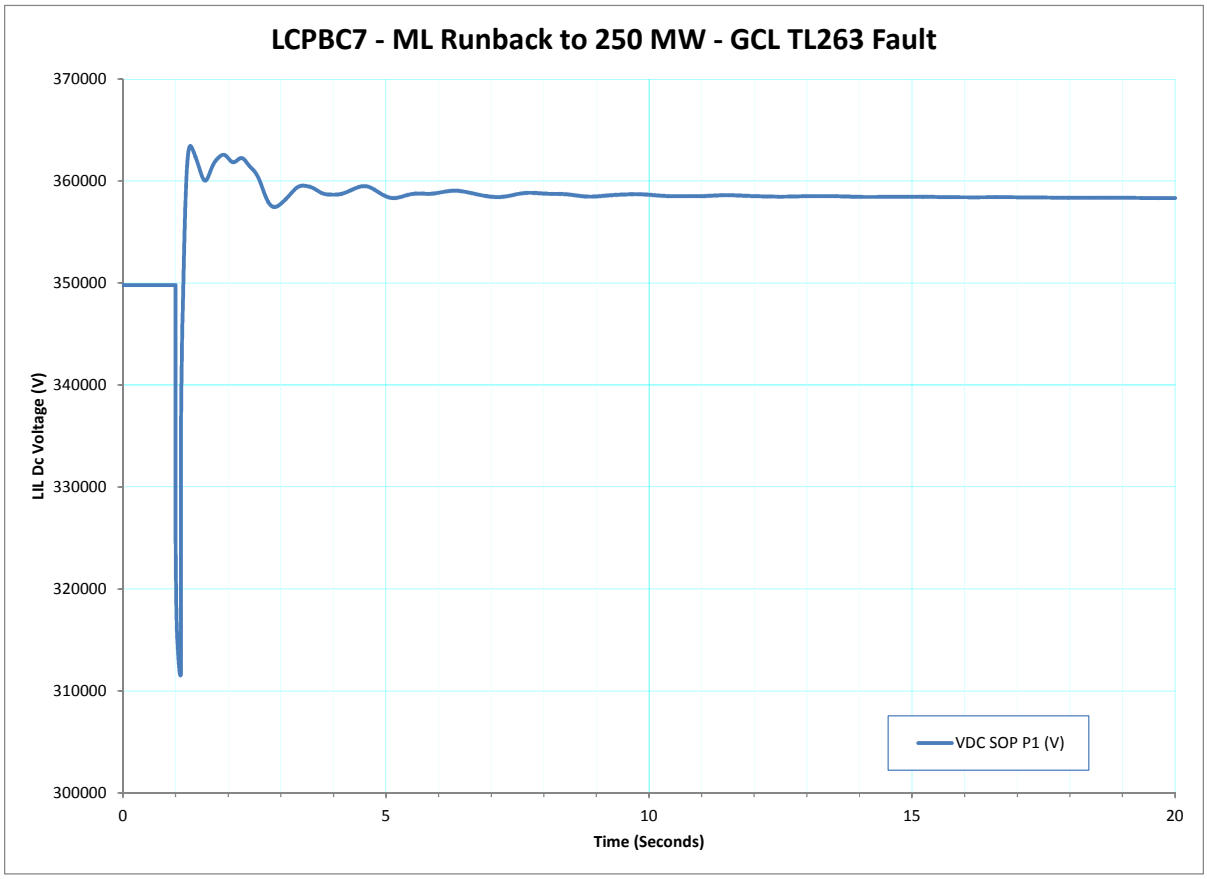

Figure 132 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - LIL Dc Voltage (V)

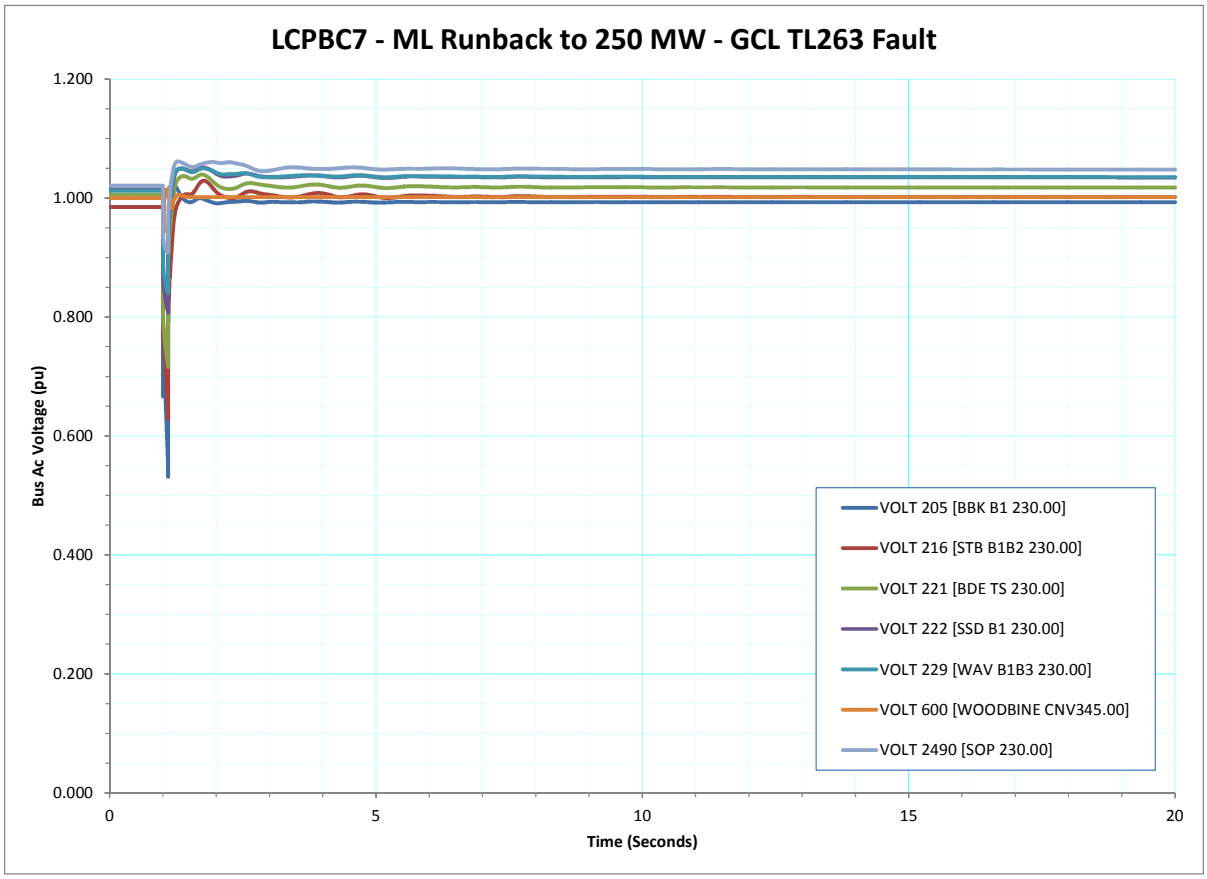

Figure 133 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - Bus Ac Voltage (pu)

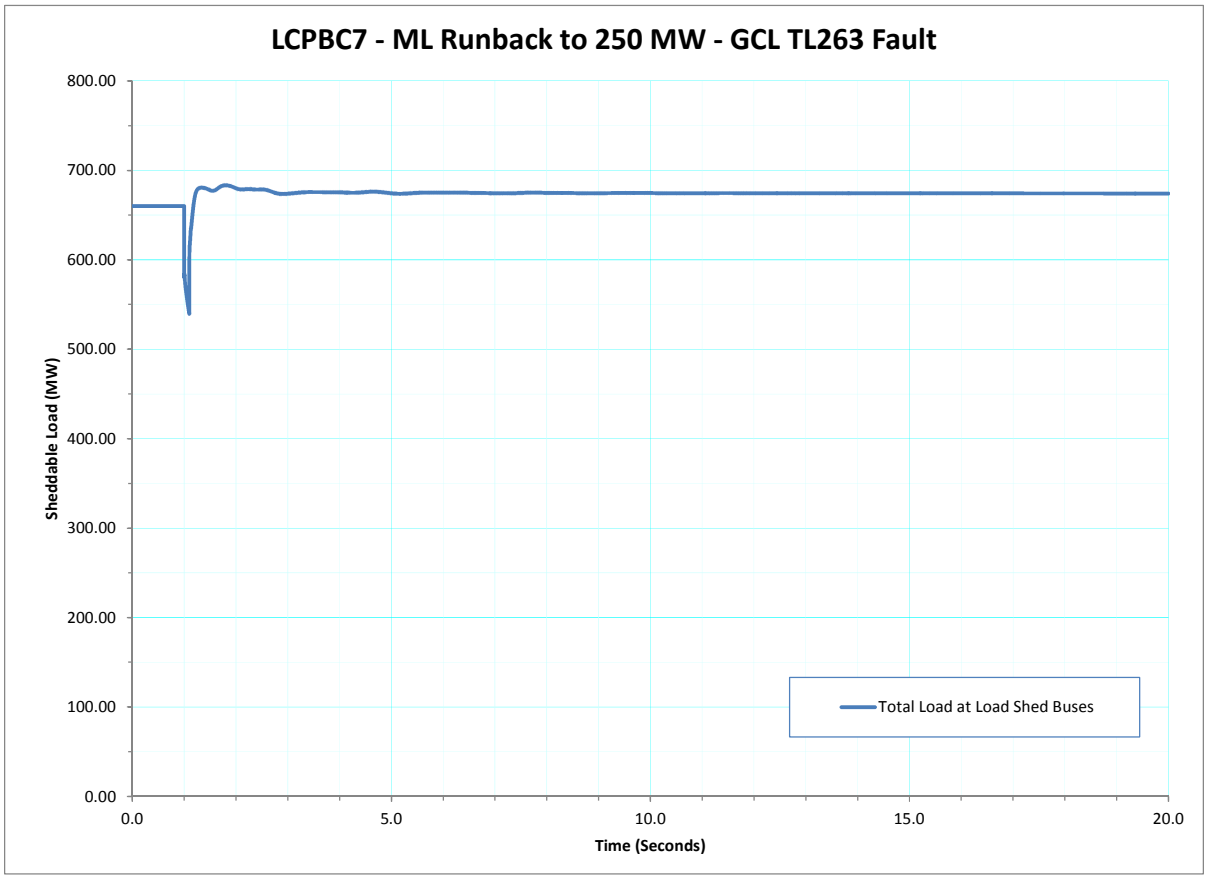

Figure 134 - LCPBC7 - ML Runback to 250 MW - GCL TL263 Fault - Sheddable Load (MW)

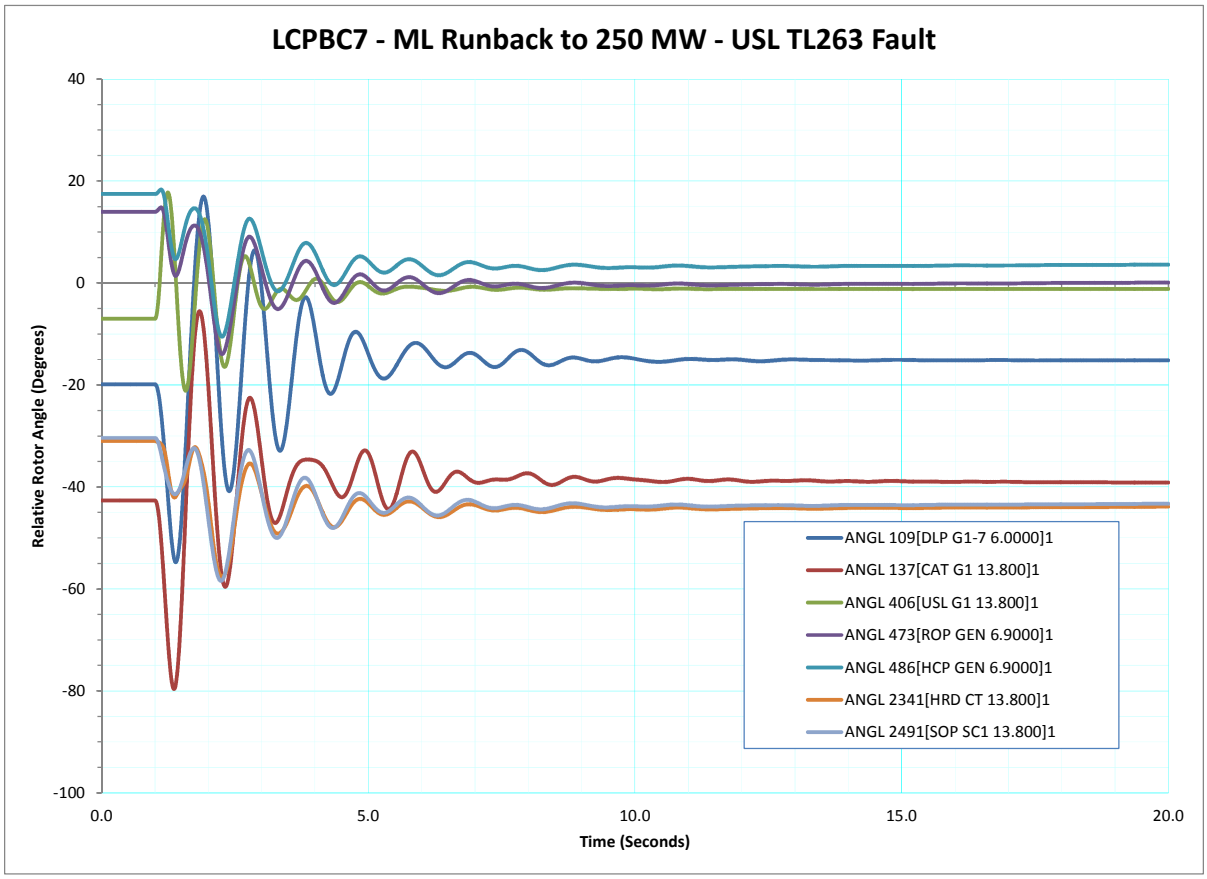

Figure 135 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - Relative Rotor Angle (Degrees)

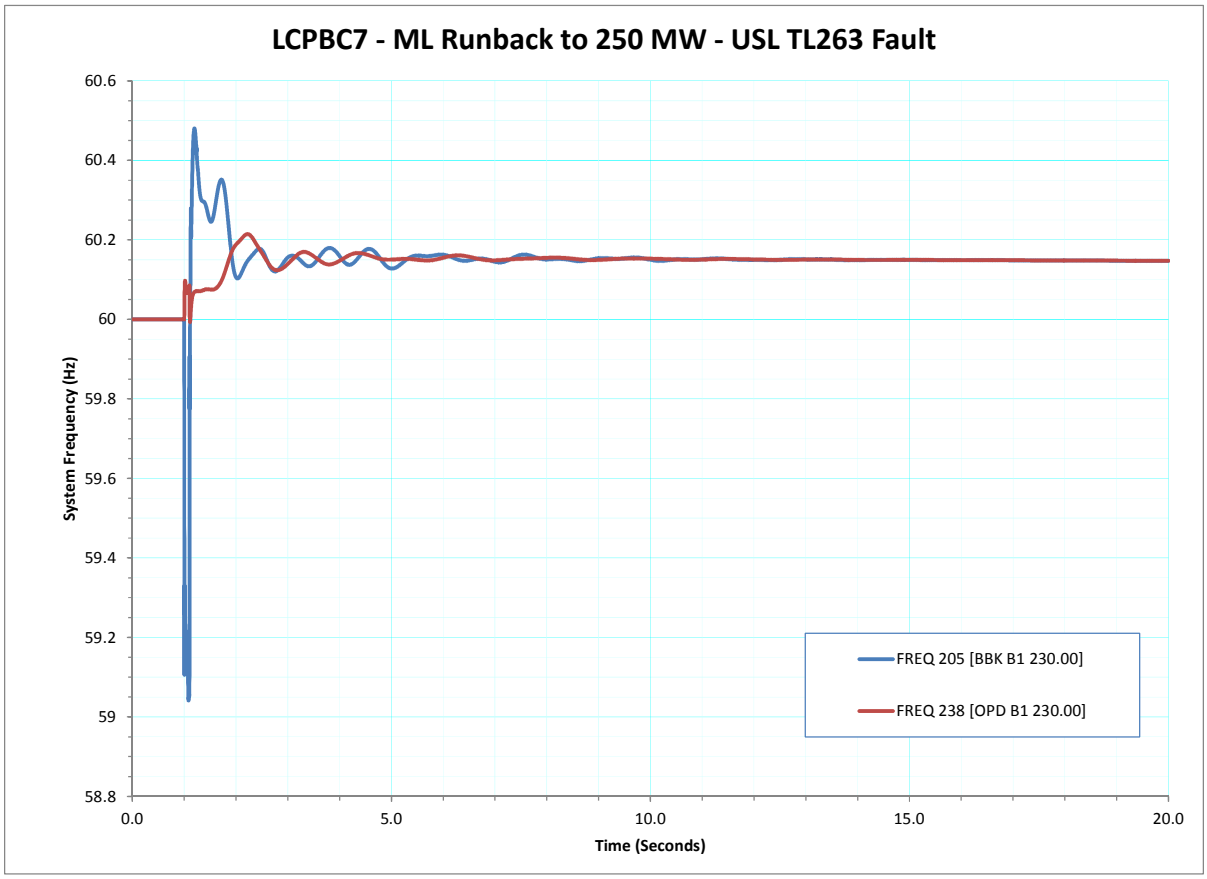

Figure 136 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - System Frequency (Hz)

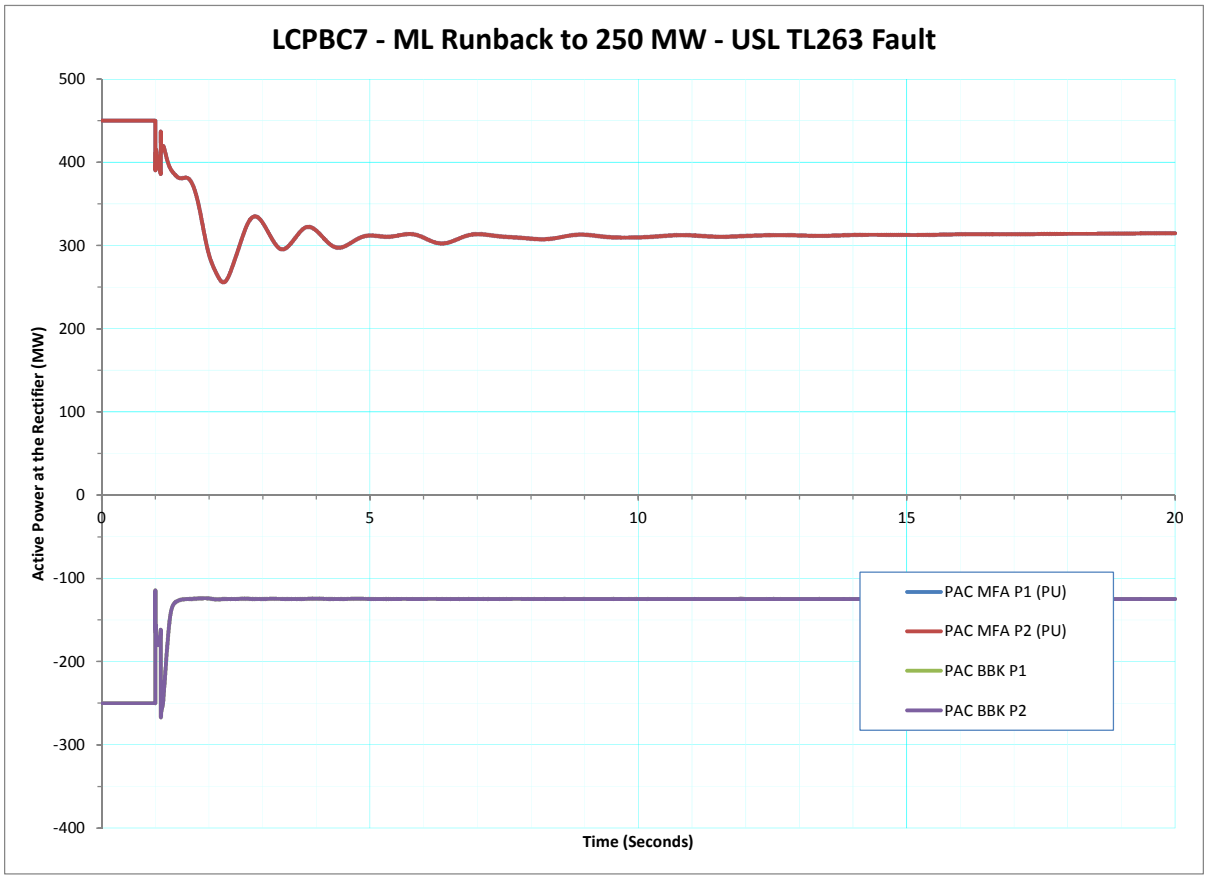

Figure 137 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - Active Power at the Rectifier (MW)

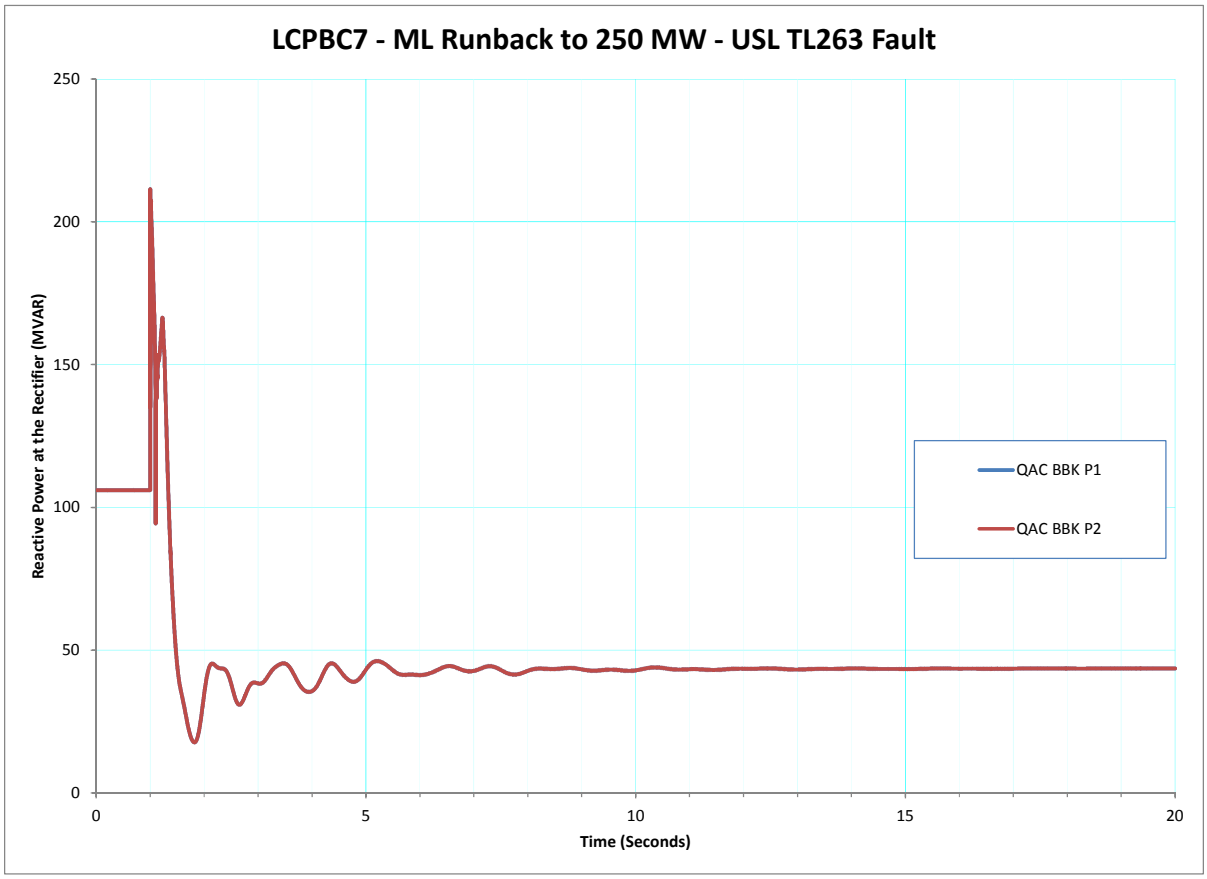

Figure 138 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - Reactive Power at the Rectifier (MVAR)

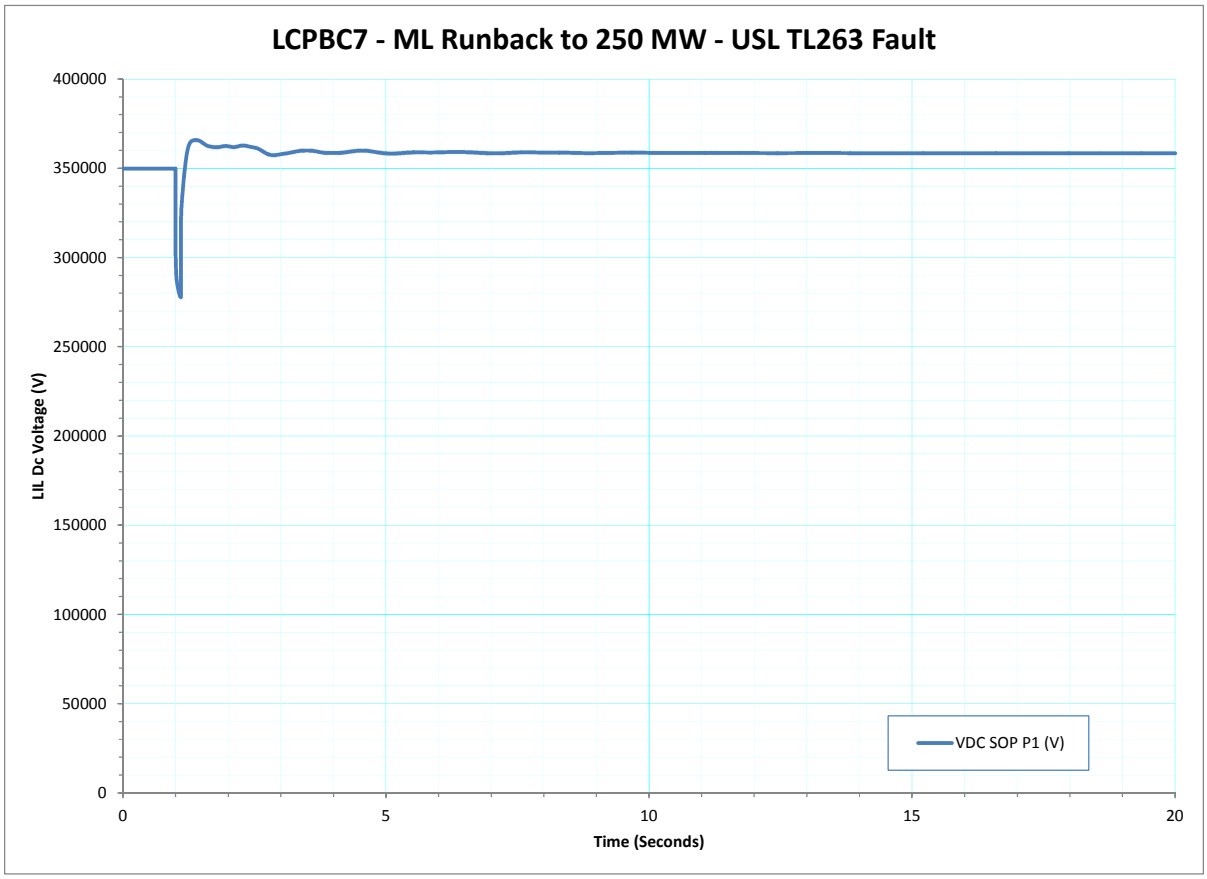

Figure 139 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - LIL Dc Voltage (V)

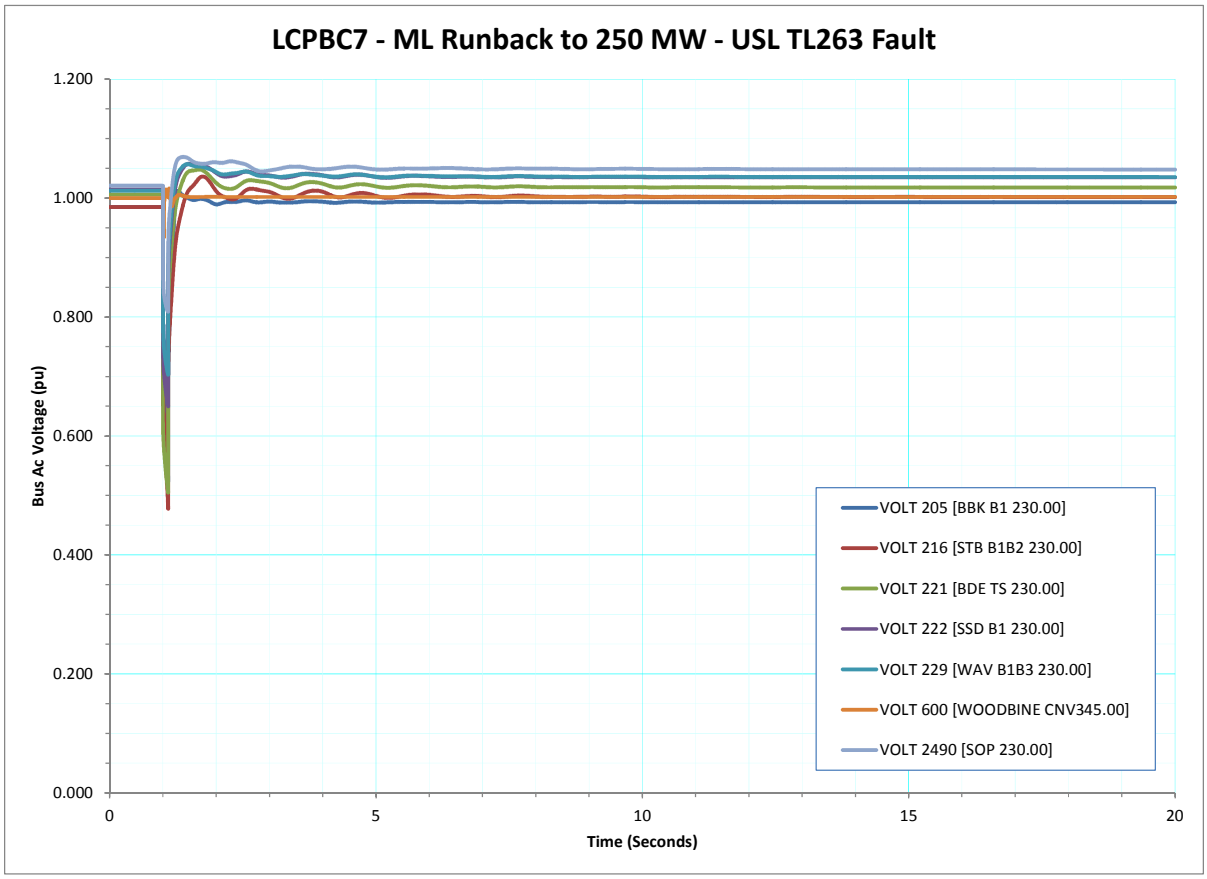

Figure 140 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - Bus Ac Voltage (pu)

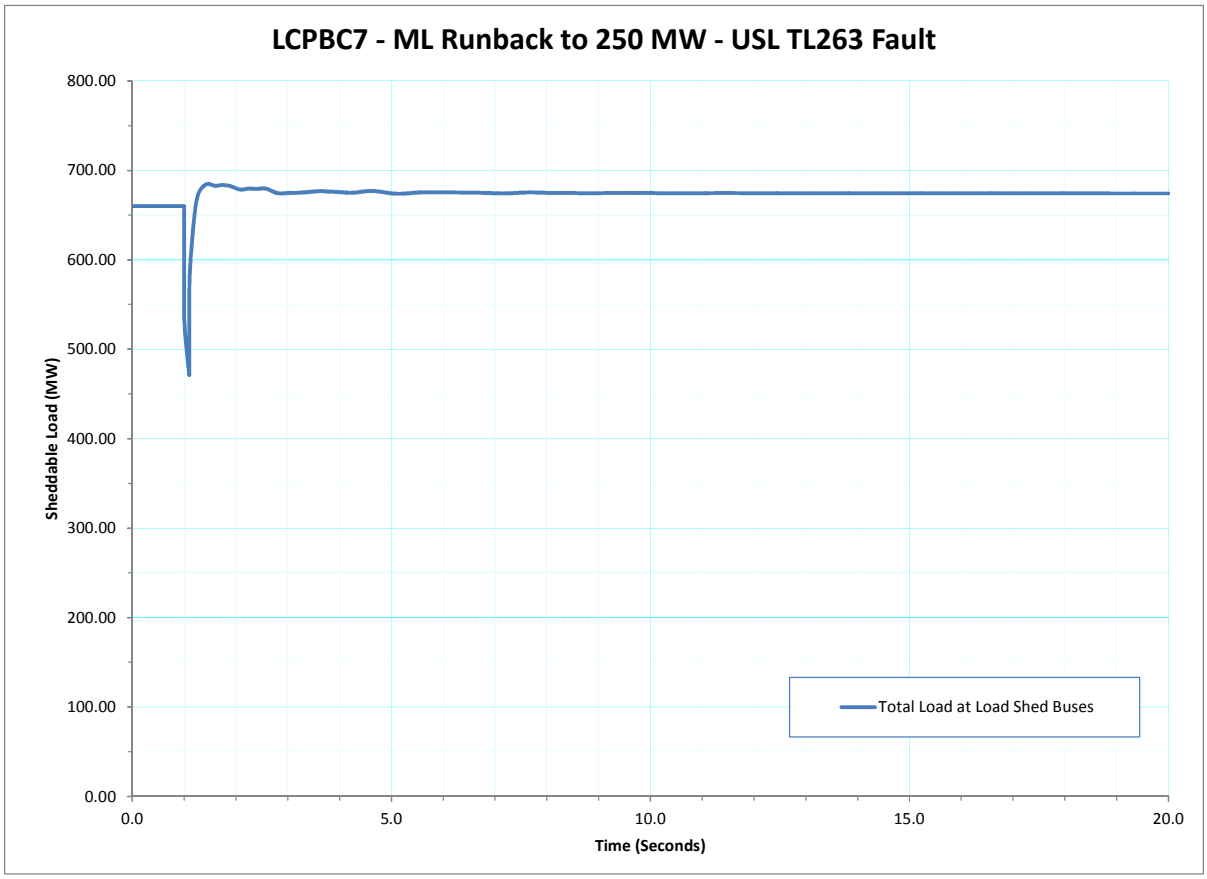

Figure 141 - LCPBC7 - ML Runback to 250 MW - USL TL263 Fault - Sheddable Load (MW)

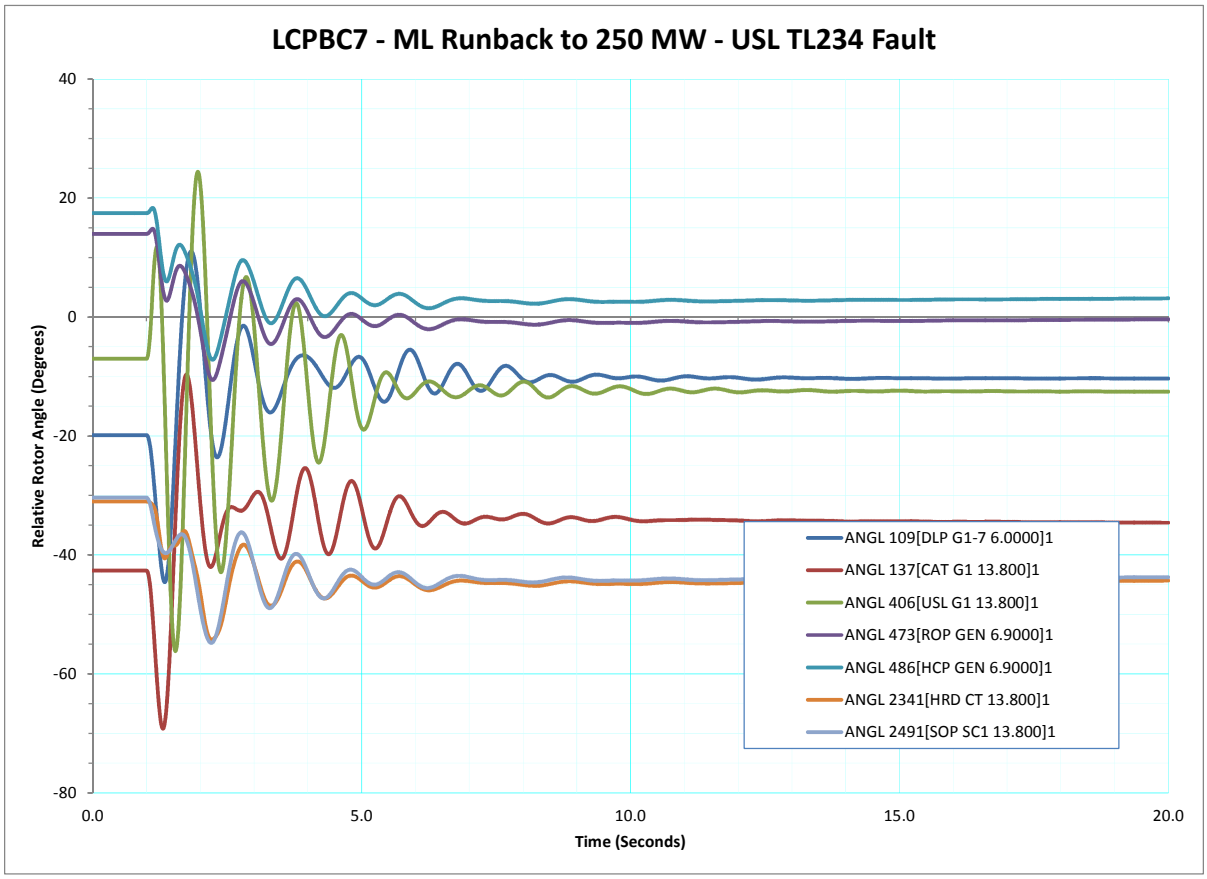

Figure 142 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - Relative Rotor Angle (Degrees)

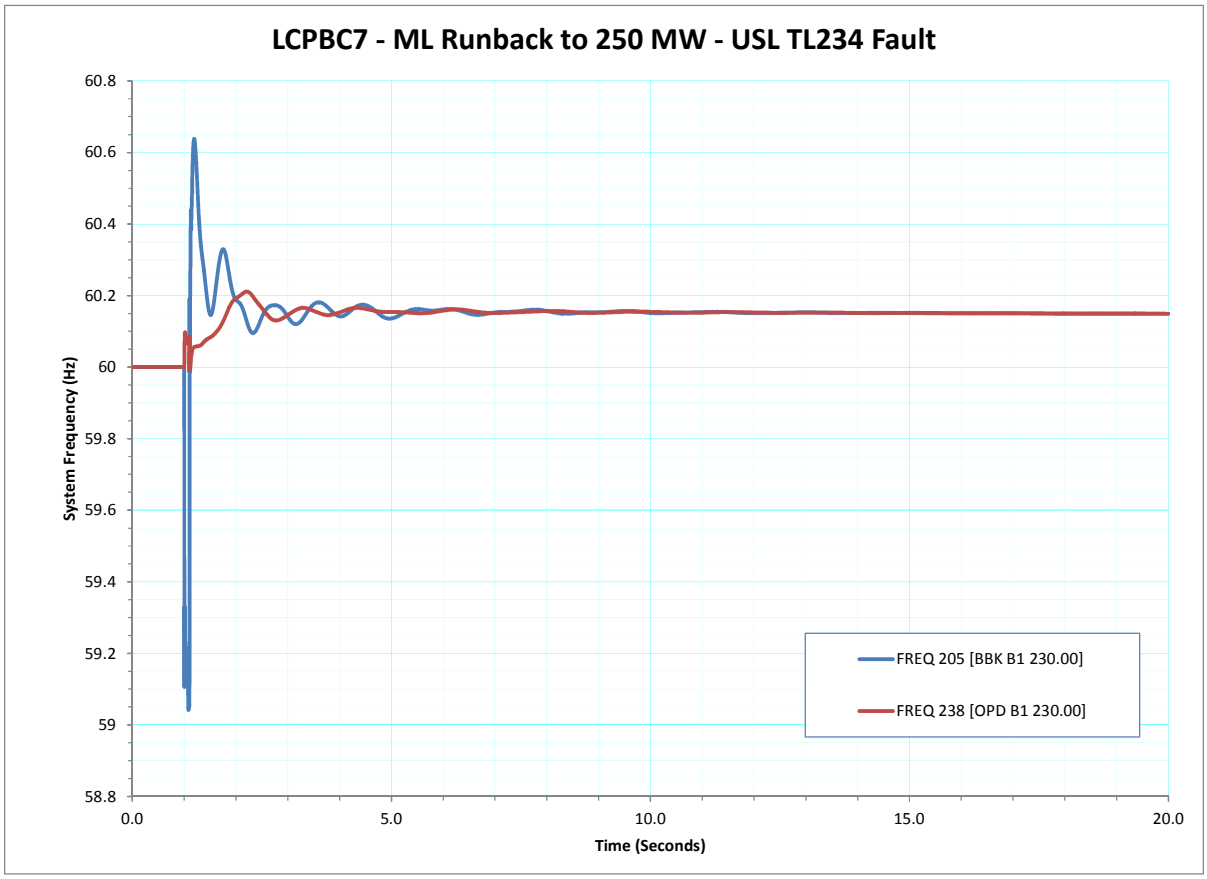

Figure 143 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - System Frequency (Hz)

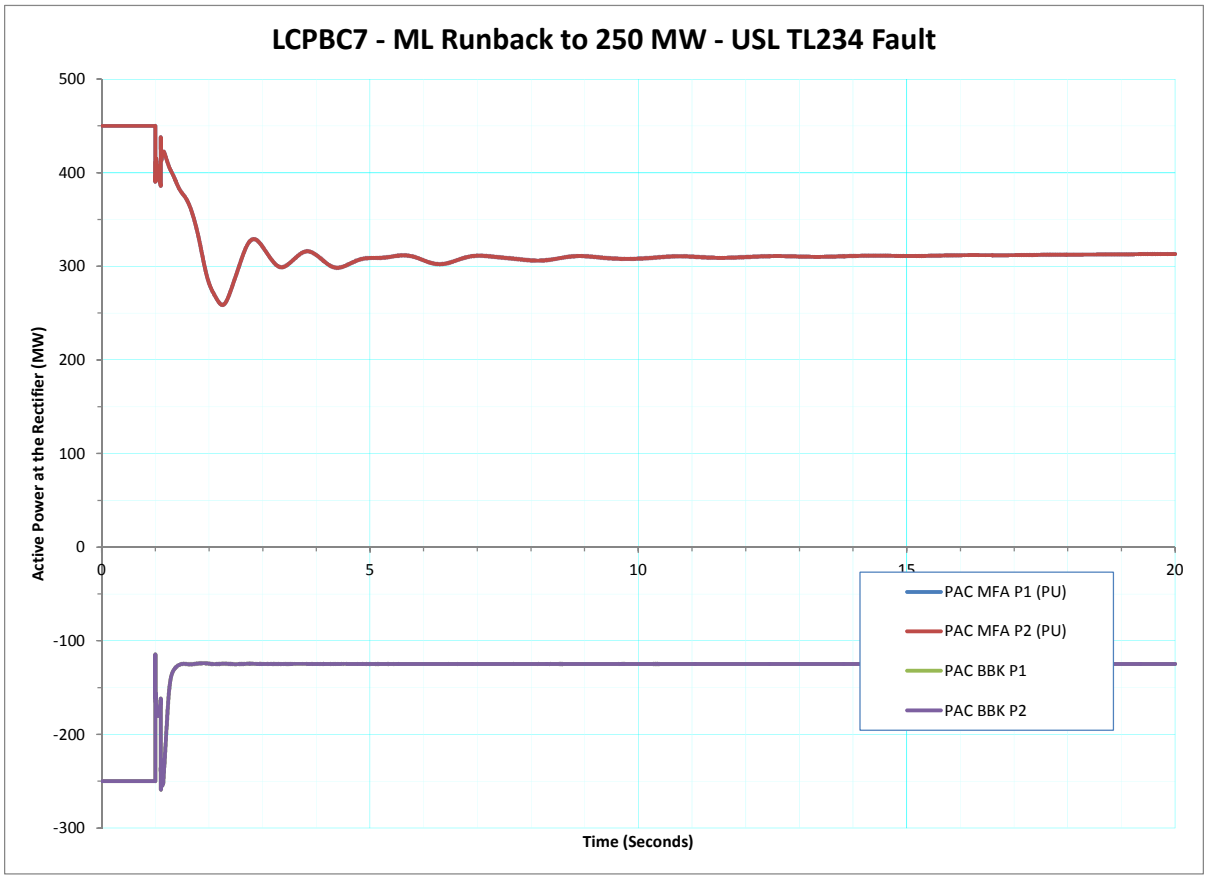

Figure 144 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - Active Power at the Rectifier (MW)

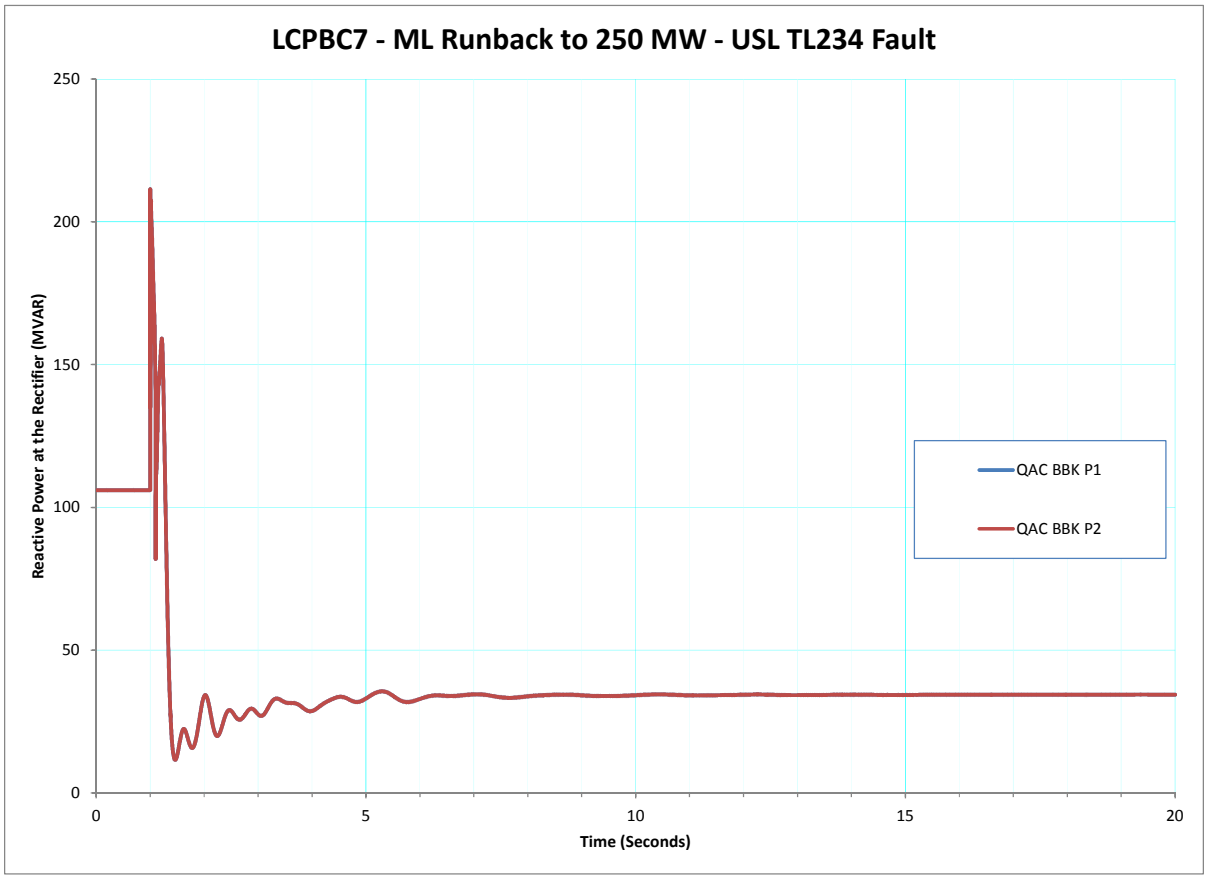

Figure 145 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - Reactive Power at the Rectifier (MVAR)

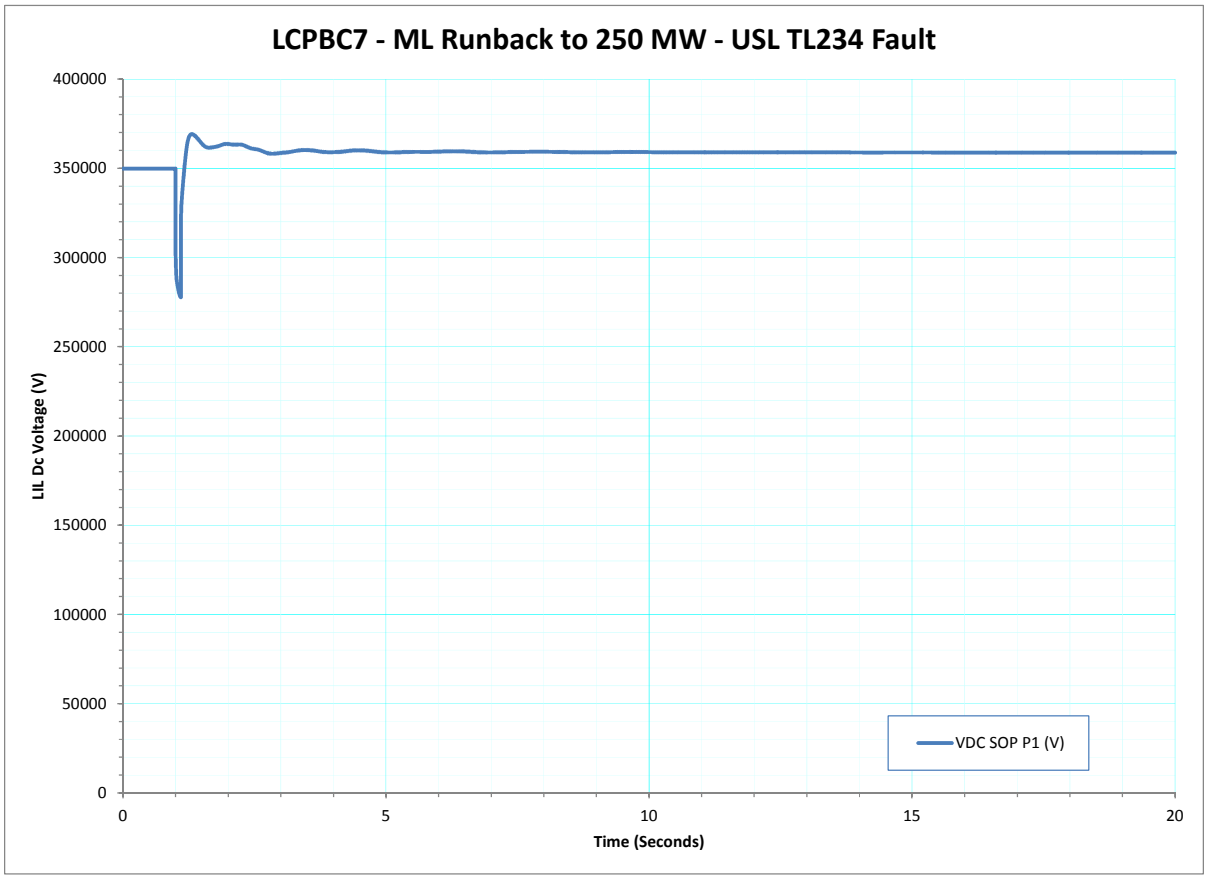

Figure 146 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - LIL Dc Voltage (V)

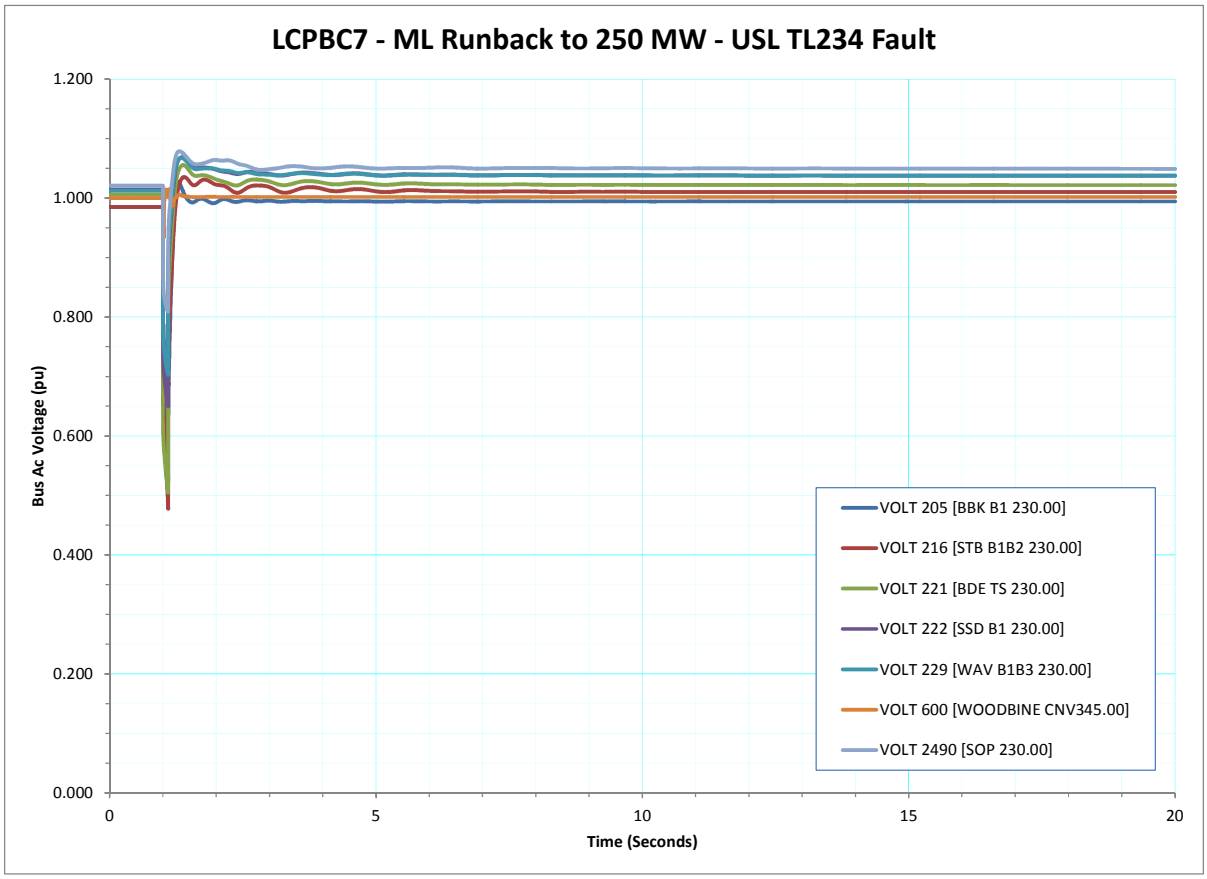

Figure 147 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - Bus Ac Voltage (pu)

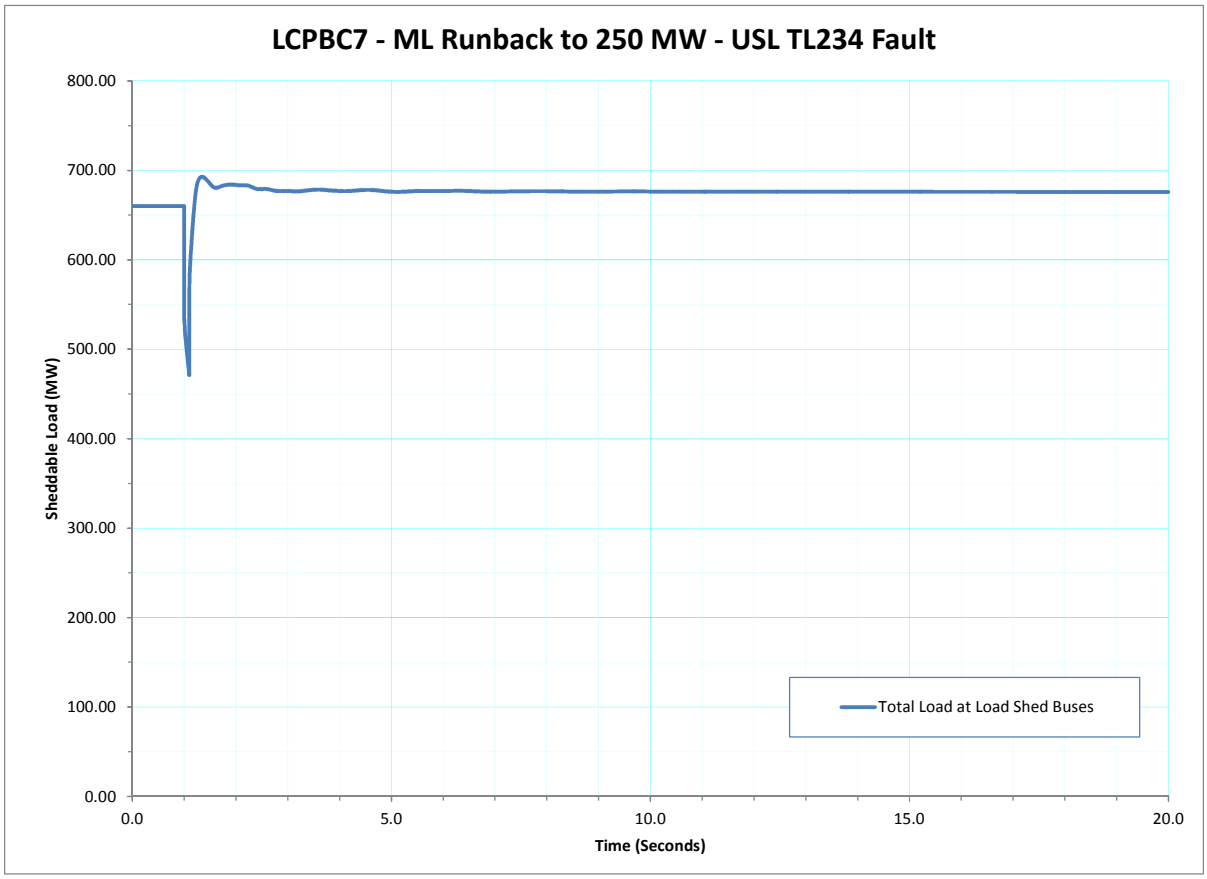

Figure 148 - LCPBC7 - ML Runback to 250 MW - USL TL234 Fault - Sheddable Load (MW)

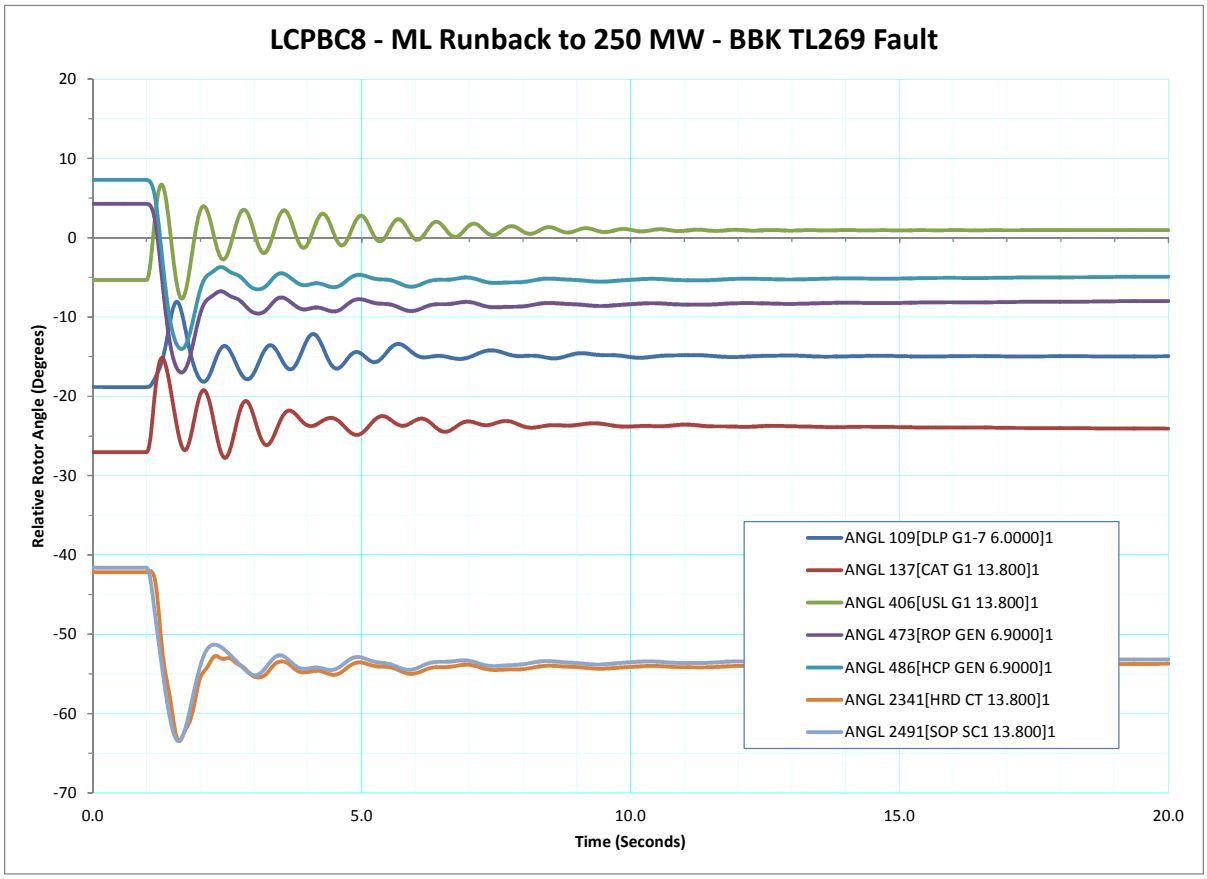

Figure 149 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - Relative Rotor Angle (Degrees)

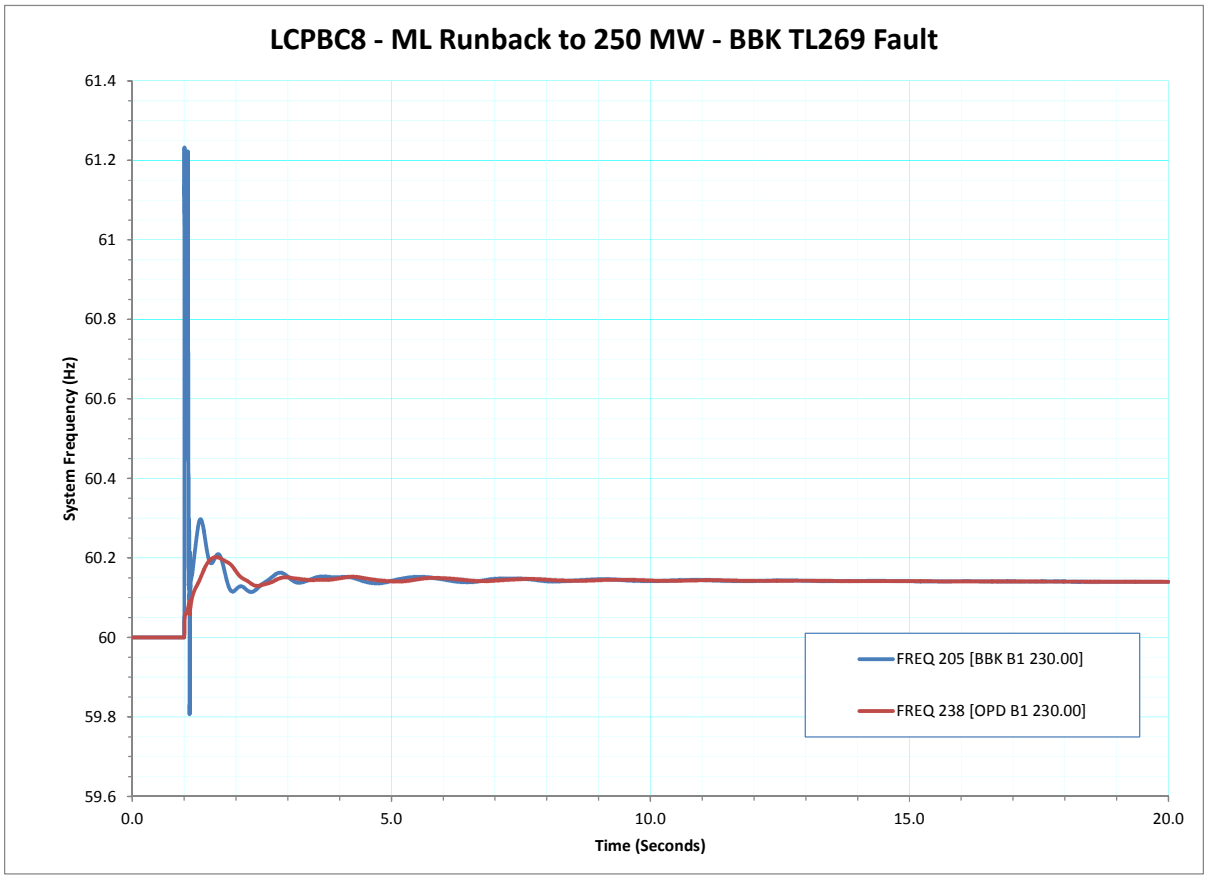

Figure 150 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - System Frequency (Hz)

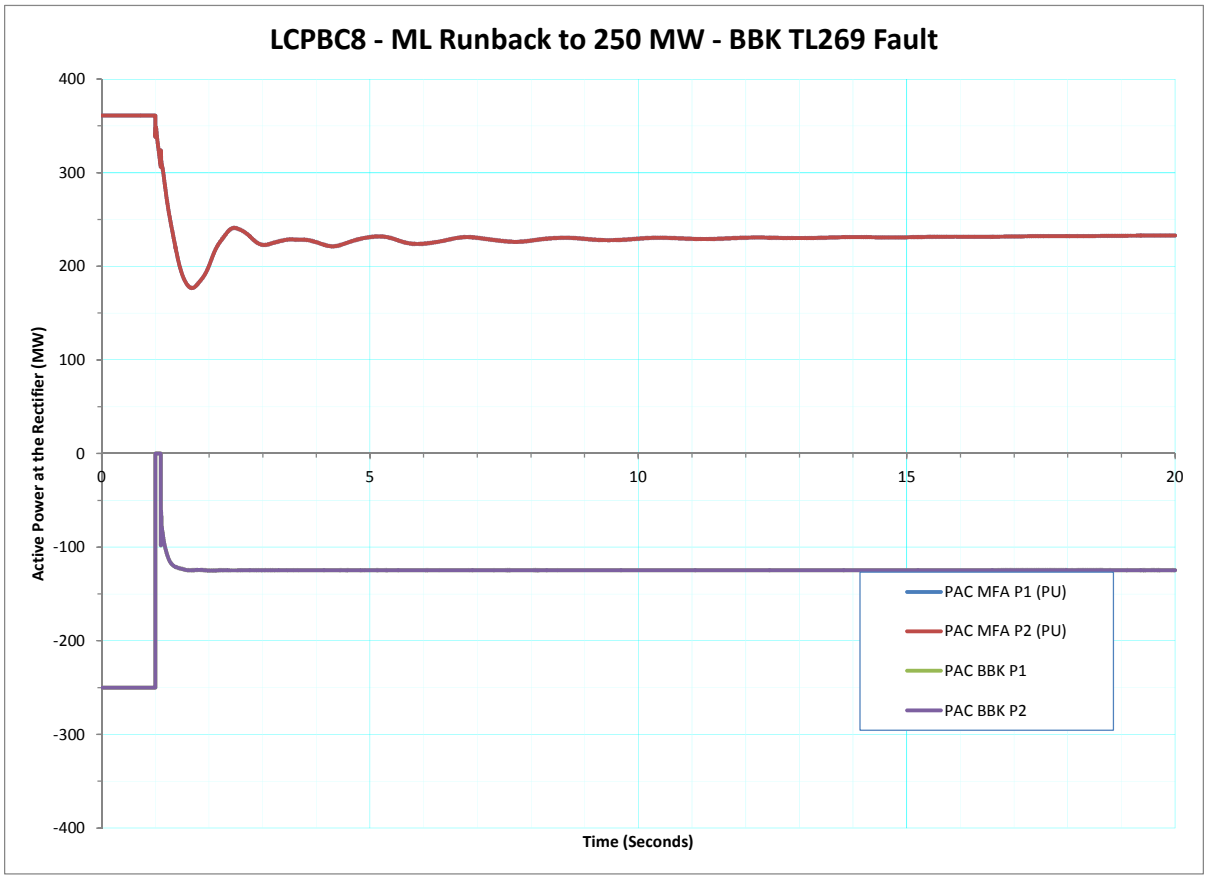

Figure 151 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - Active Power at the Rectifier (MW)

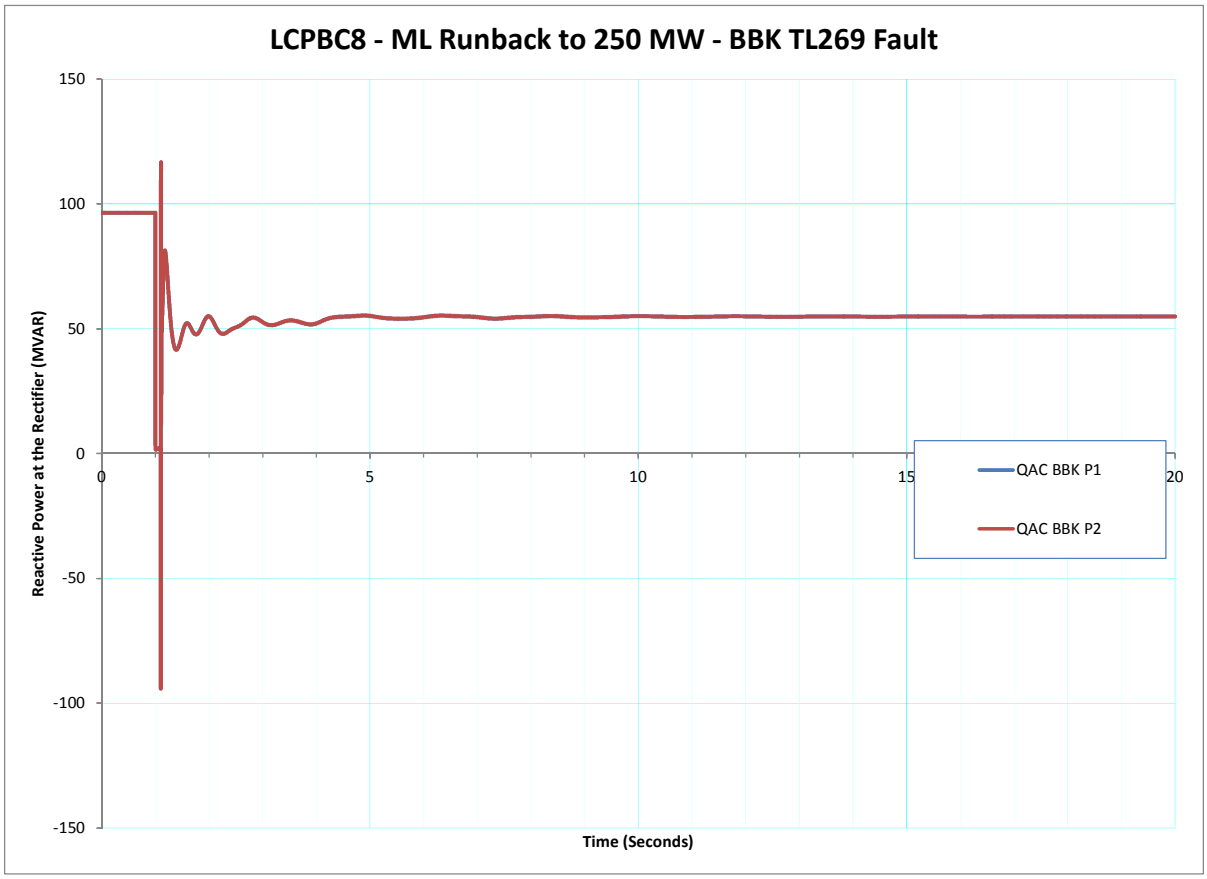

Figure 152 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - Reactive Power at the Rectifier (MVAR)

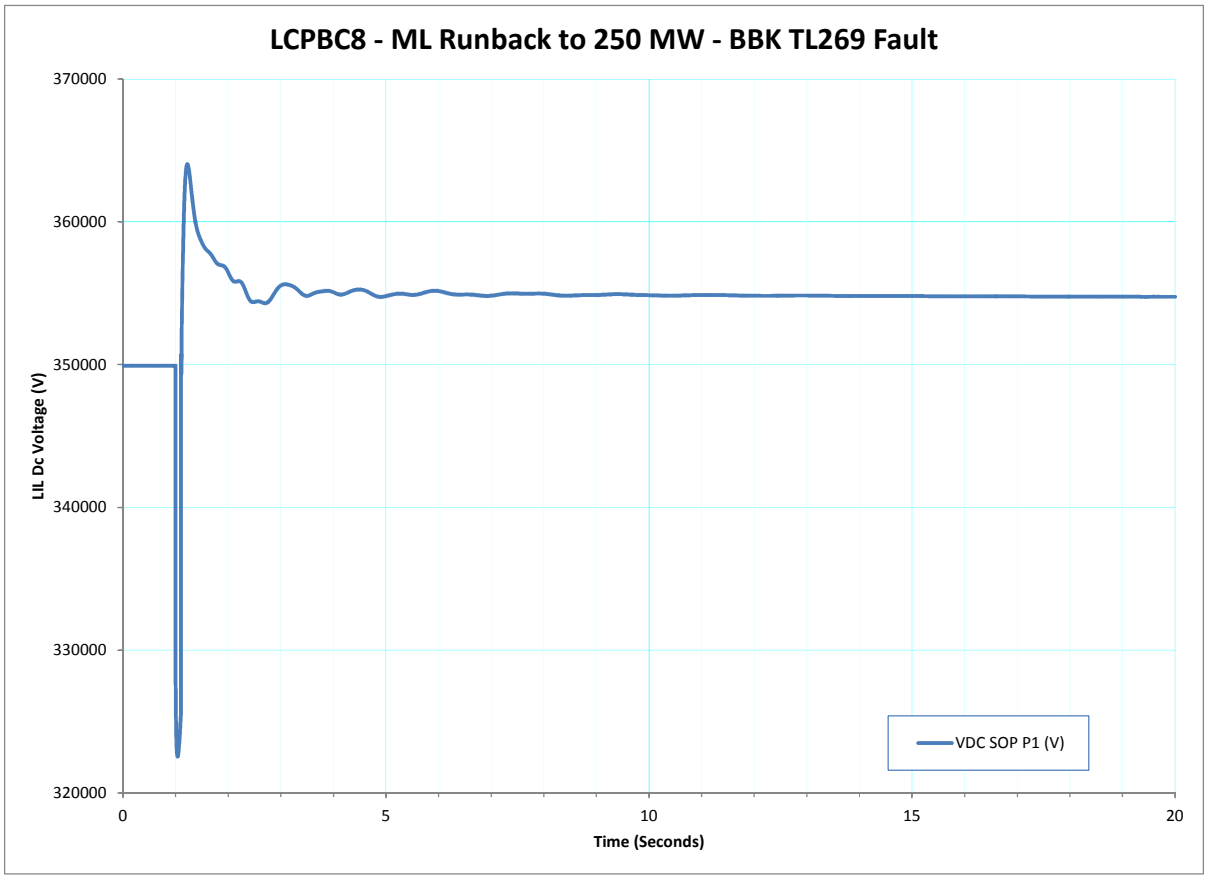

Figure 153 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - LIL Dc Voltage (V)

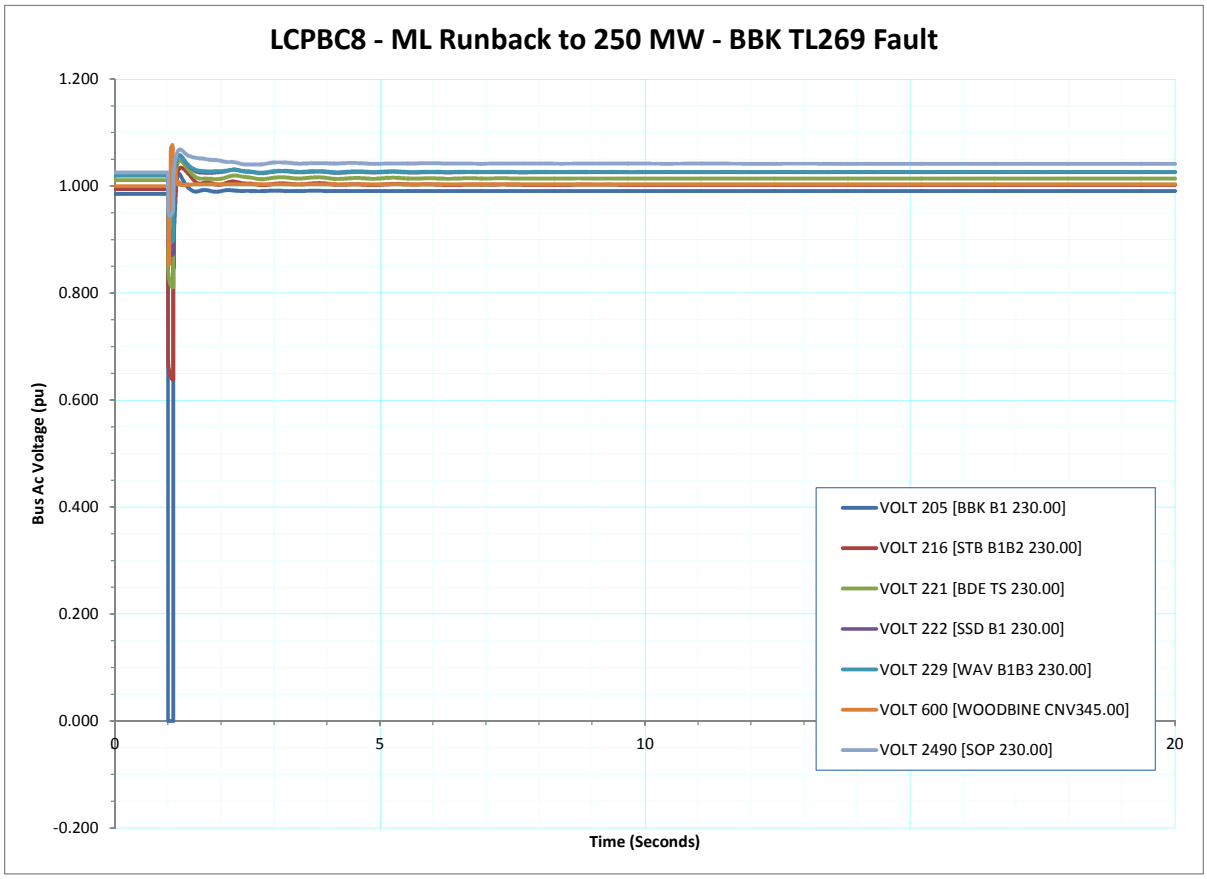

Figure 154 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - Bus Ac Voltage (pu)

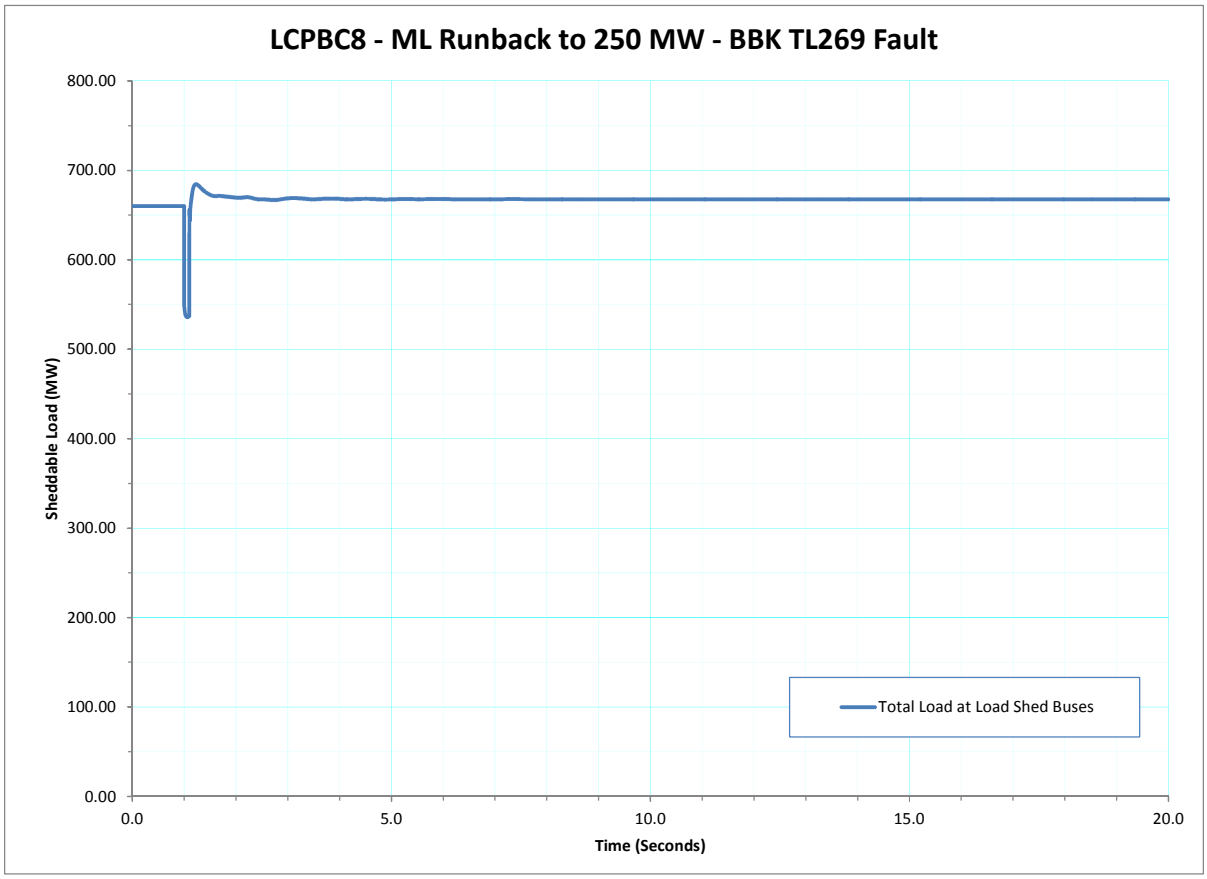

Figure 155 - LCPBC8 - ML Runback to 250 MW - BBK TL269 Fault - Sheddable Load (MW)

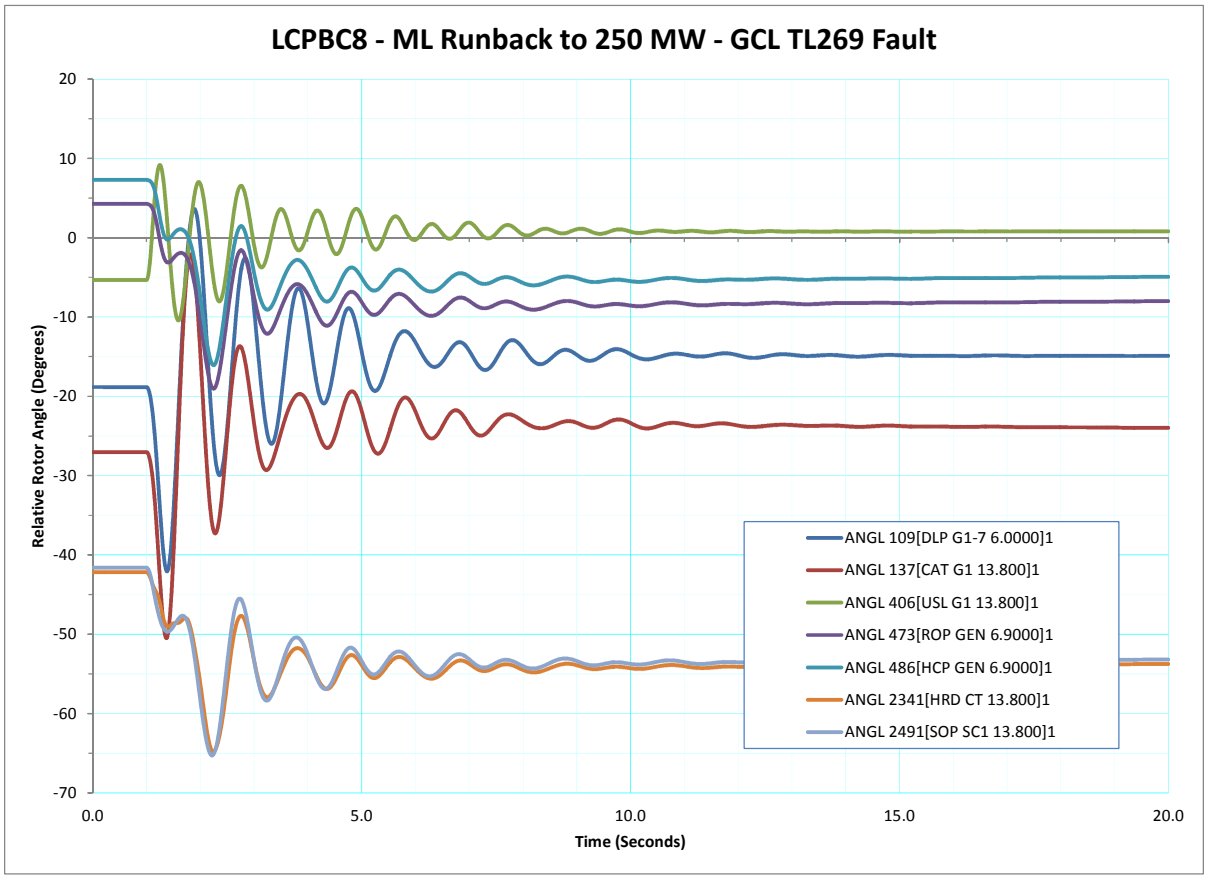

Figure 156 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - Relative Rotor Angle (Degrees)

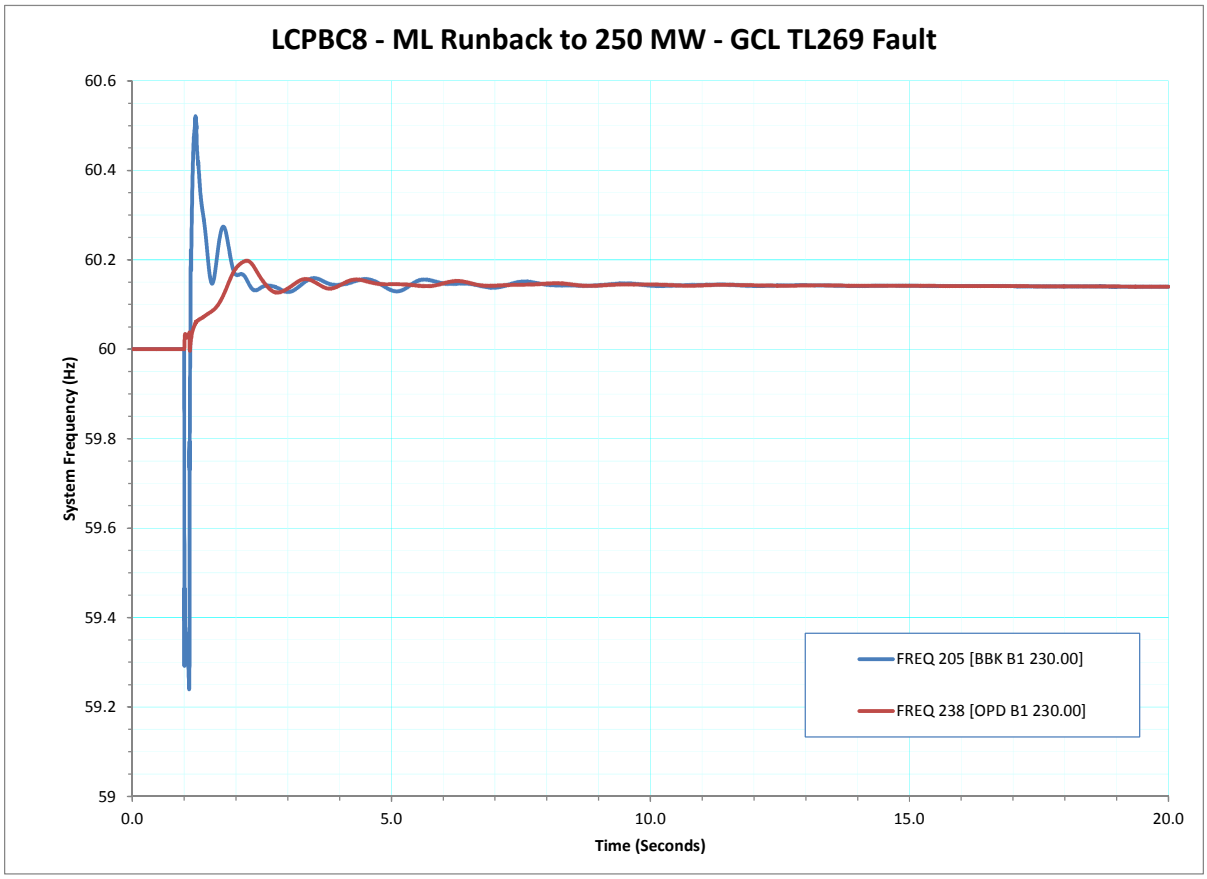

Figure 157 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - System Frequency (Hz)

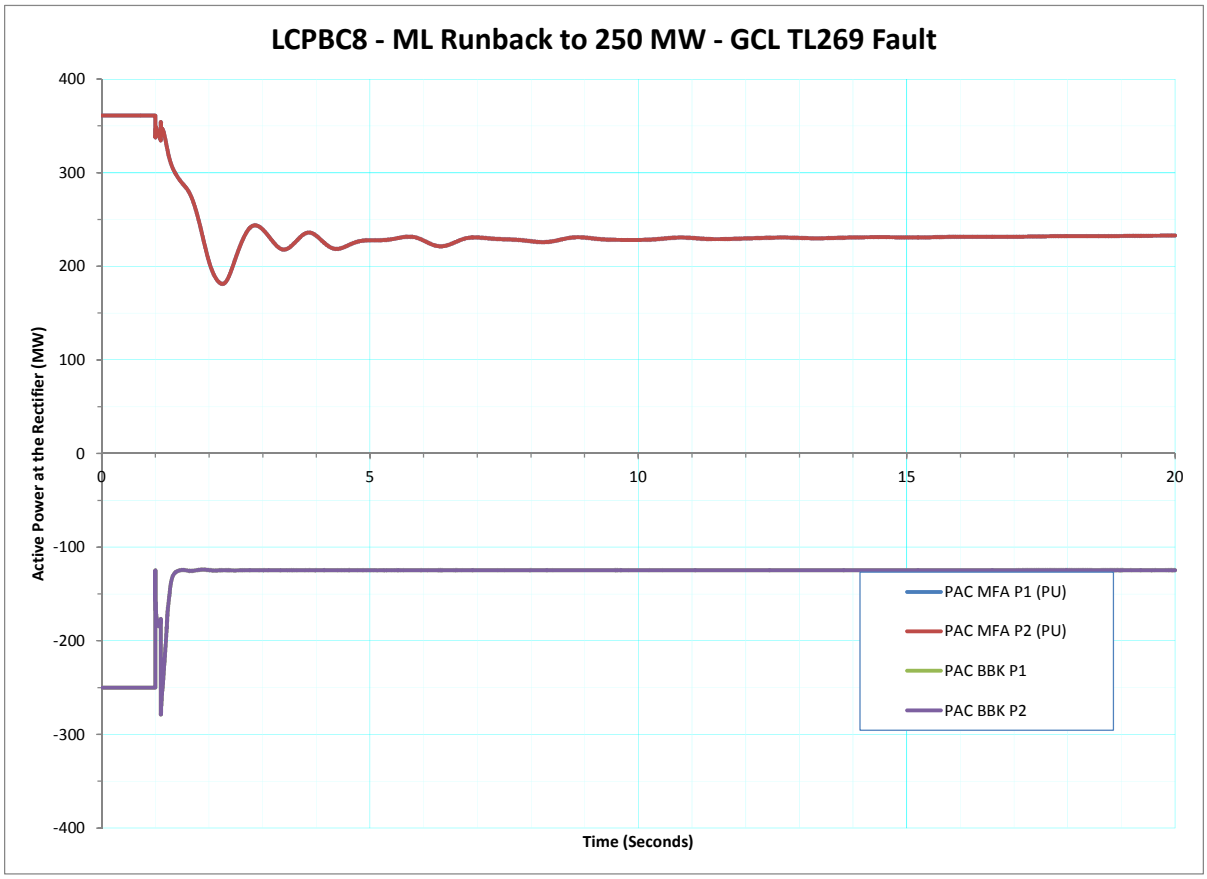

Figure 158 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - Active Power at the Rectifier (MW)

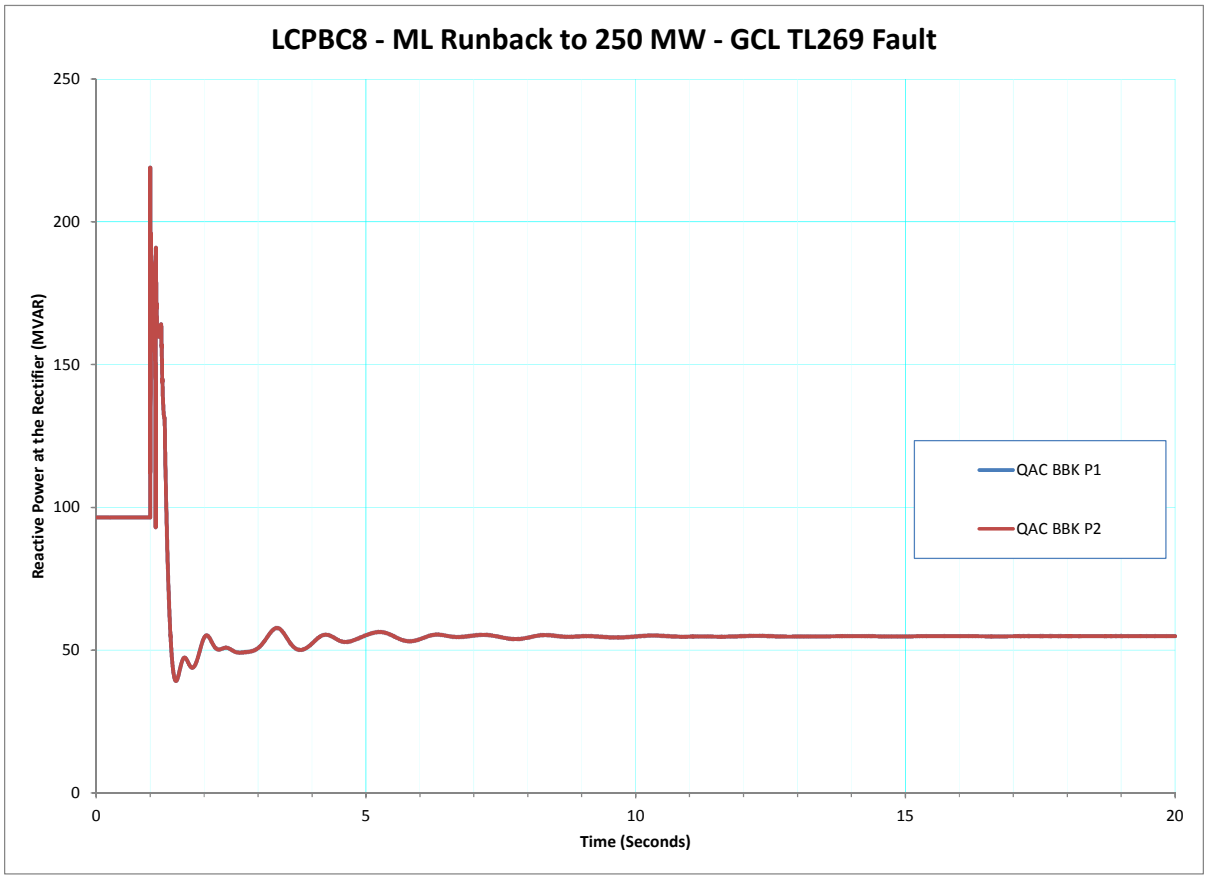

Figure 159 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - Reactive Power at the Rectifier (MVAR)

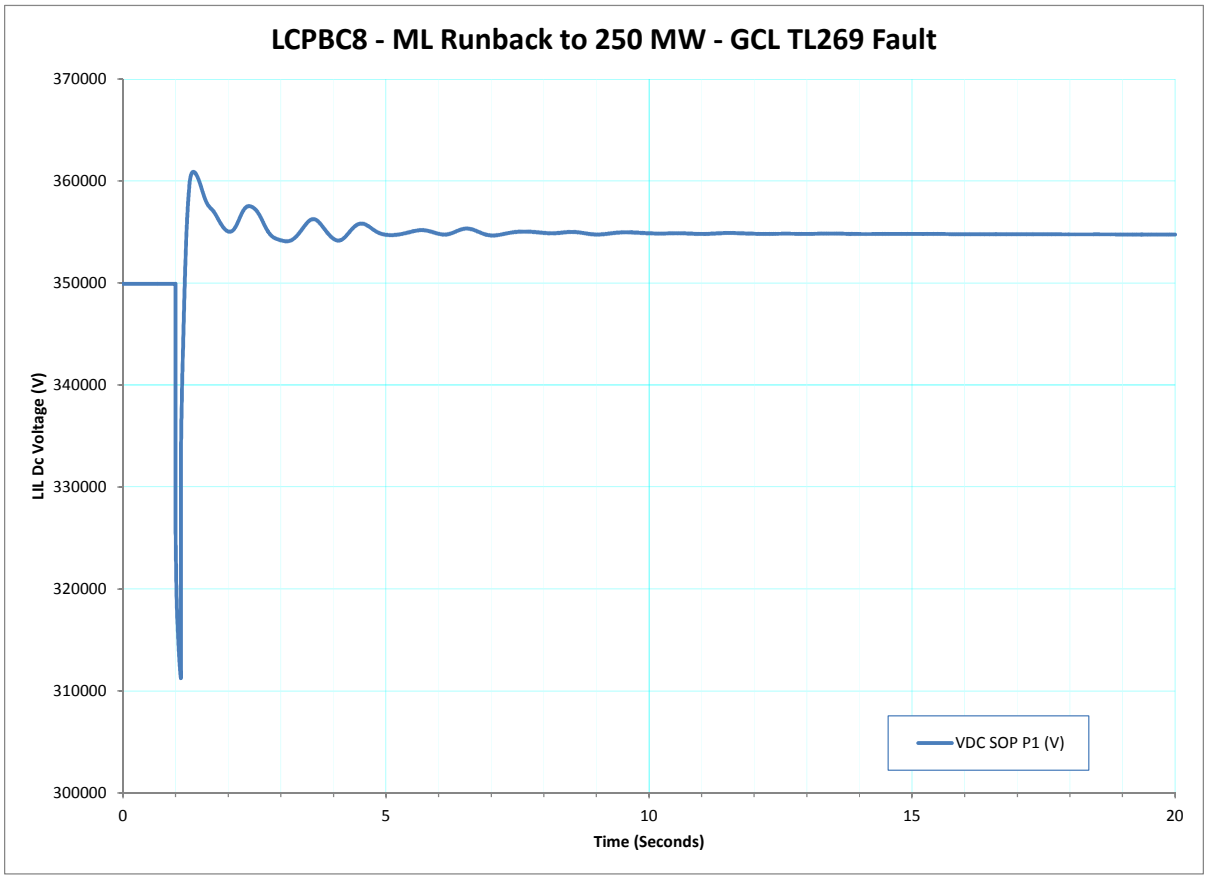

Figure 160 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - LIL Dc Voltage (V)

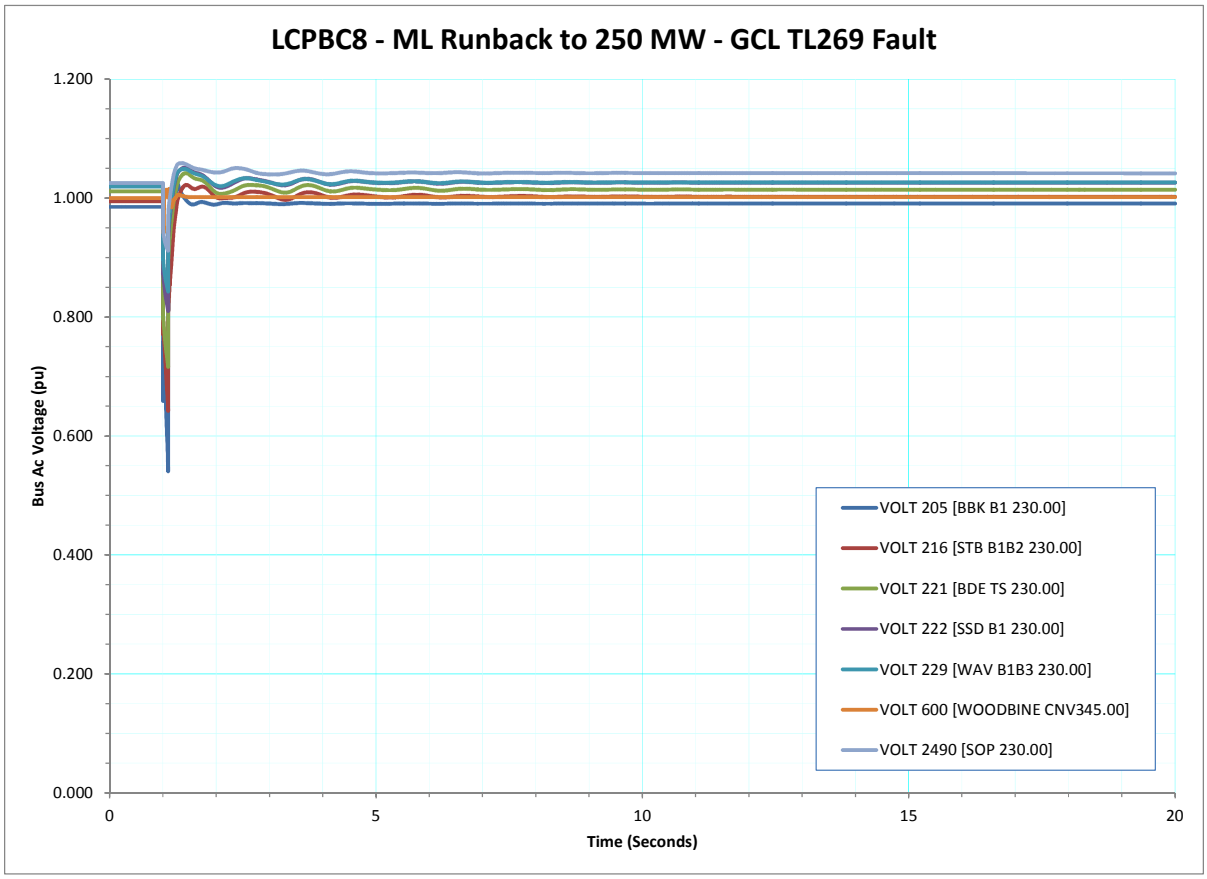

Figure 161 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - Bus Ac Voltage (pu)

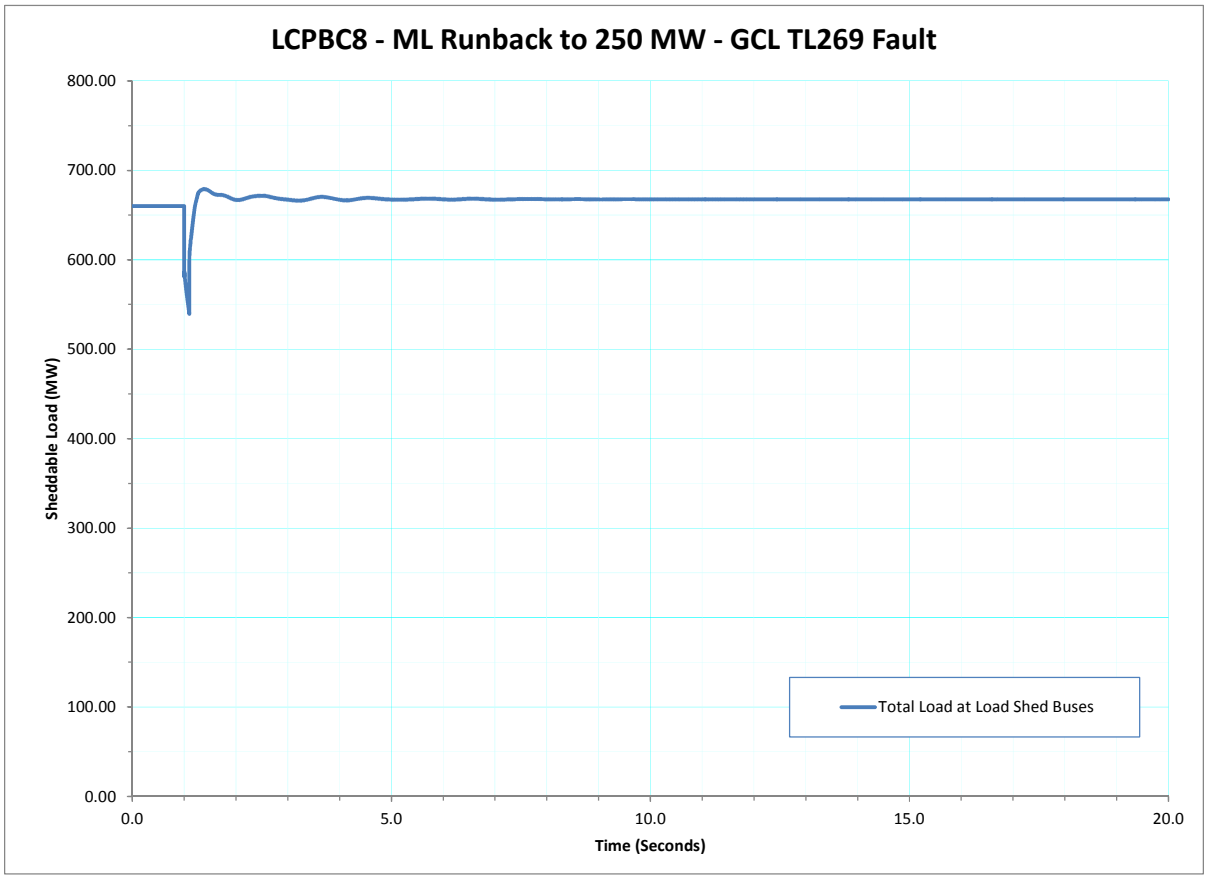

Figure 162 - LCPBC8 - ML Runback to 250 MW - GCL TL269 Fault - Sheddable Load (MW)

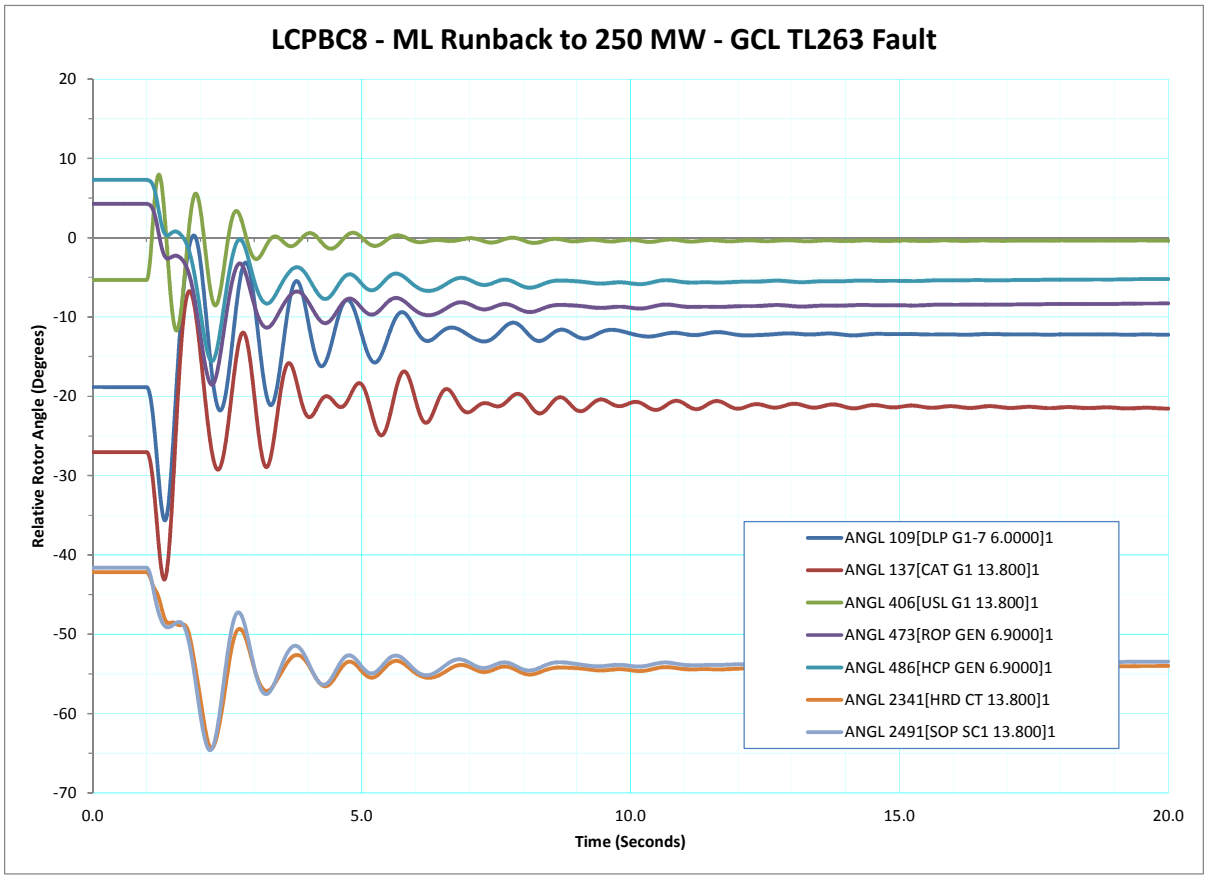

Figure 163 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - Relative Rotor Angle (Degrees)

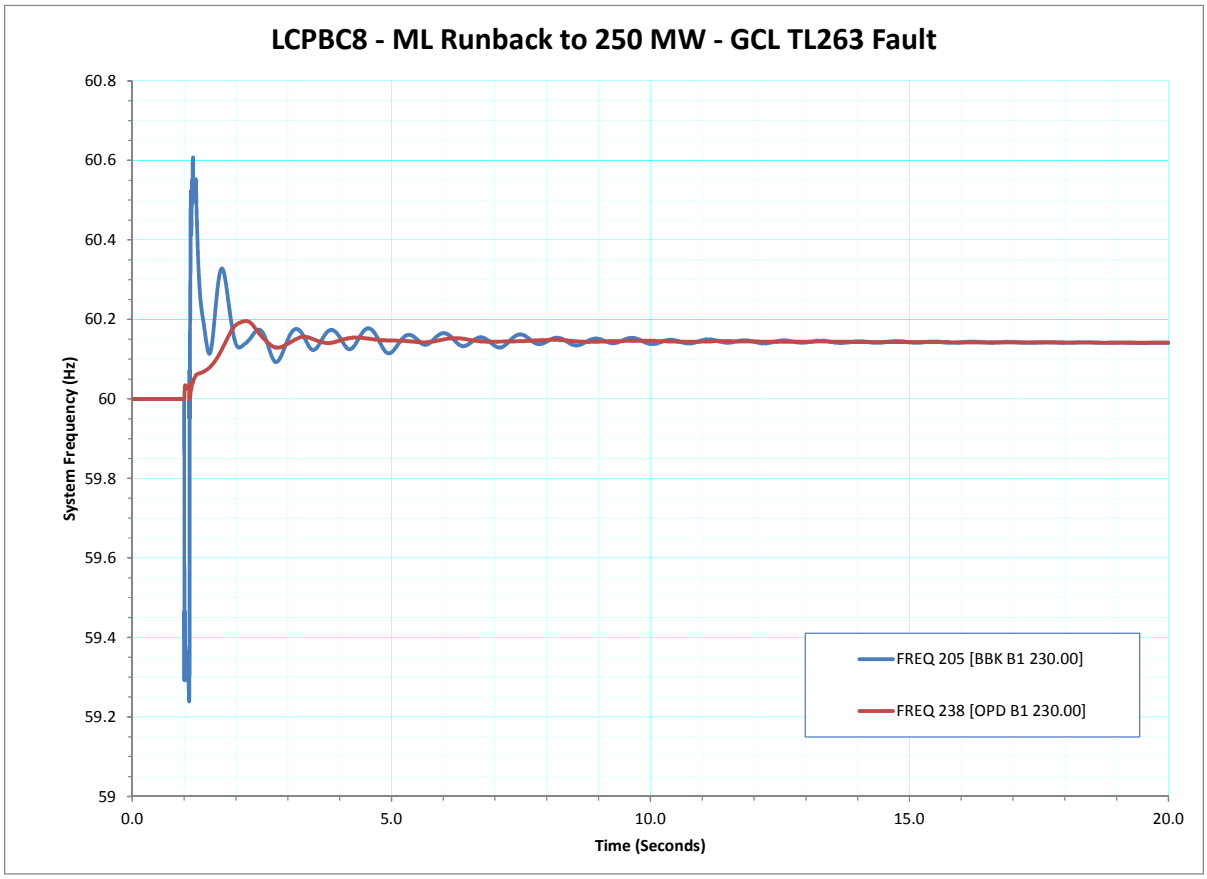

Figure 164 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - System Frequency (Hz)

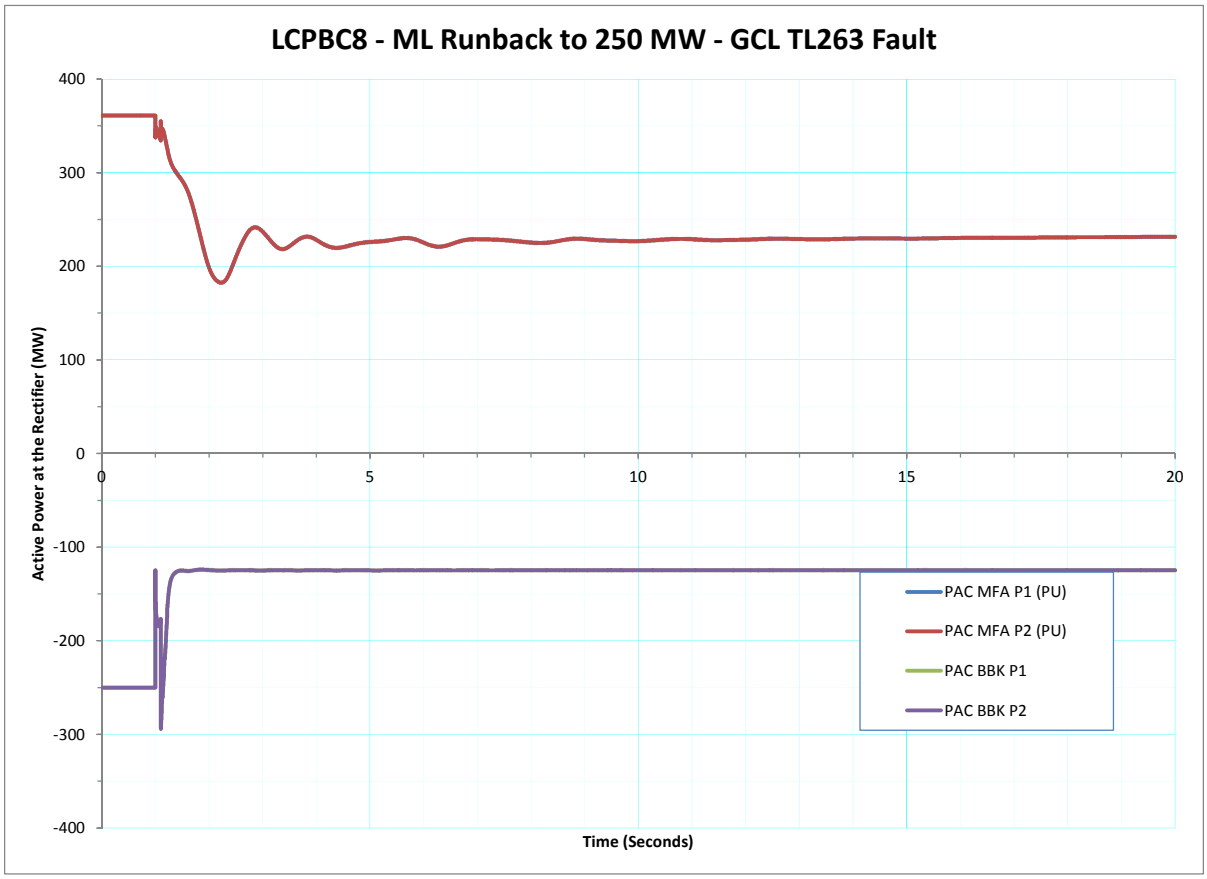

Figure 165 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - Active Power at the Rectifier (MW)

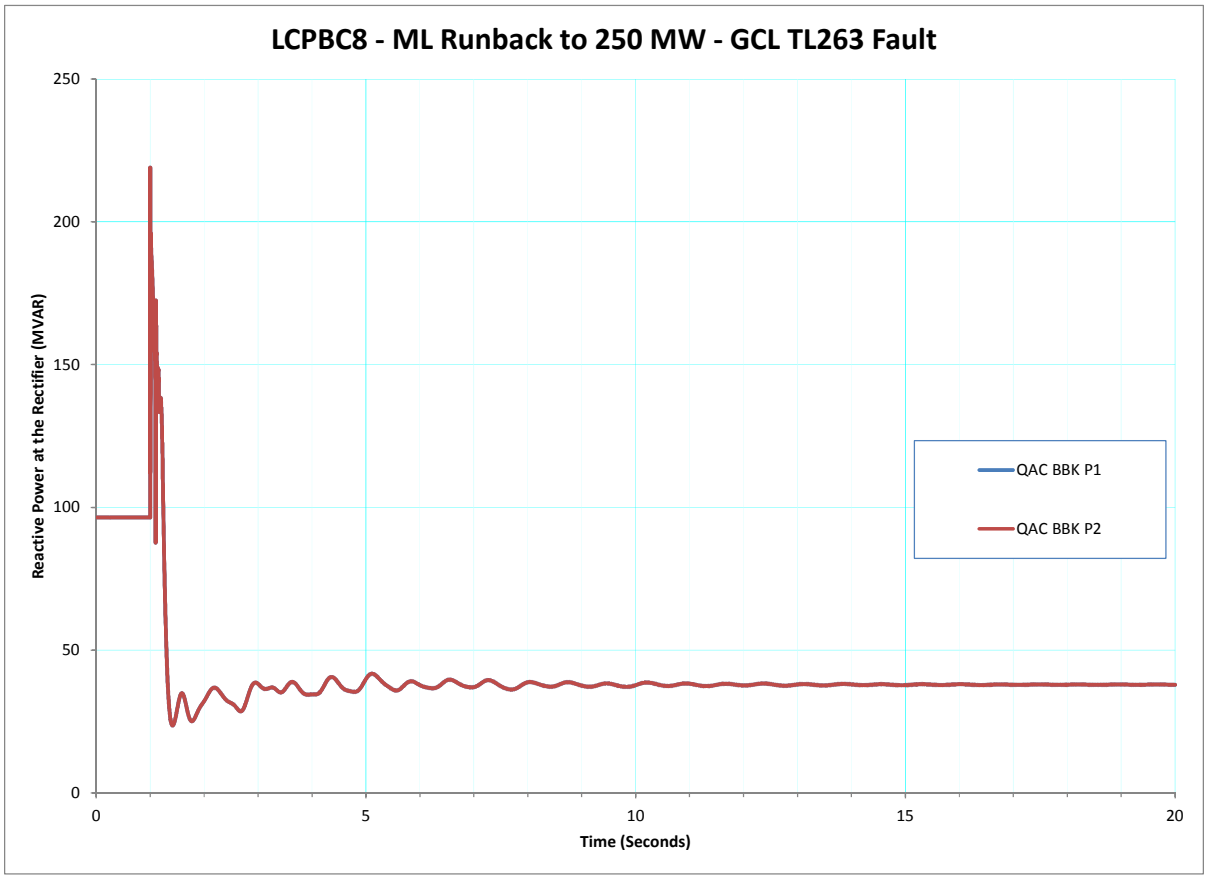

Figure 166 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - Reactive Power at the Rectifier (MVAR)

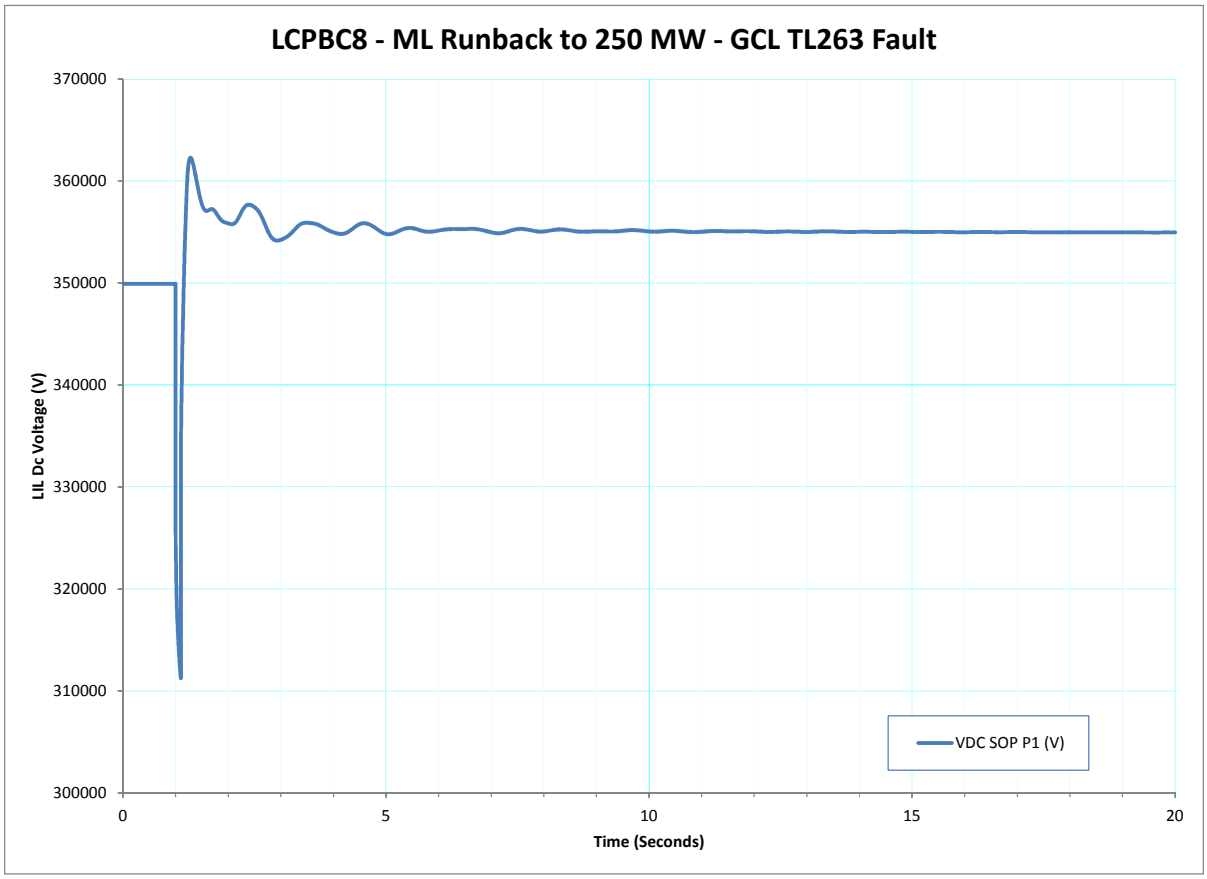

Figure 167 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - LIL Dc Voltage (V)

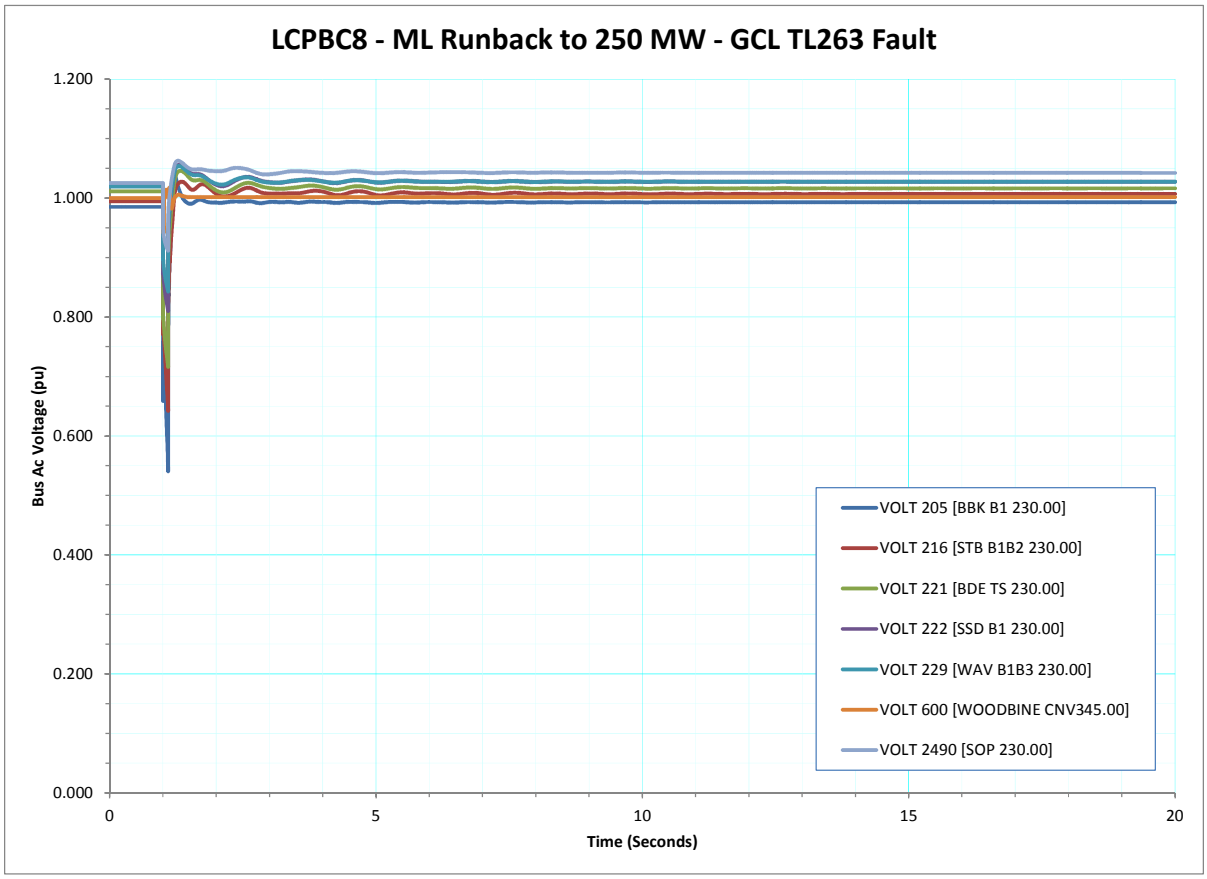

Figure 168 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - Bus Ac Voltage (pu)

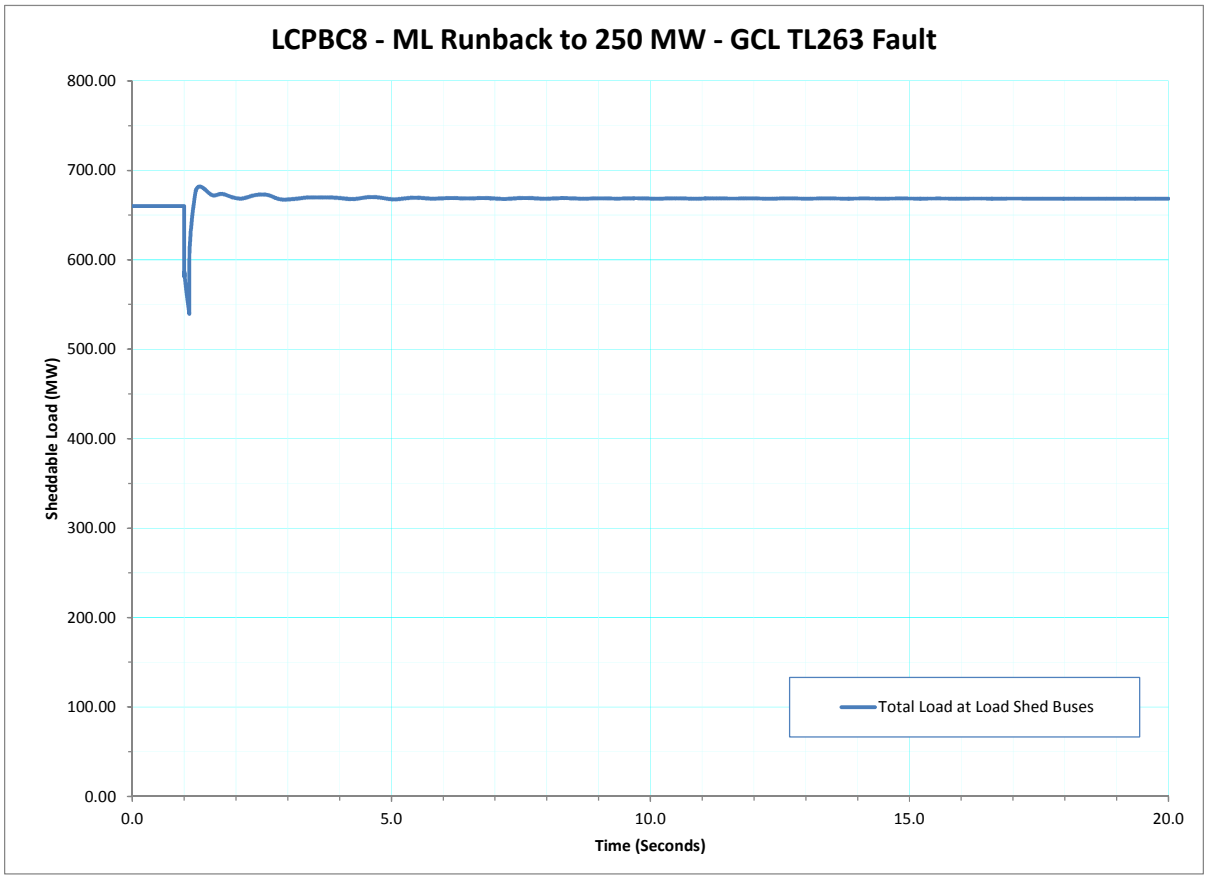

Figure 169 - LCPBC8 - ML Runback to 250 MW - GCL TL263 Fault - Sheddable Load (MW)

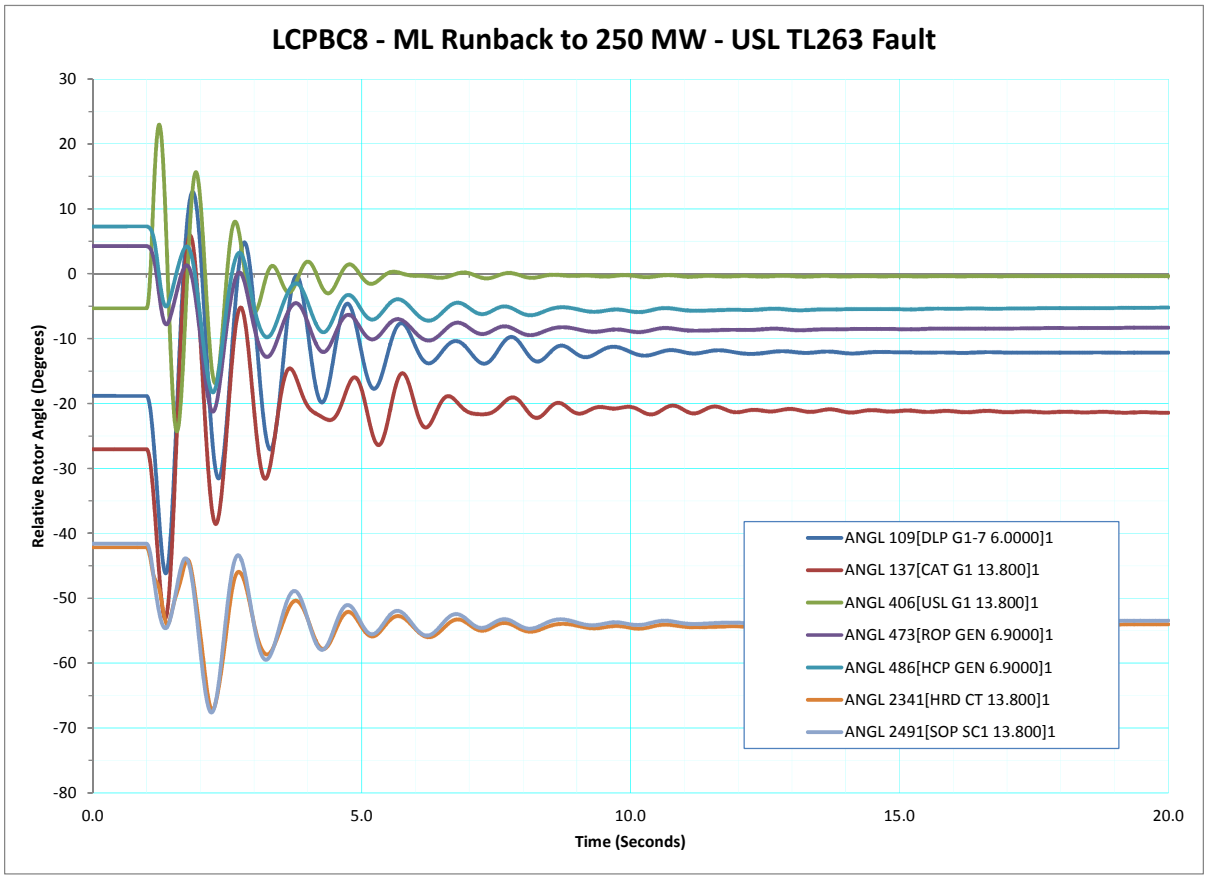

Figure 170 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - Relative Rotor Angle (Degrees)

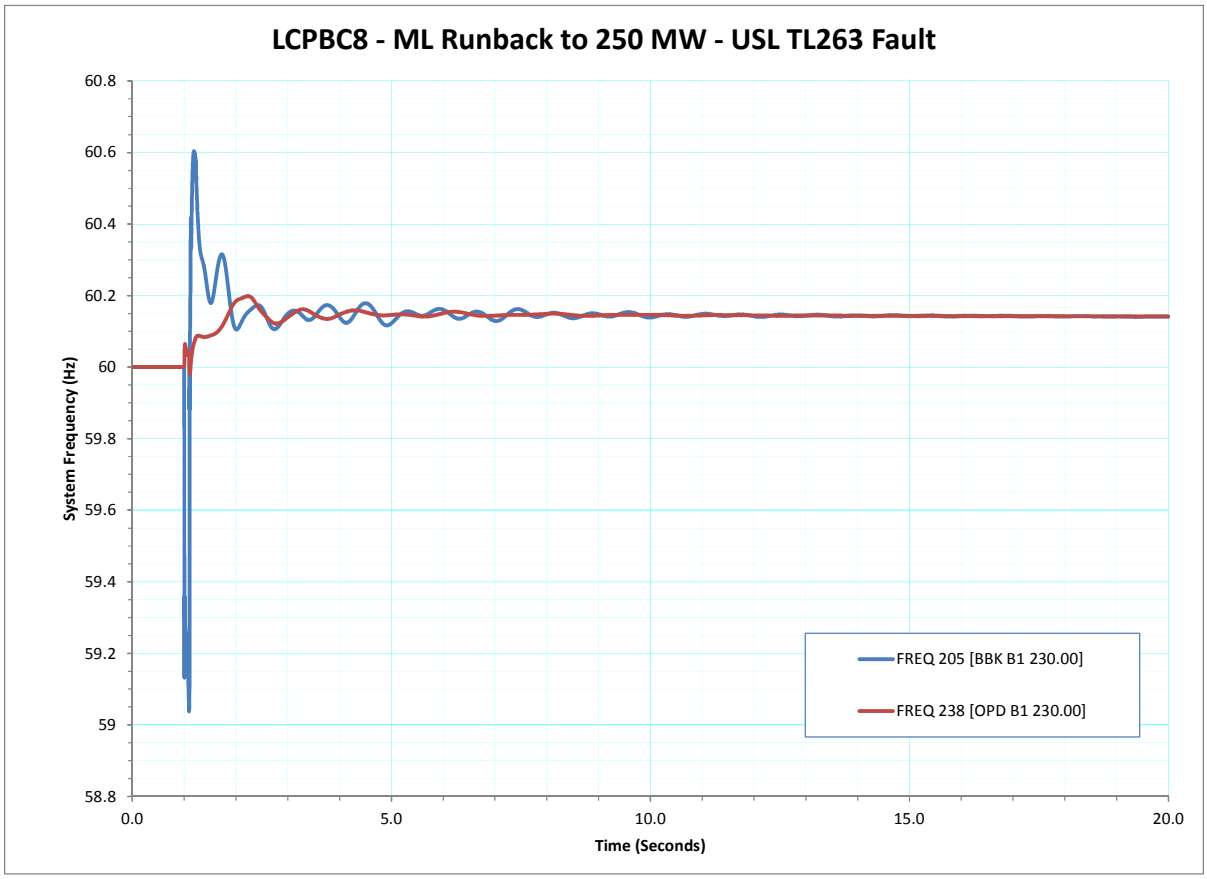

Figure 171 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - System Frequency (Hz)

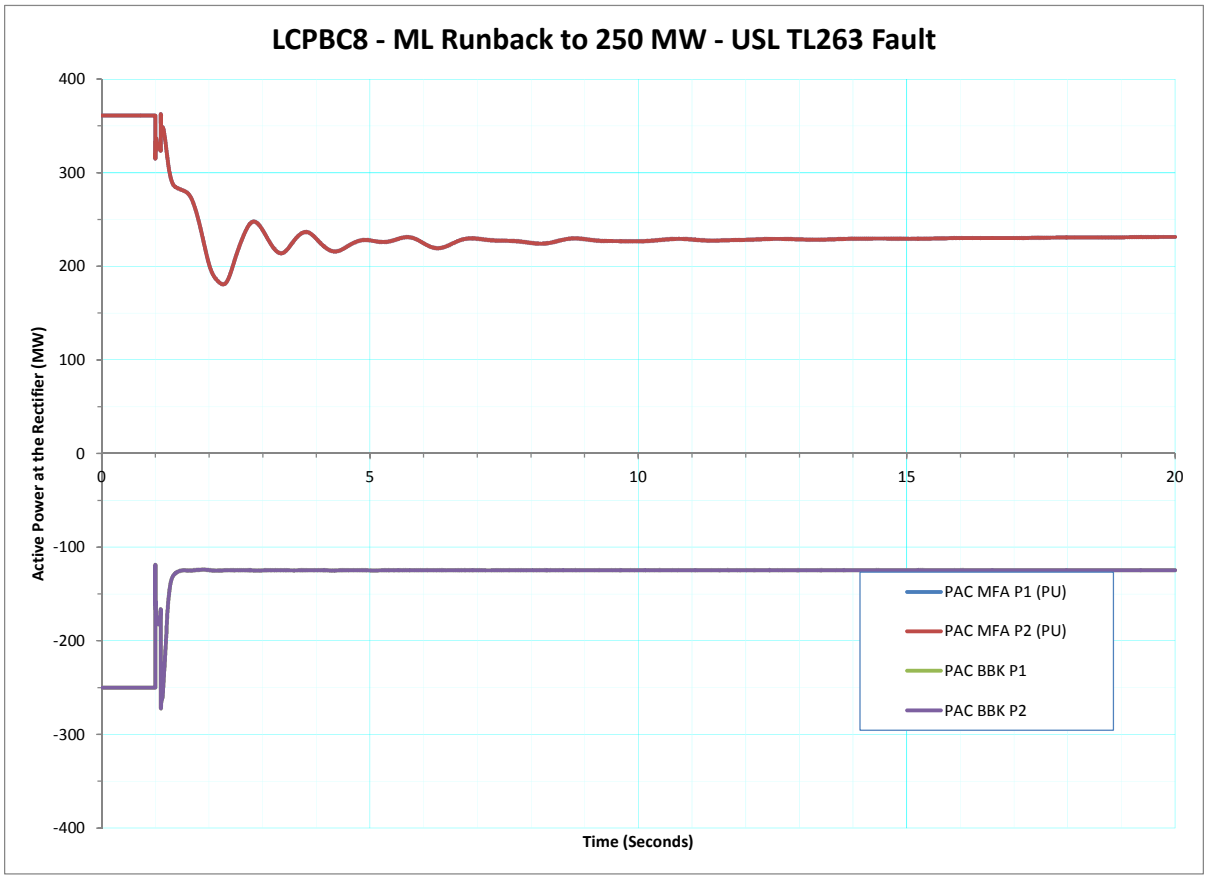

Figure 172 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - Active Power at the Rectifier (MW)

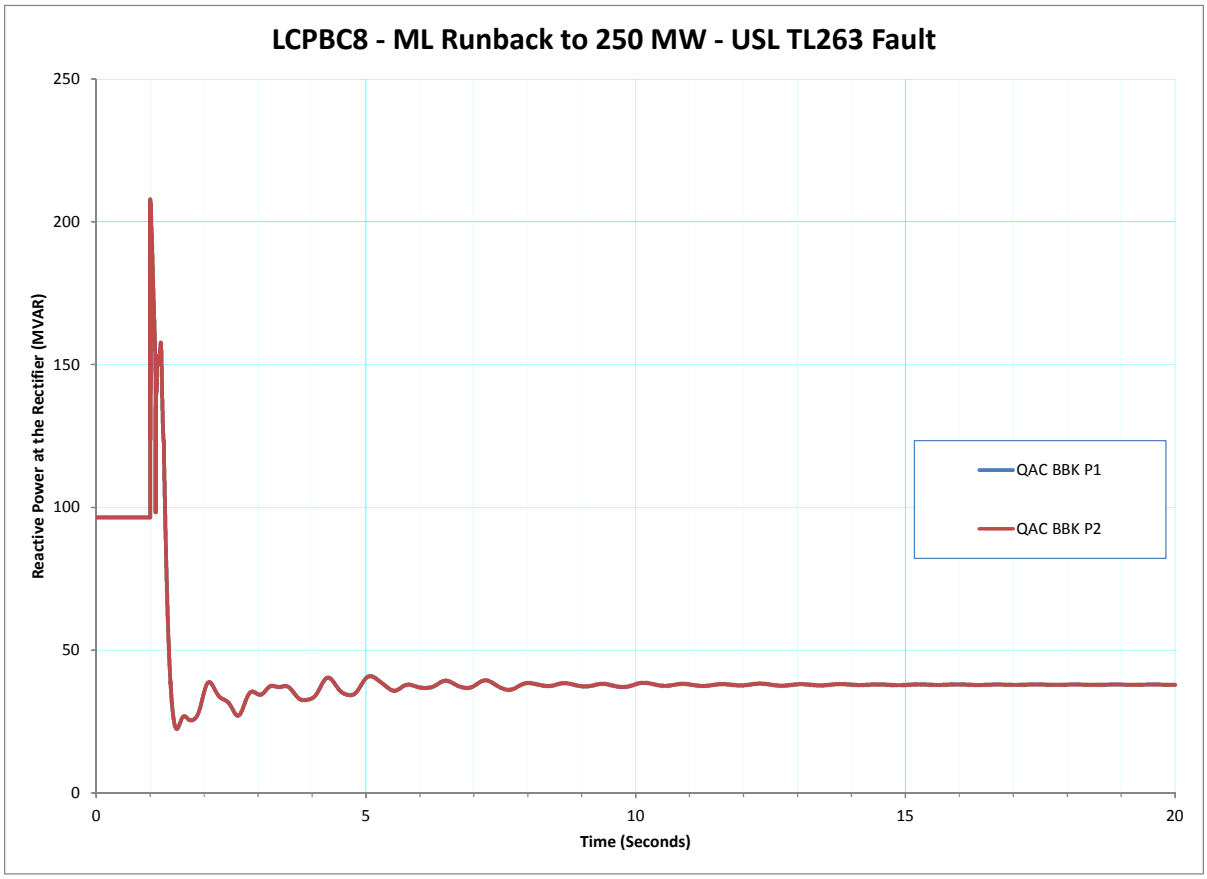

Figure 173 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - Reactive Power at the Rectifier (MVAR)

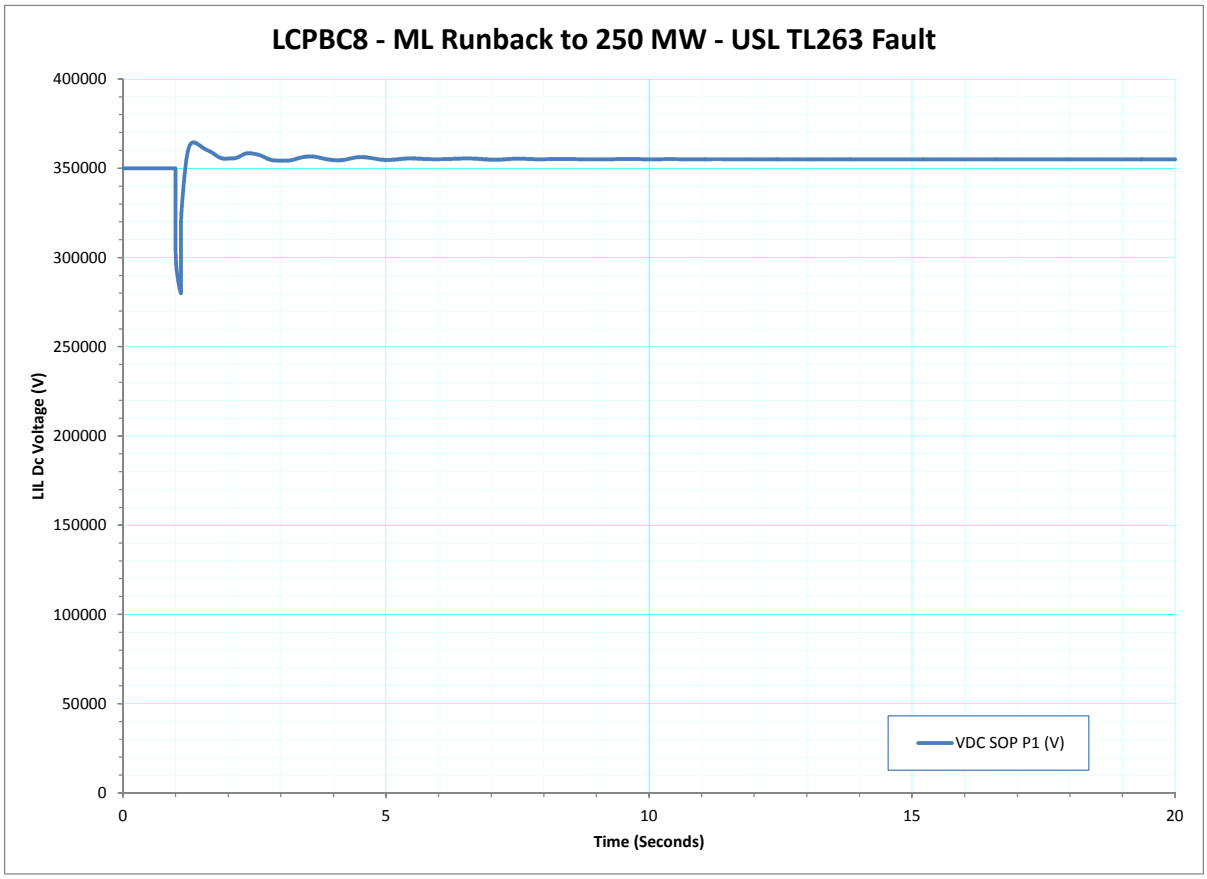

Figure 174 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - LIL Dc Voltage (V)

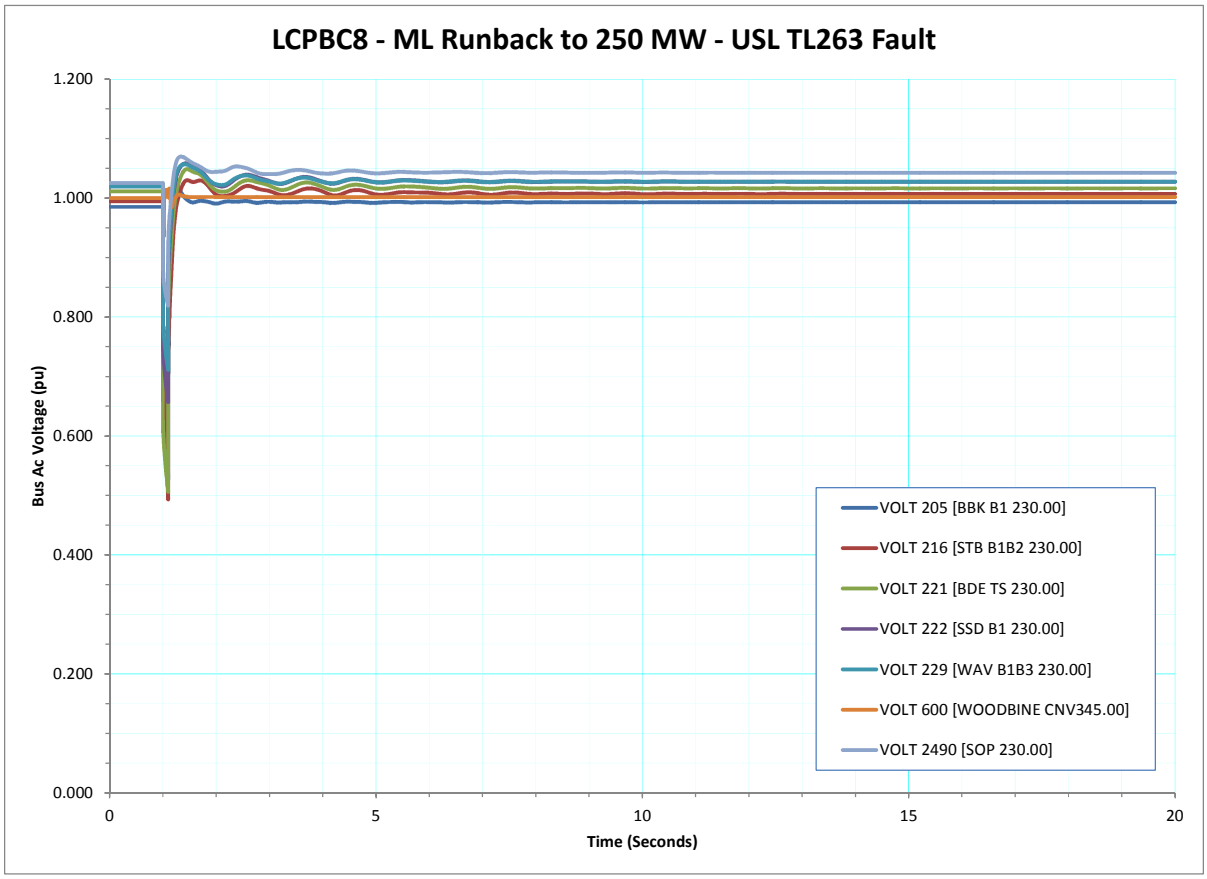

Figure 175 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - Bus Ac Voltage (pu)

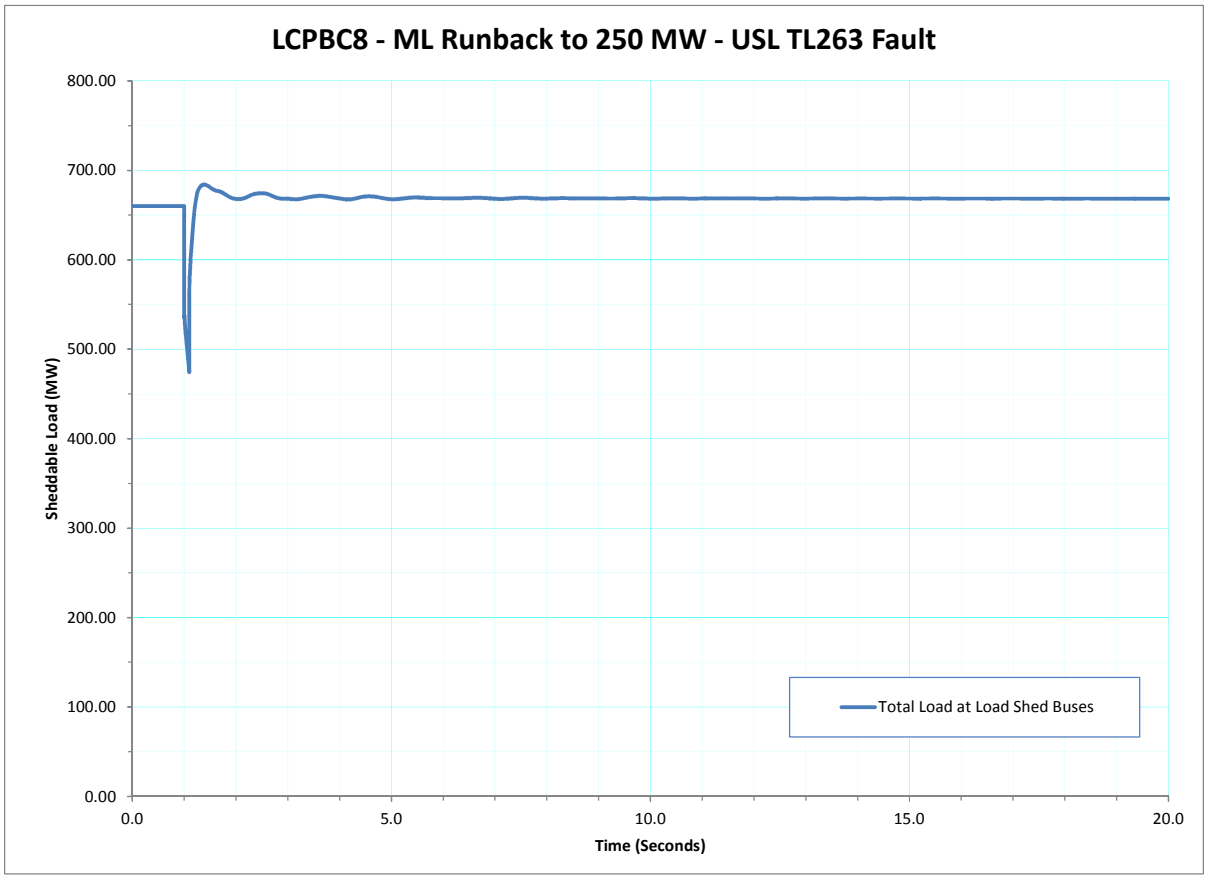

Figure 176 - LCPBC8 - ML Runback to 250 MW - USL TL263 Fault - Sheddable Load (MW)

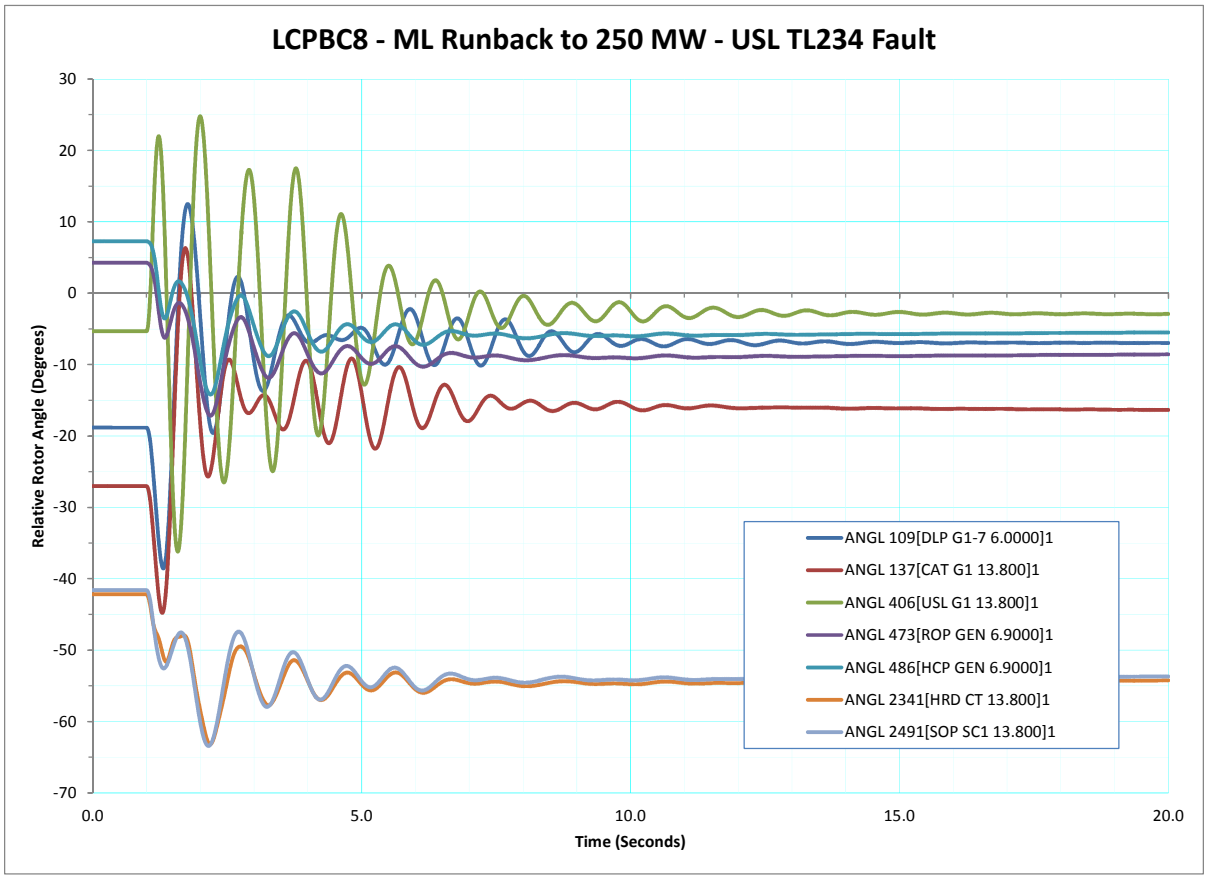

Figure 177 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - Relative Rotor Angle (Degrees)

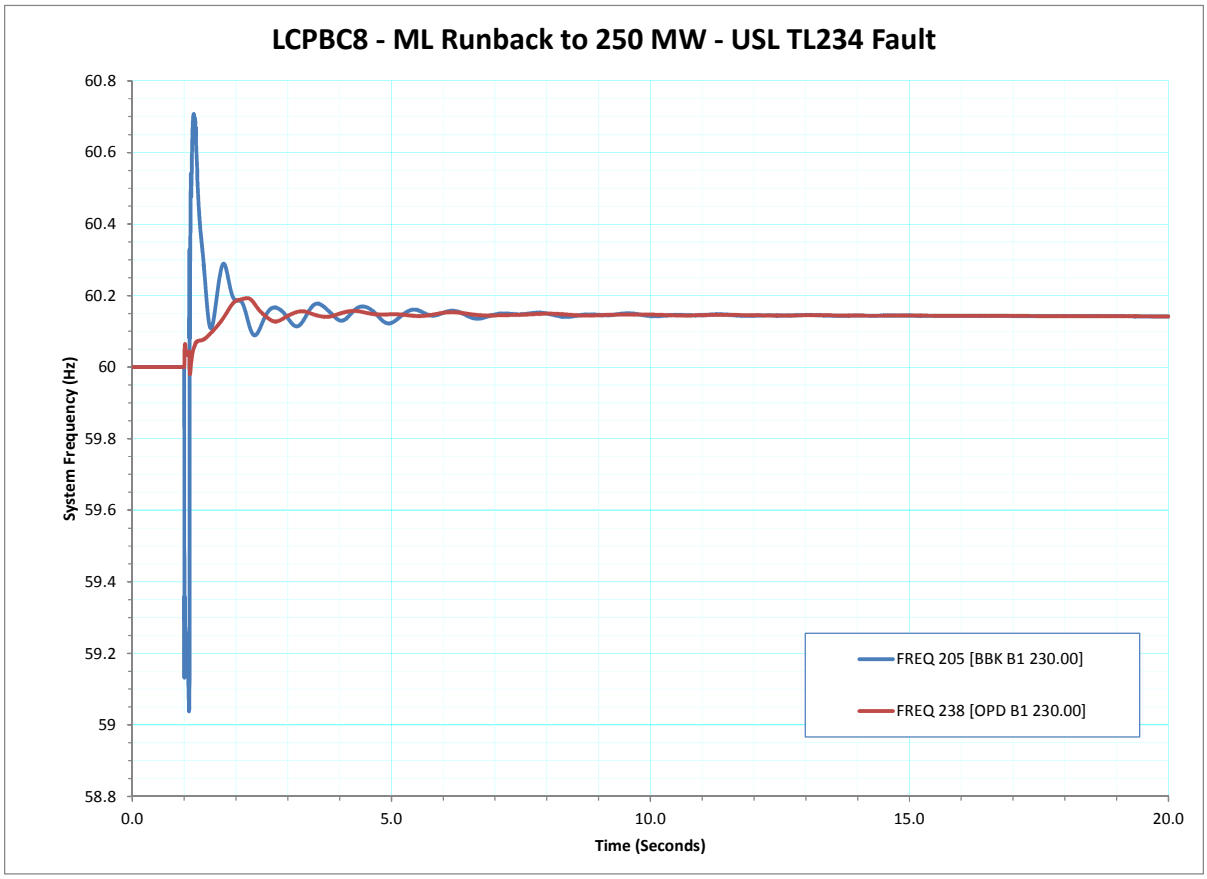

Figure 178 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - System Frequency (Hz)

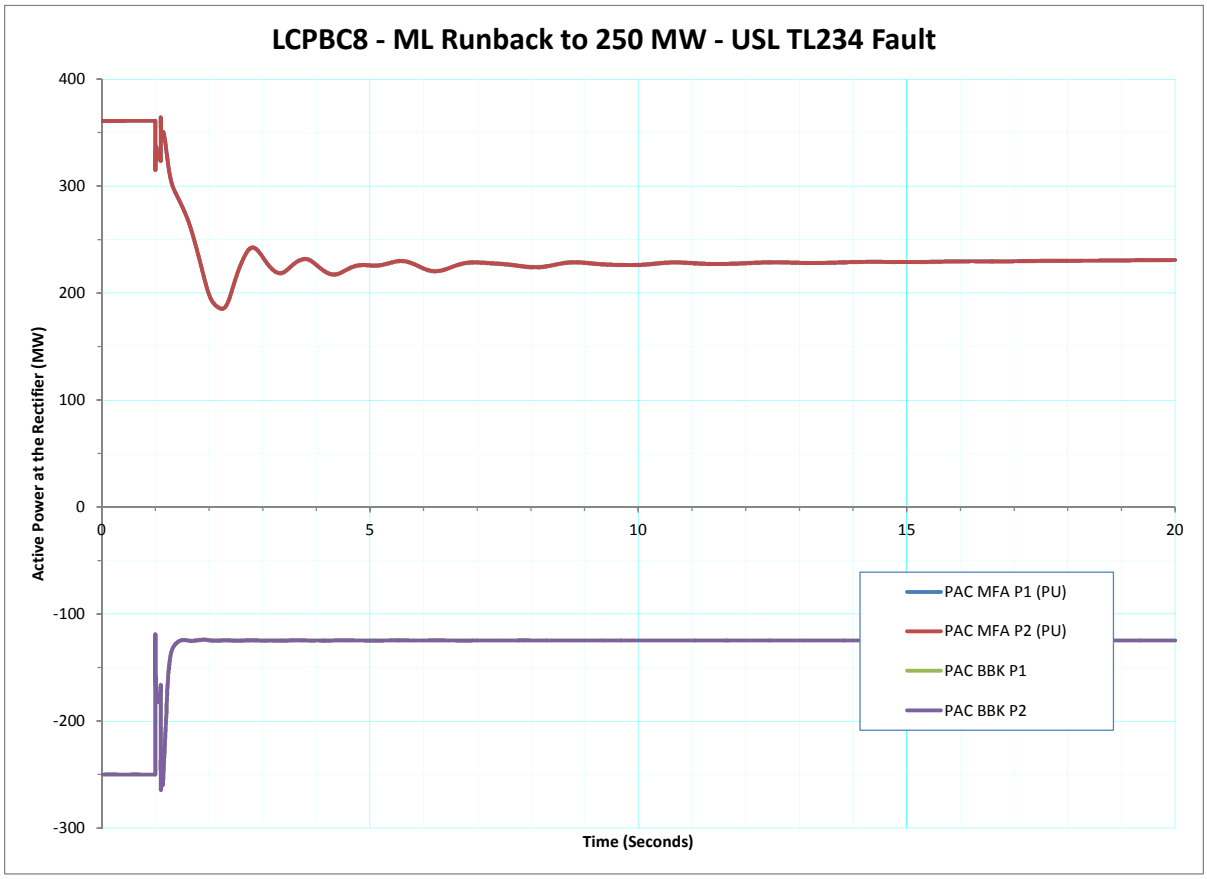

Figure 179 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - Active Power at the Rectifier (MW)

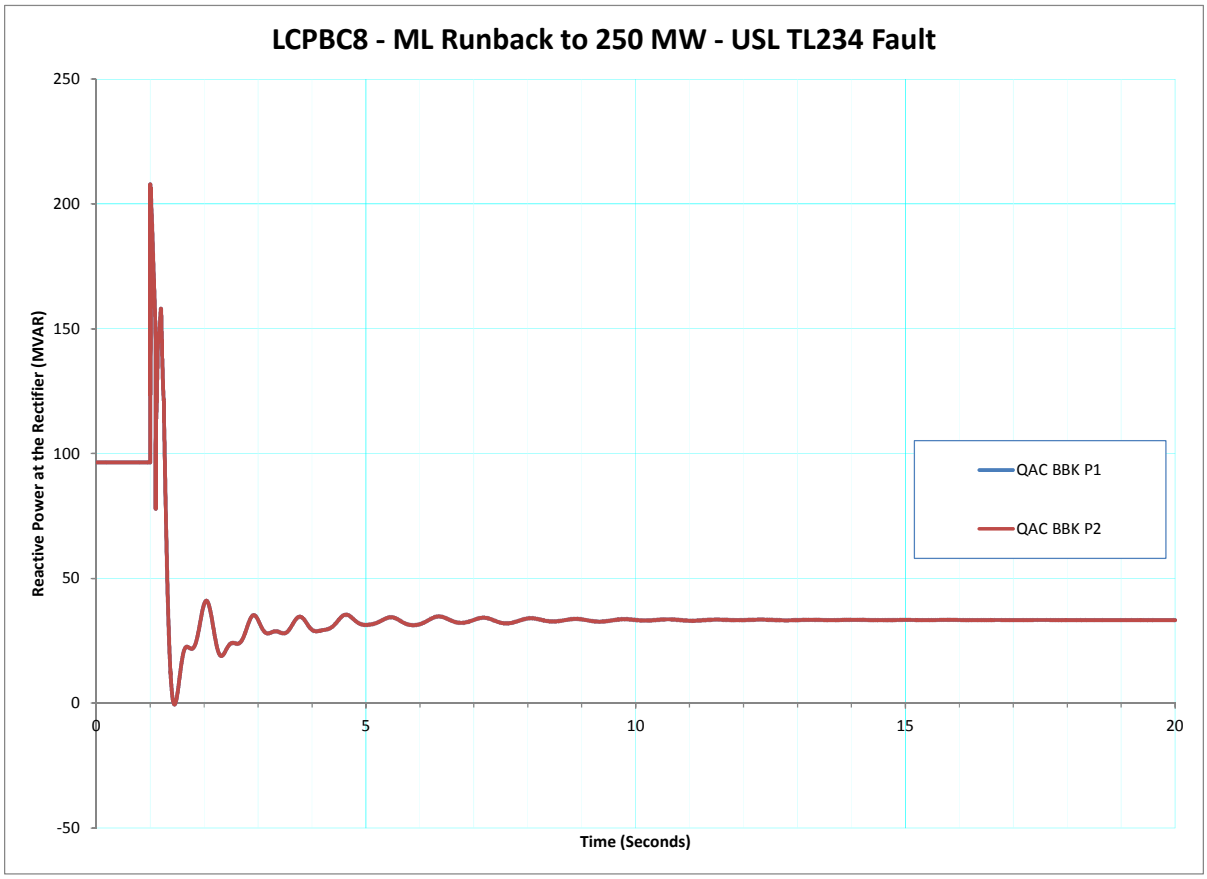

Figure 180 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - Reactive Power at the Rectifier (MVAR)

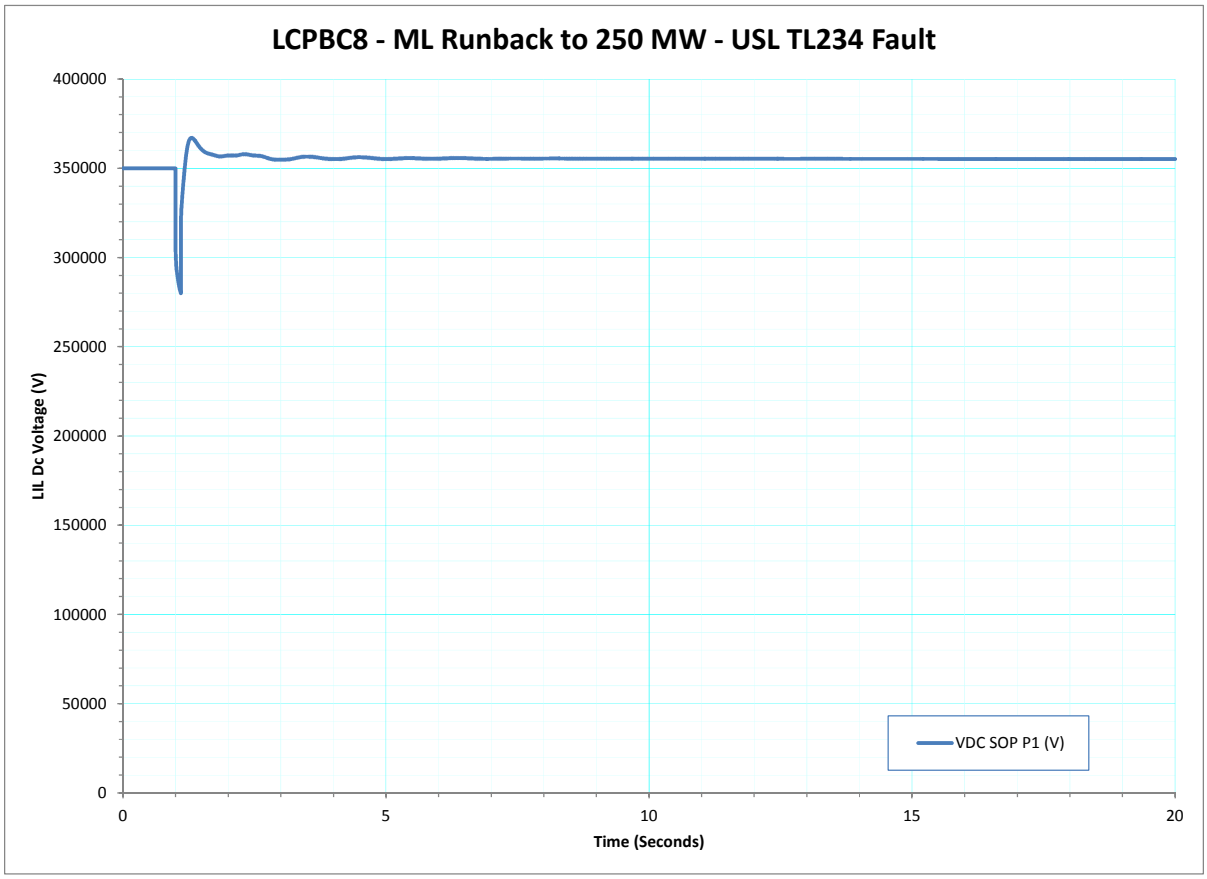

Figure 181 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - LIL Dc Voltage (V)

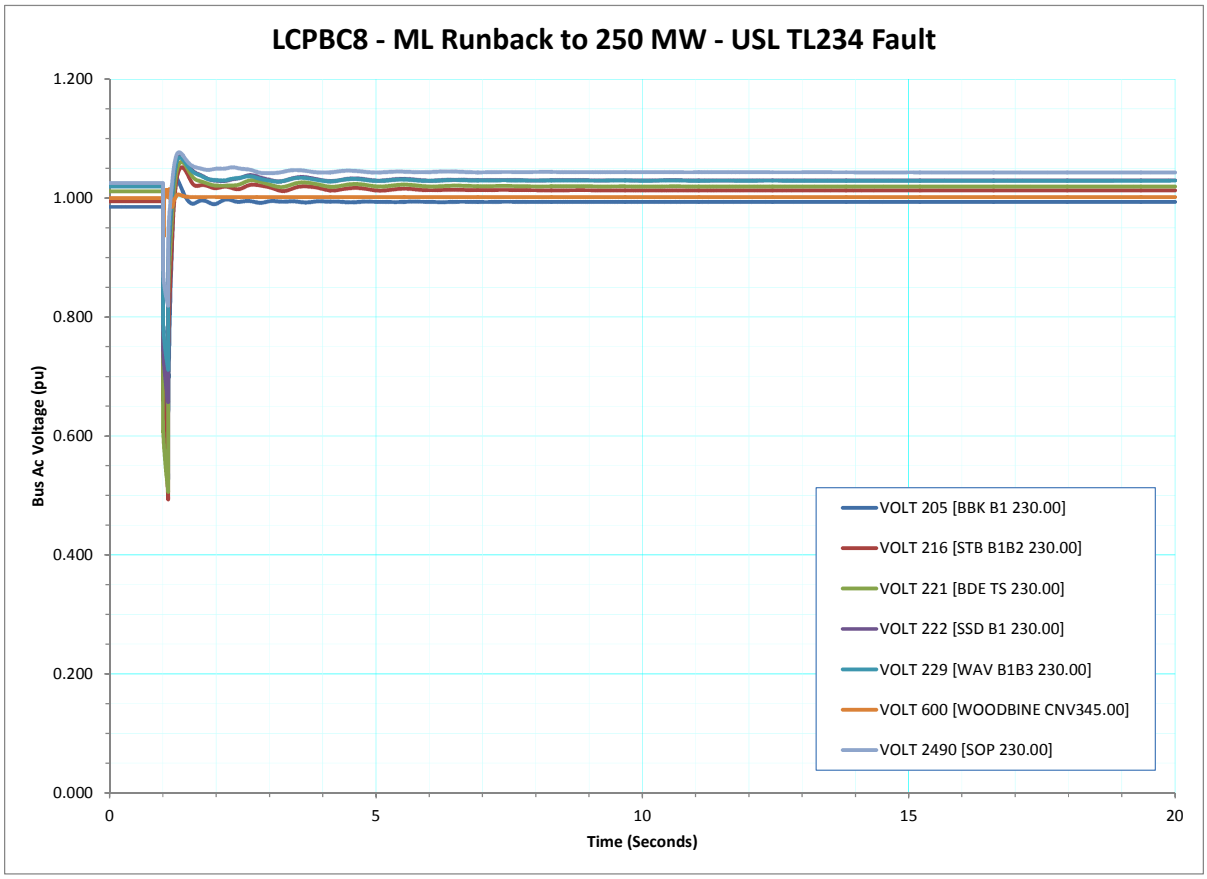

Figure 182 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - Bus Ac Voltage (pu)

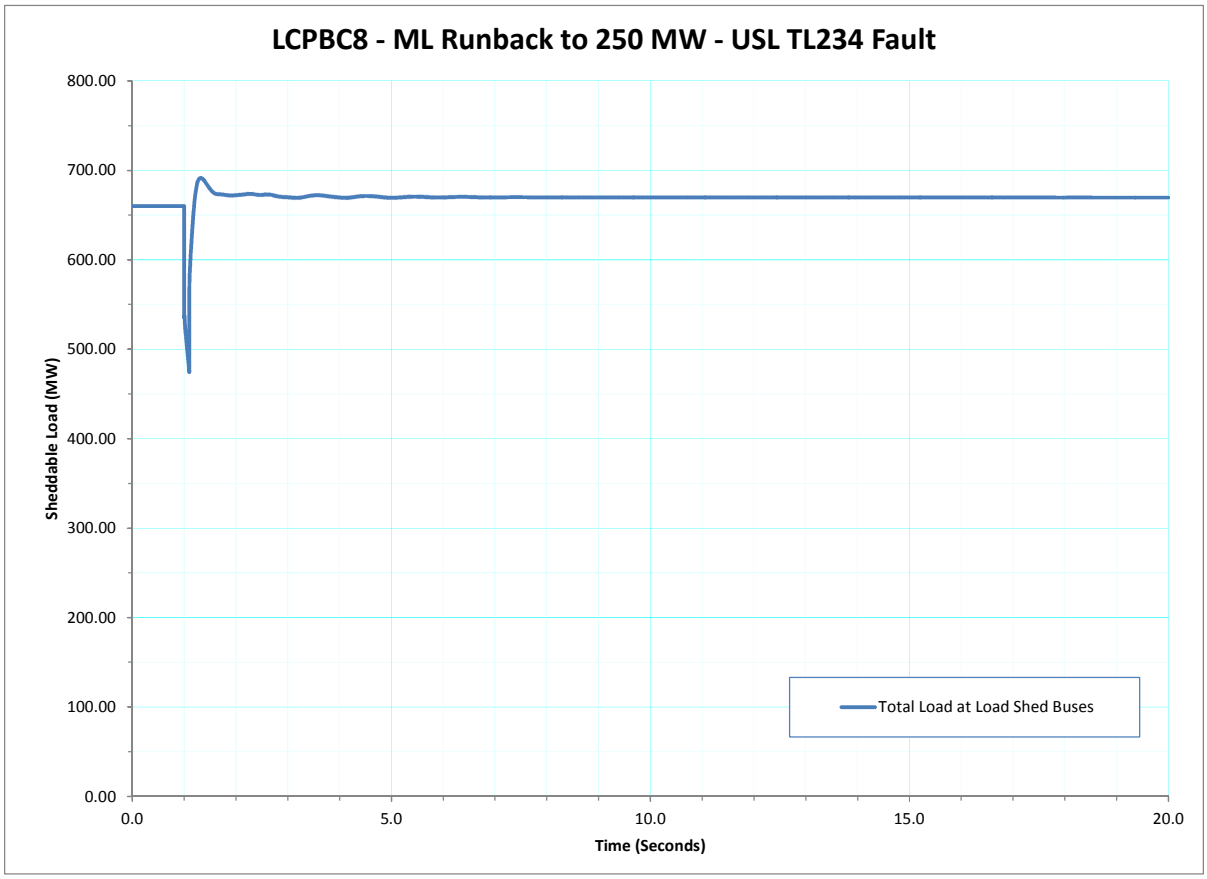

Figure 183 - LCPBC8 - ML Runback to 250 MW - USL TL234 Fault - Sheddable Load (MW)

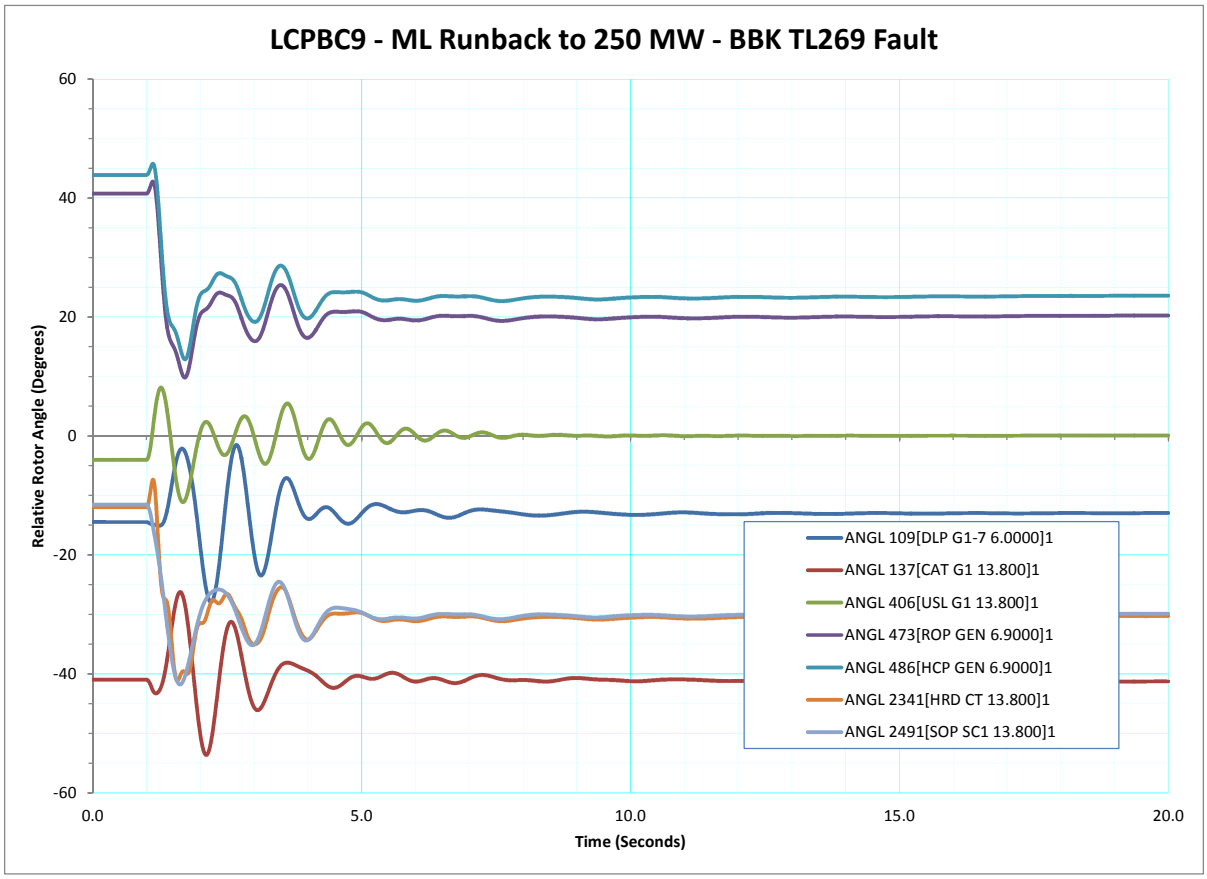

Figure 184 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - Relative Rotor Angle (Degrees)

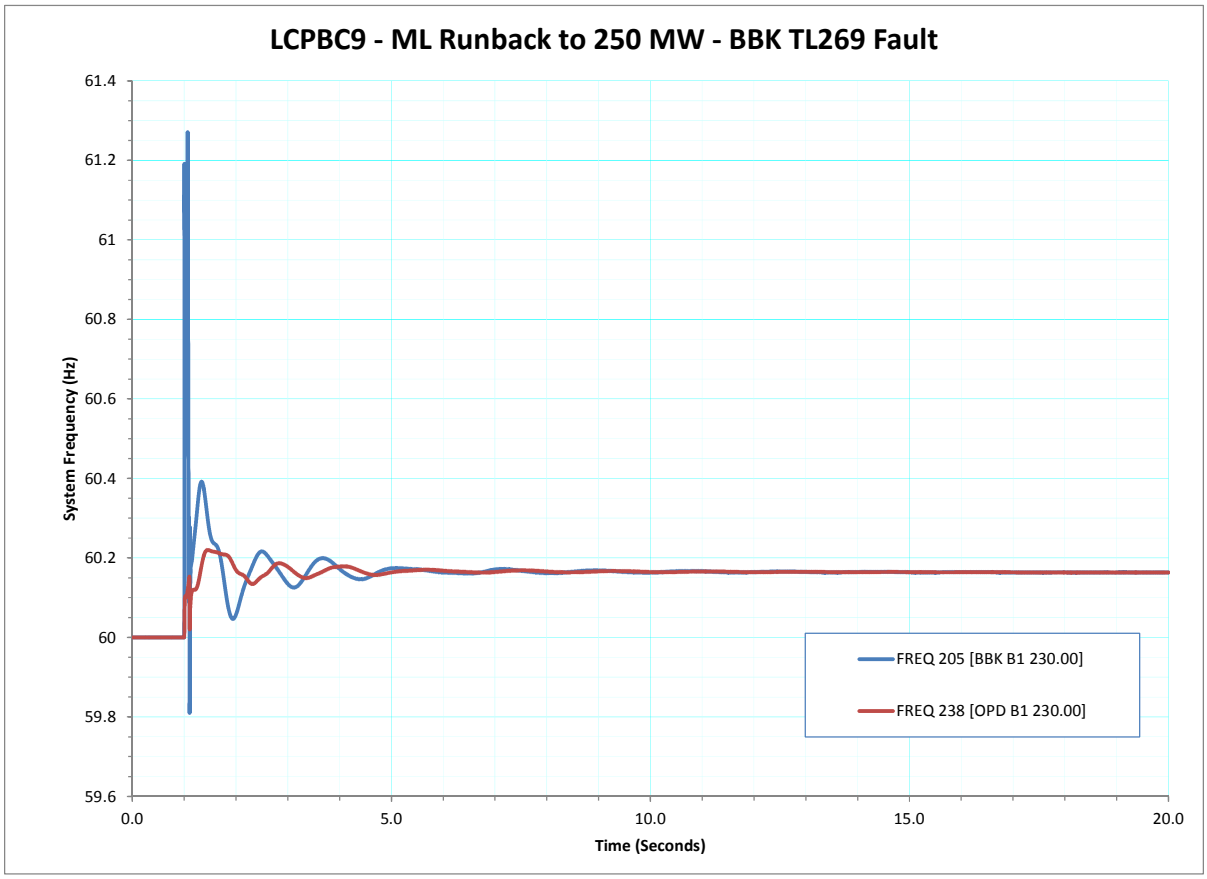

Figure 185 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - System Frequency (Hz)

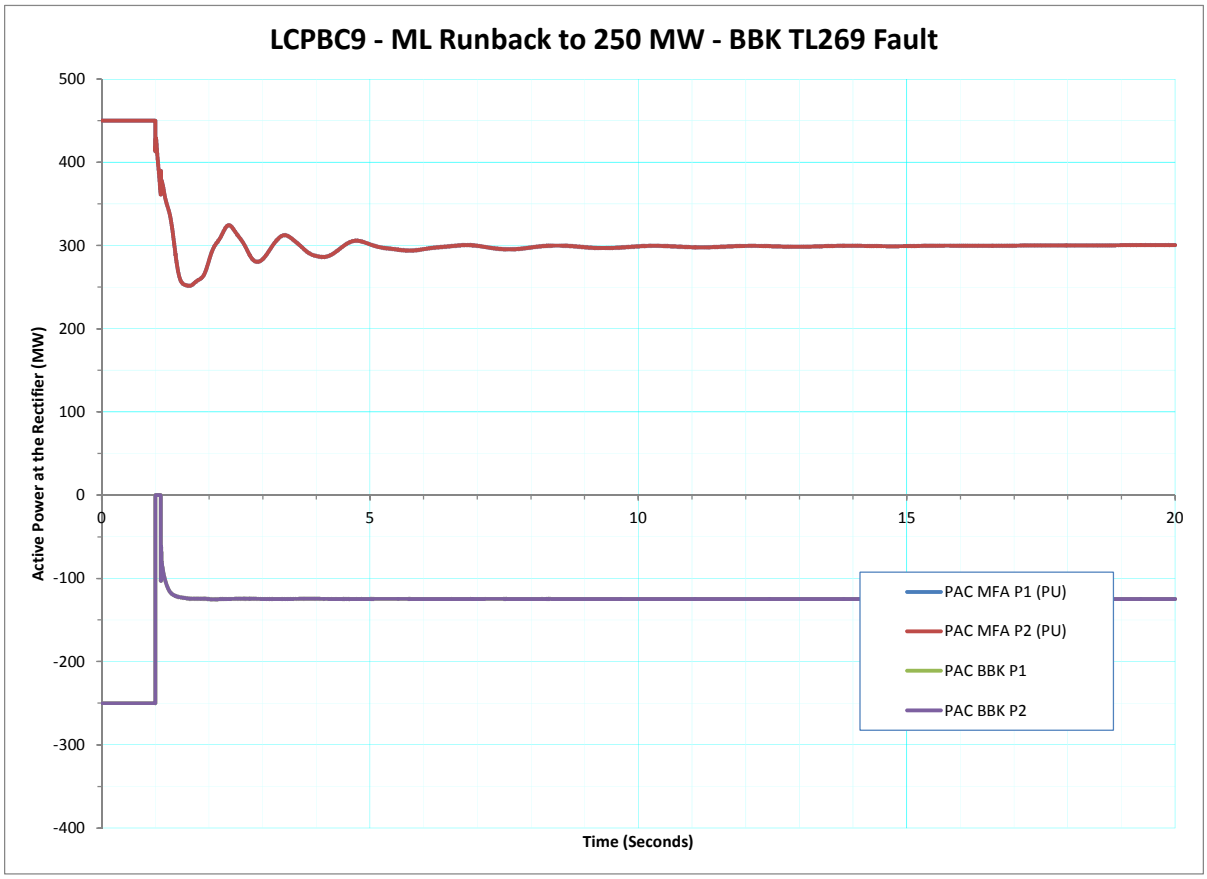

Figure 186 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - Active Power at the Rectifier (MW)

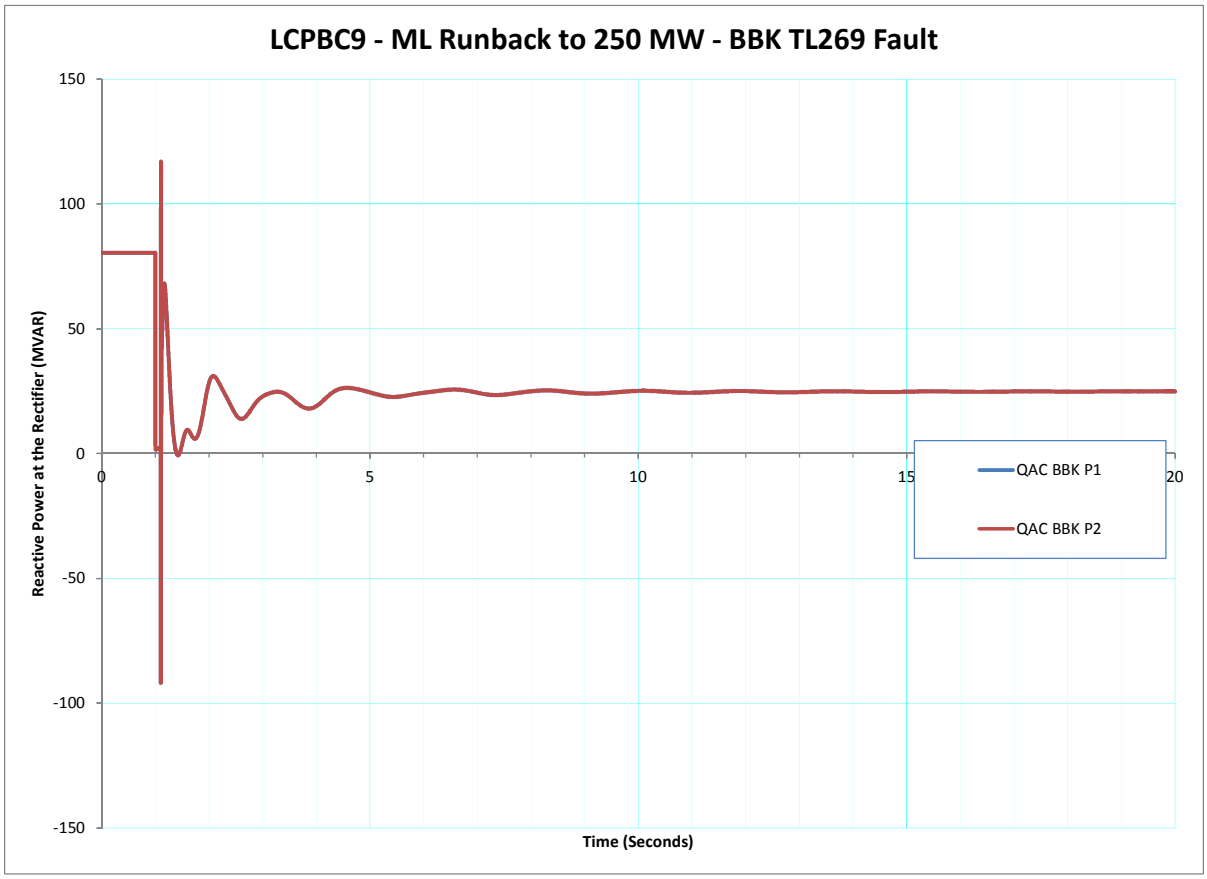

Figure 187 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - Reactive Power at the Rectifier (MVAR)

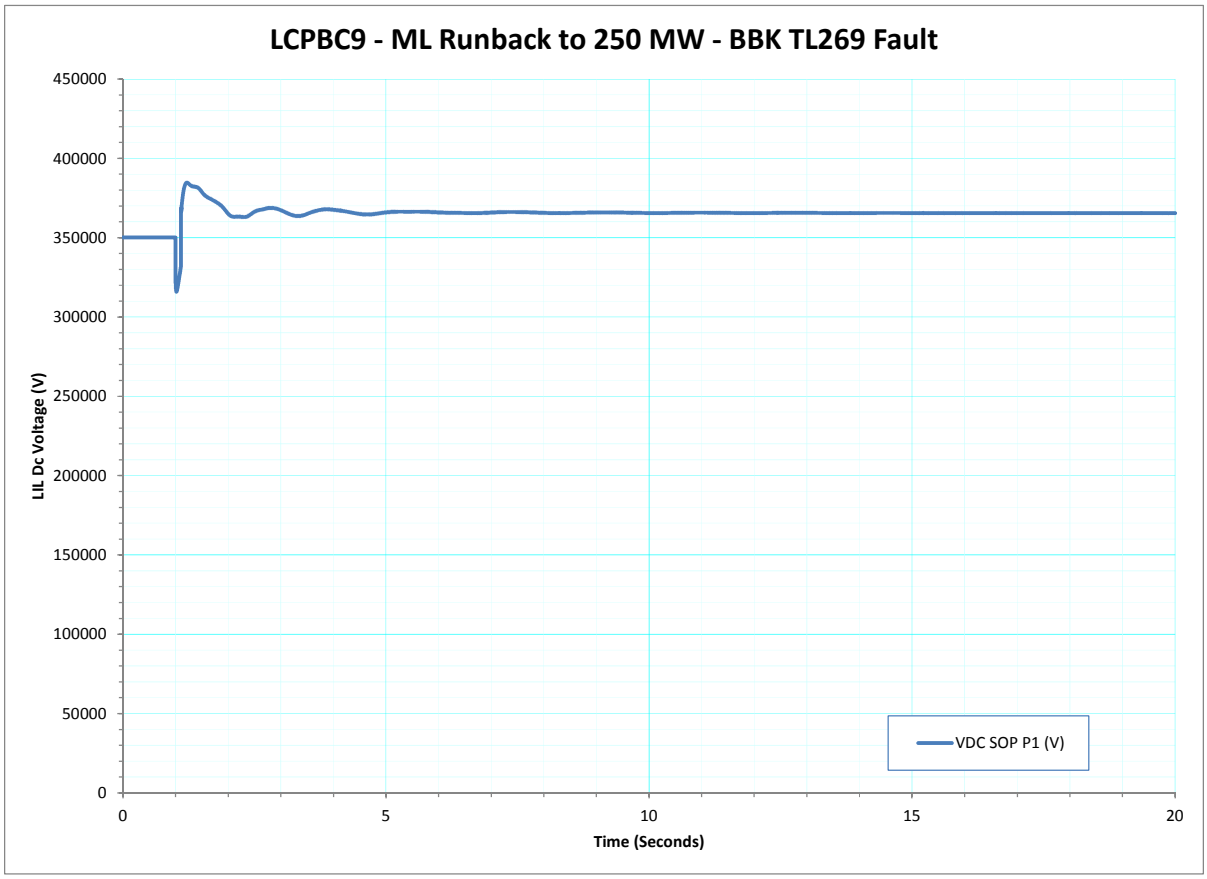

Figure 188 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - LIL Dc Voltage (V)

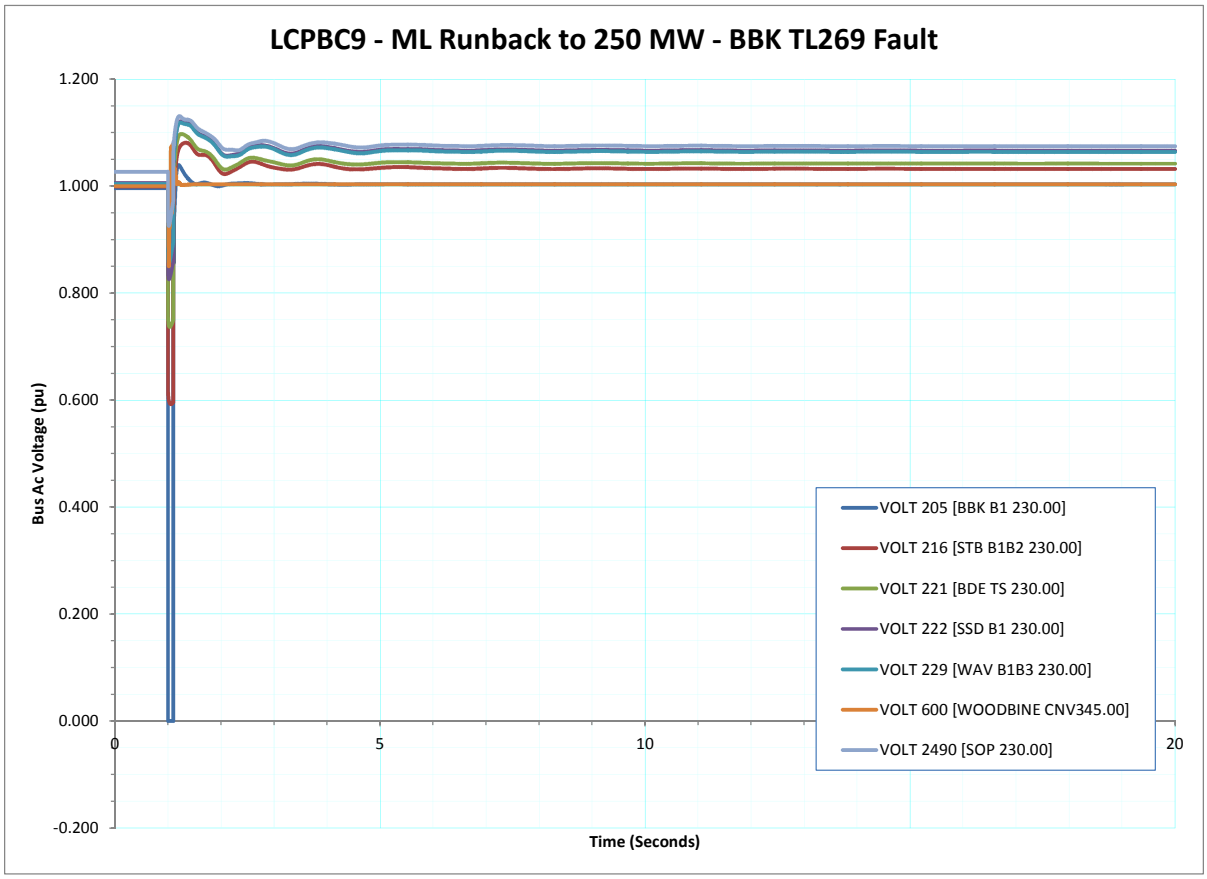

Figure 189 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - Bus Ac Voltage (pu)

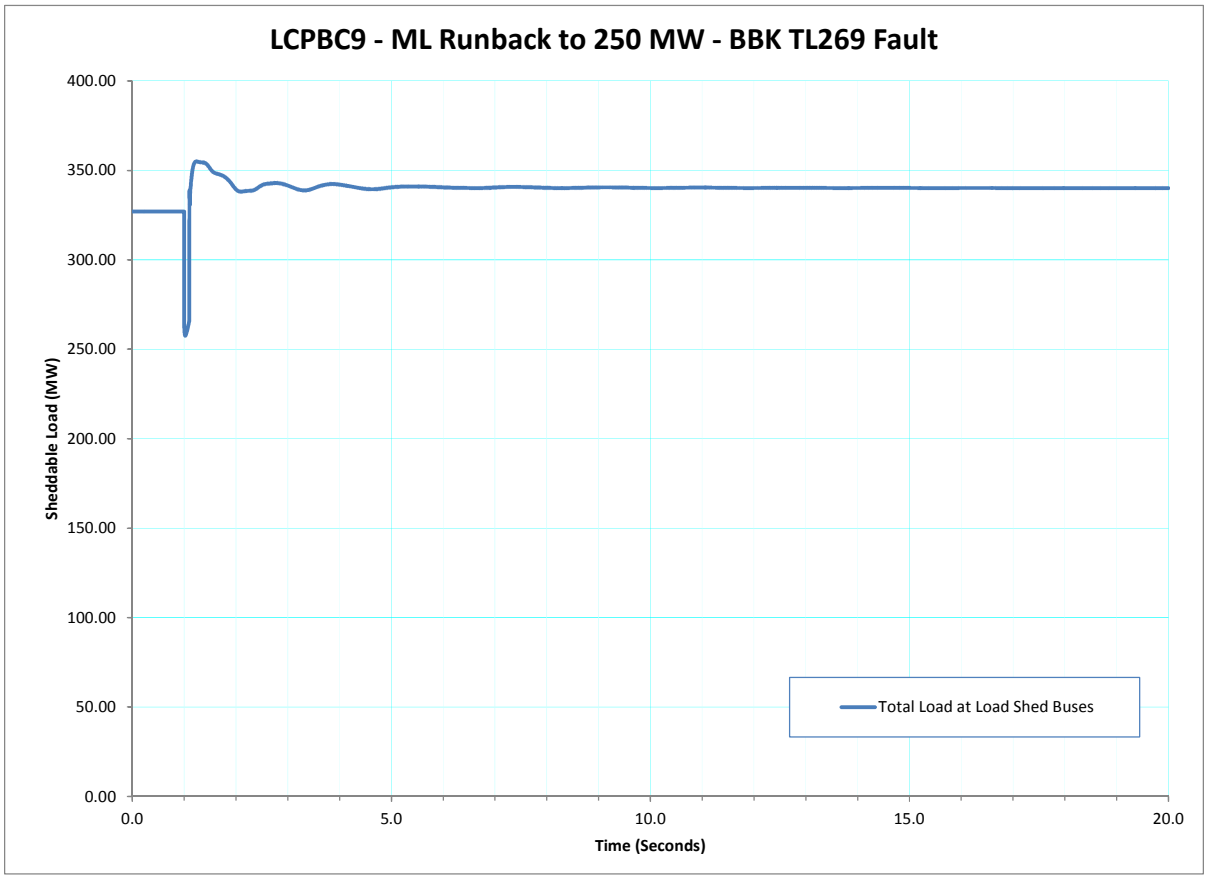
LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Sheddable Load (MW)
0.0
5.0
10.0
15.0
20.0
Time (Seconds)
Total Load at Load Shed Buses

Figure 190 - LCPBC9 - ML Runback to 250 MW - BBK TL269 Fault - Sheddable Load (MW)

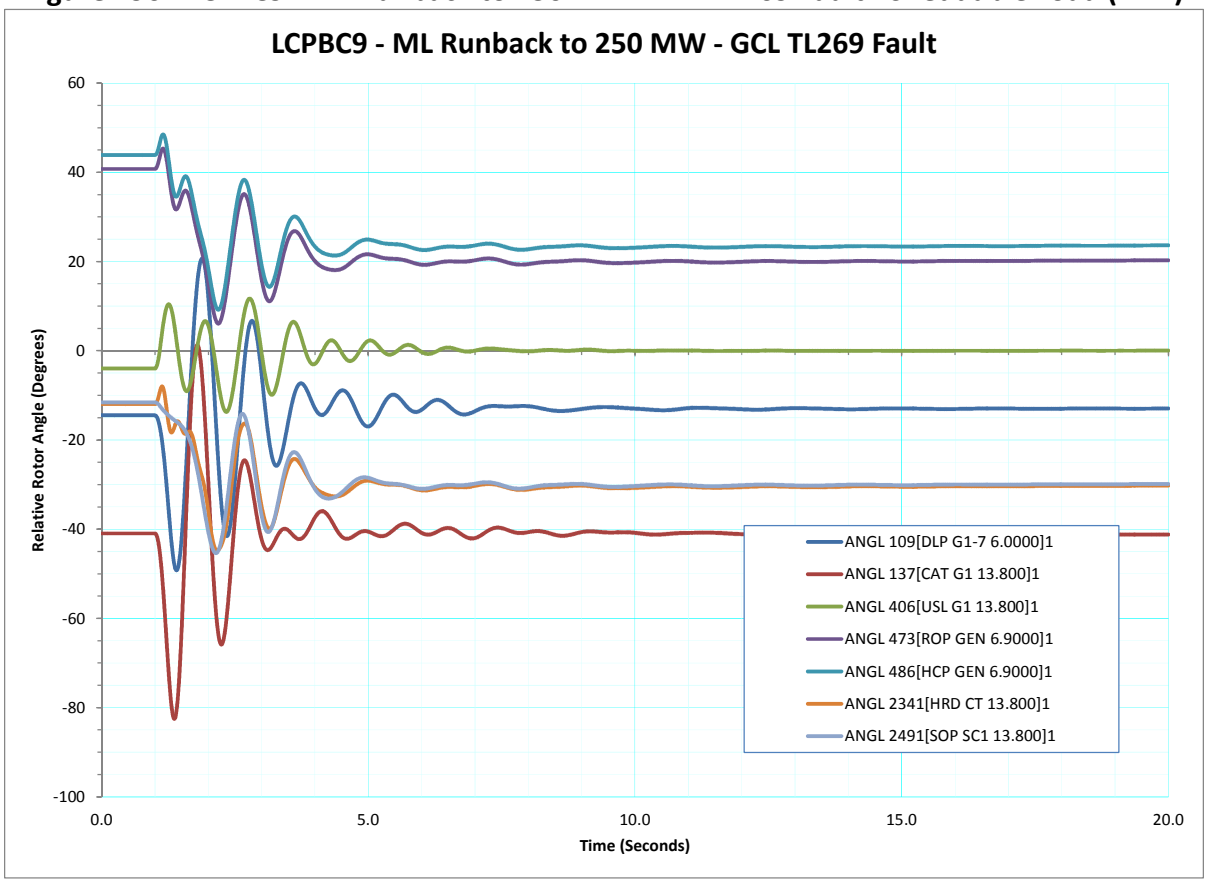

Figure 191 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - Relative Rotor Angle (Degrees)

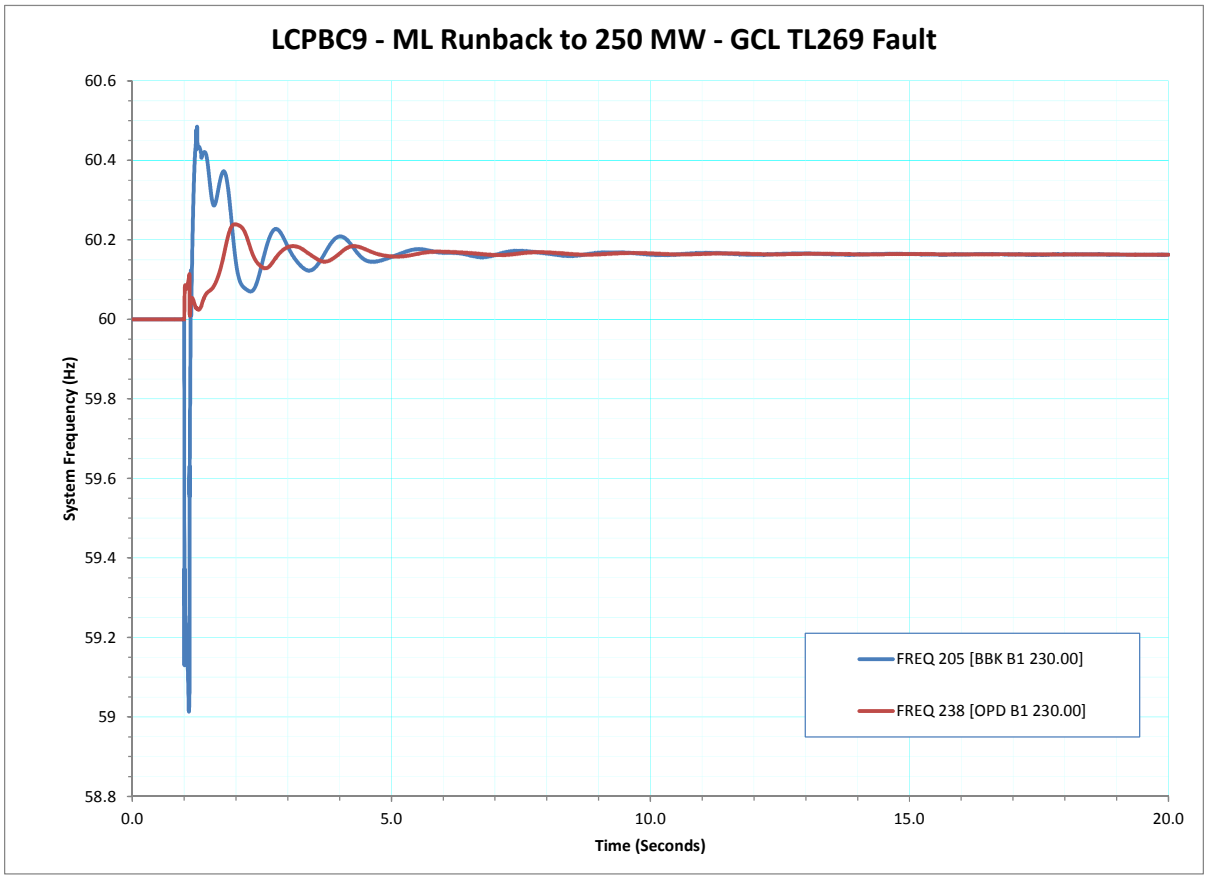

Figure 192 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - System Frequency (Hz)

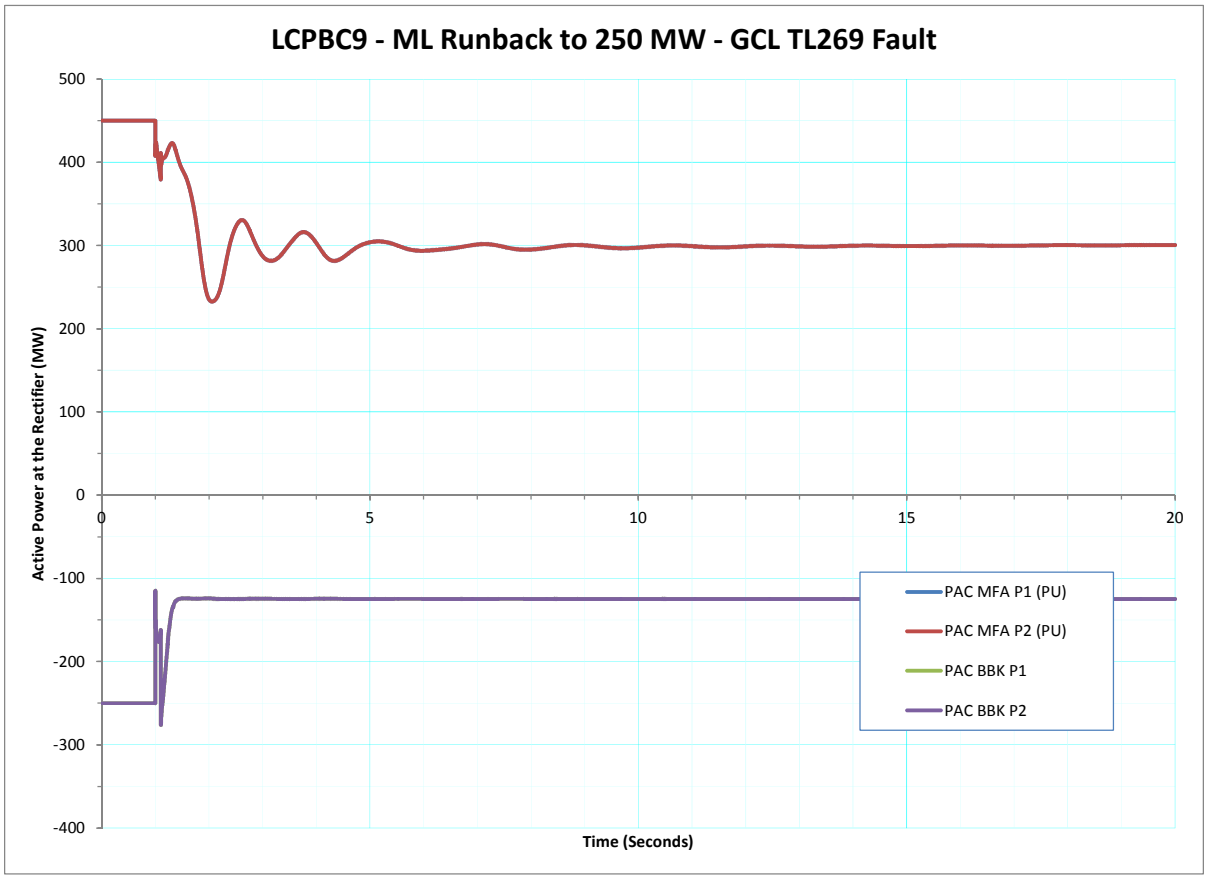

Figure 193 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - Active Power at the Rectifier (MW)

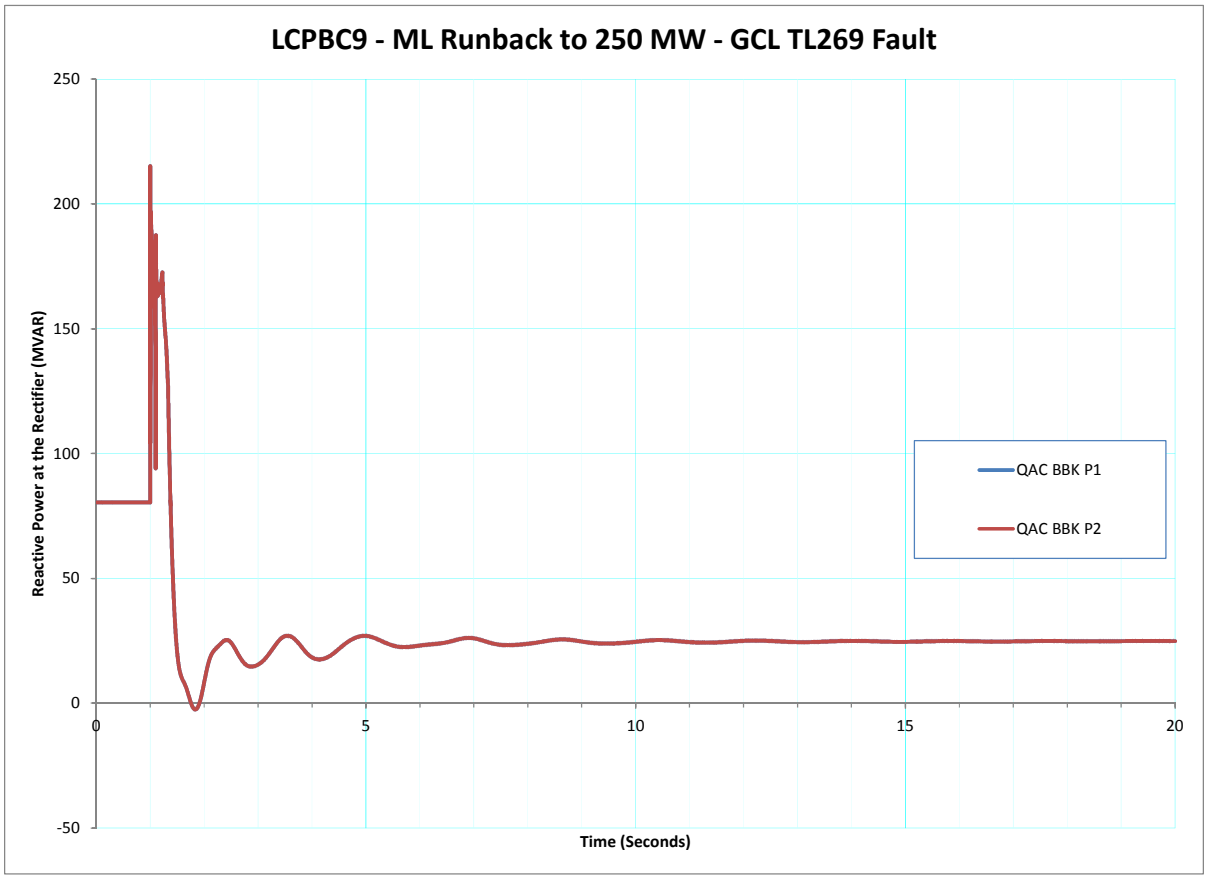

Figure 194 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - Reactive Power at the Rectifier (MVAR)

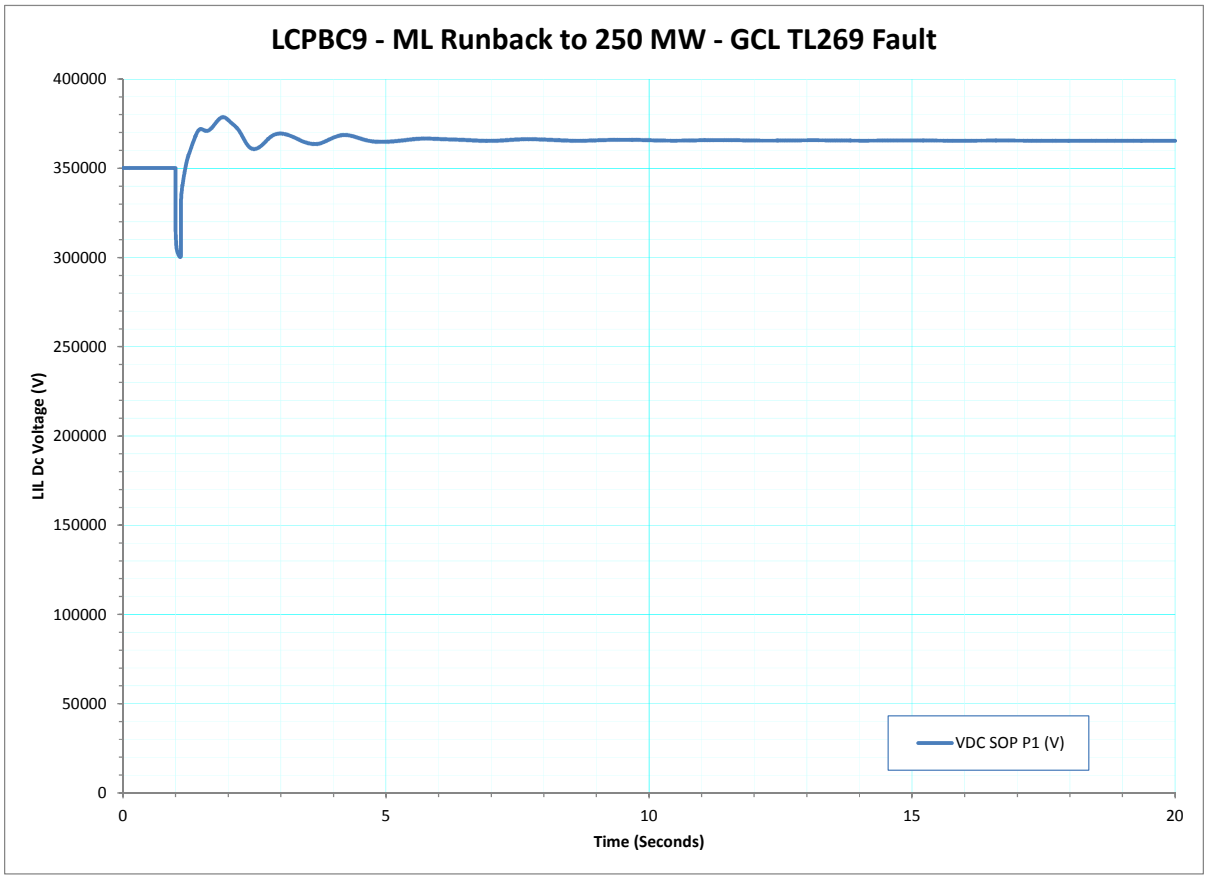

Figure 195 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - LIL Dc Voltage (V)

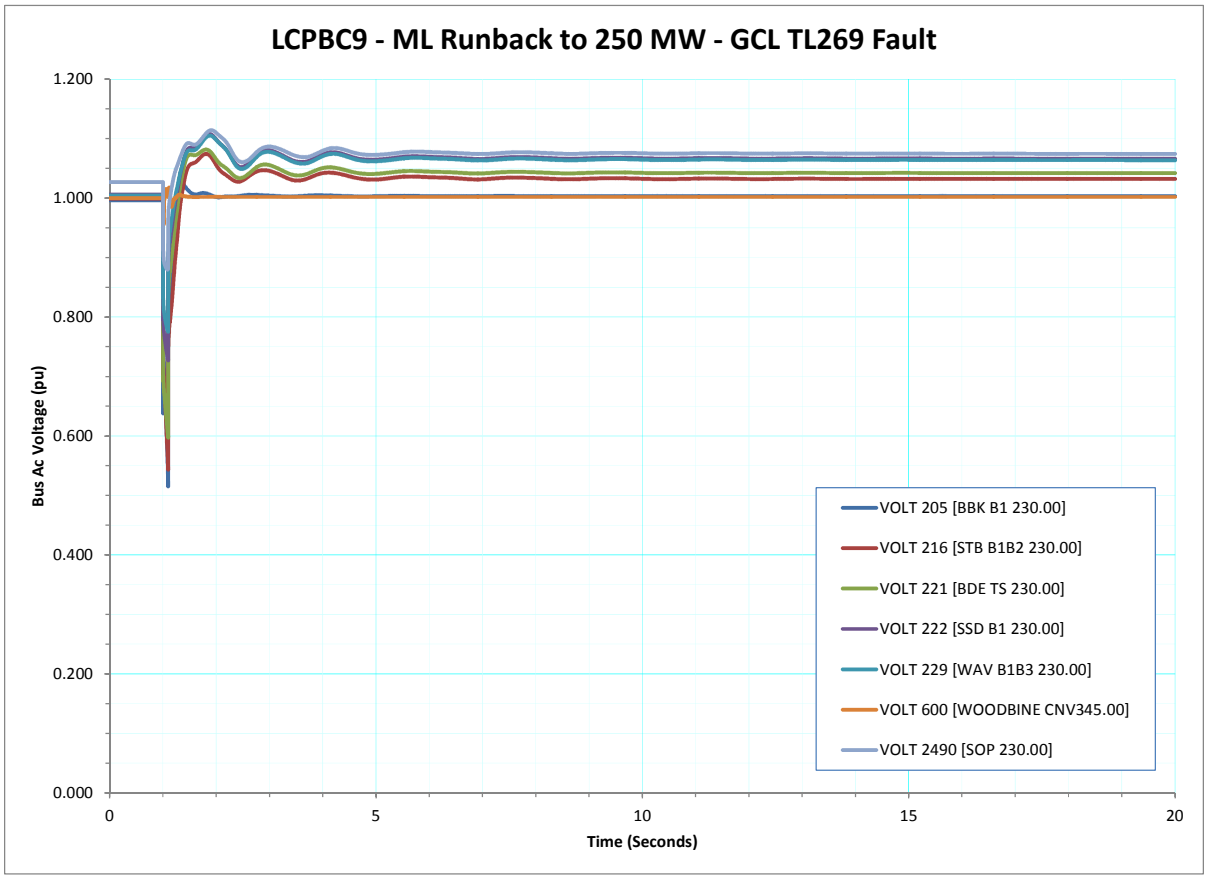

Figure 196 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - Bus Ac Voltage (pu)

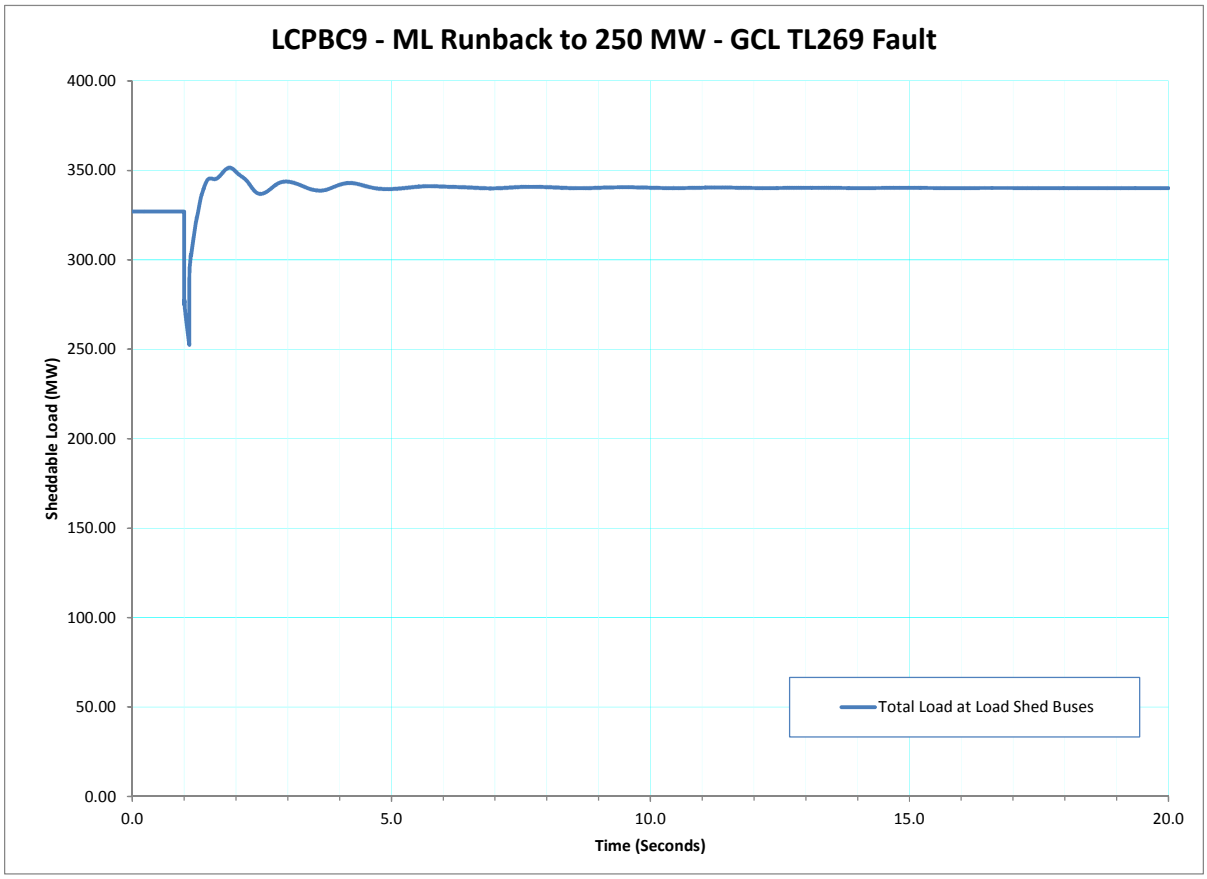

Figure 197 - LCPBC9 - ML Runback to 250 MW - GCL TL269 Fault - Sheddable Load (MW)

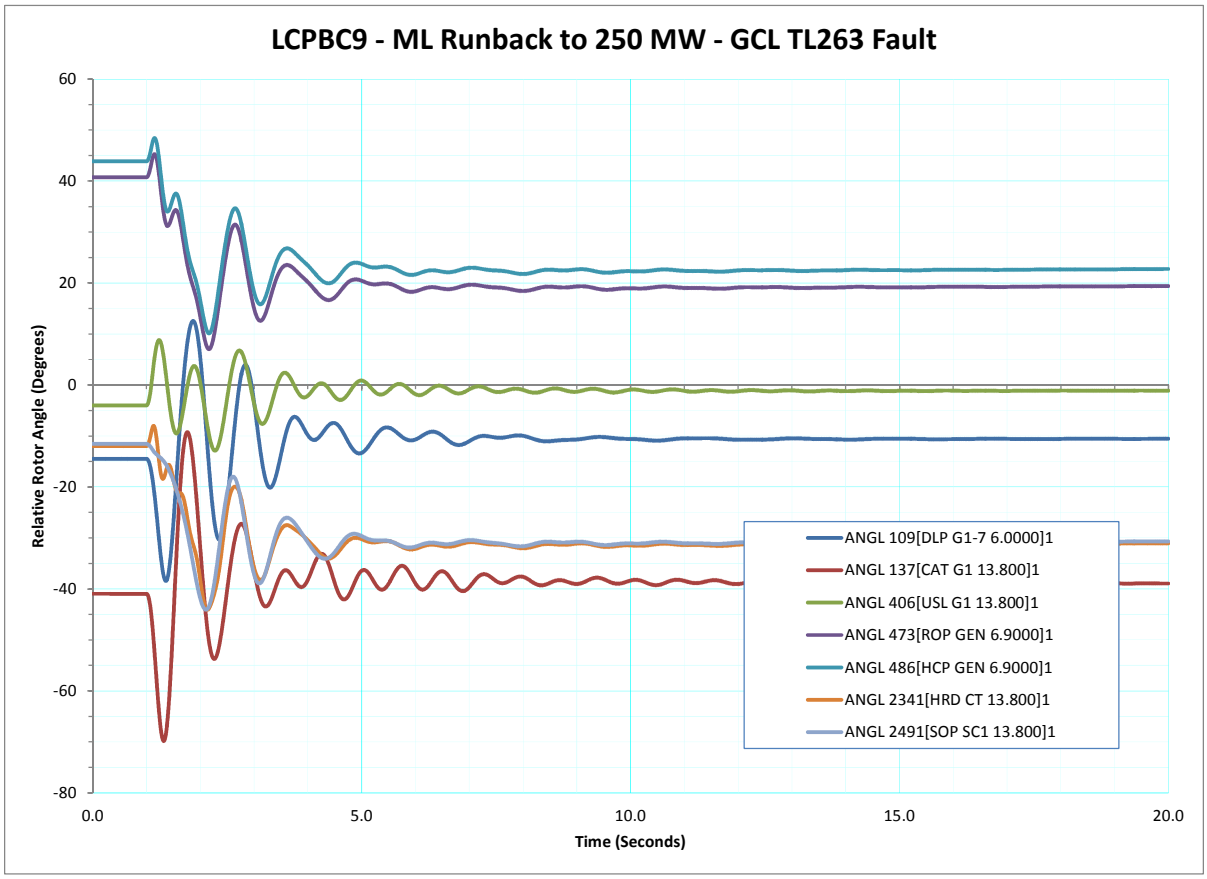

Figure 198 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - Relative Rotor Angle (Degrees)

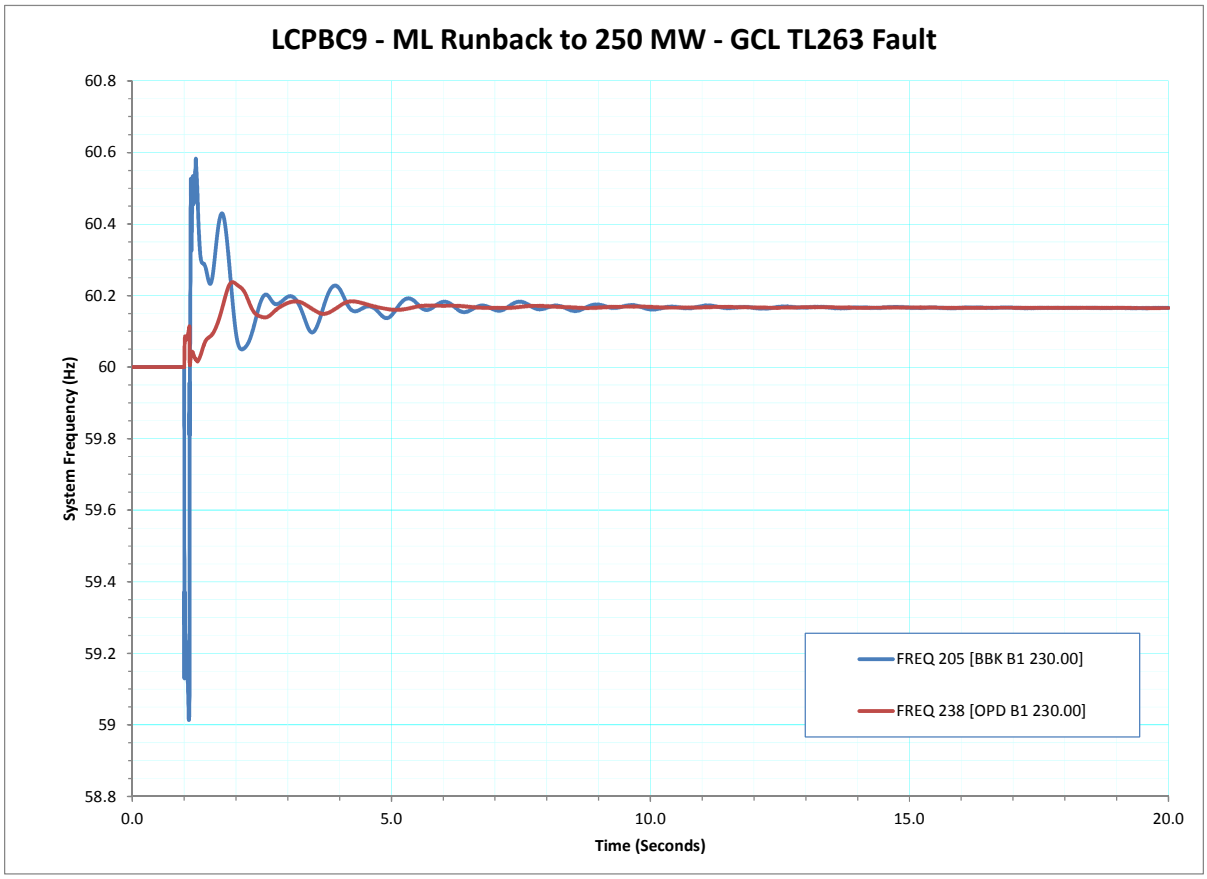

Figure 199 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - System Frequency (Hz)

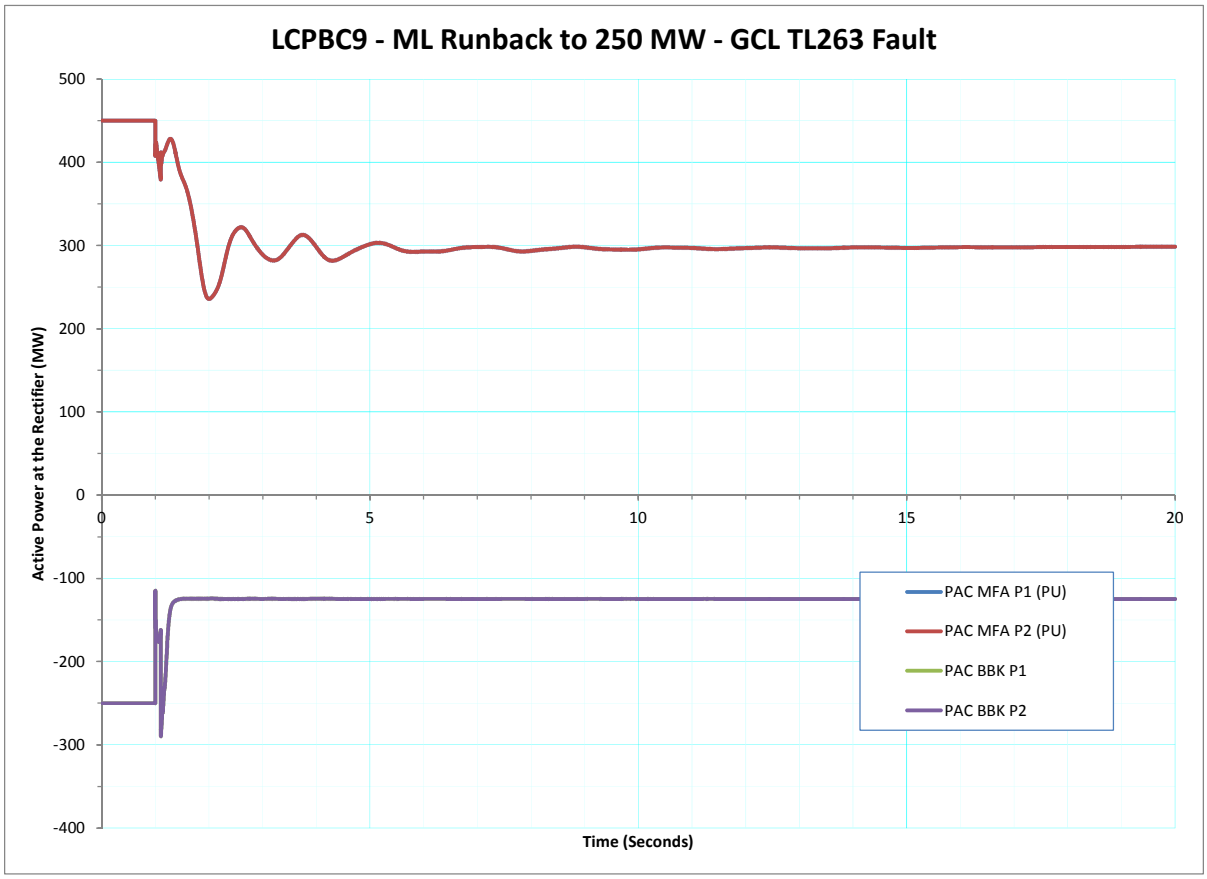

Figure 200 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - Active Power at the Rectifier (MW)

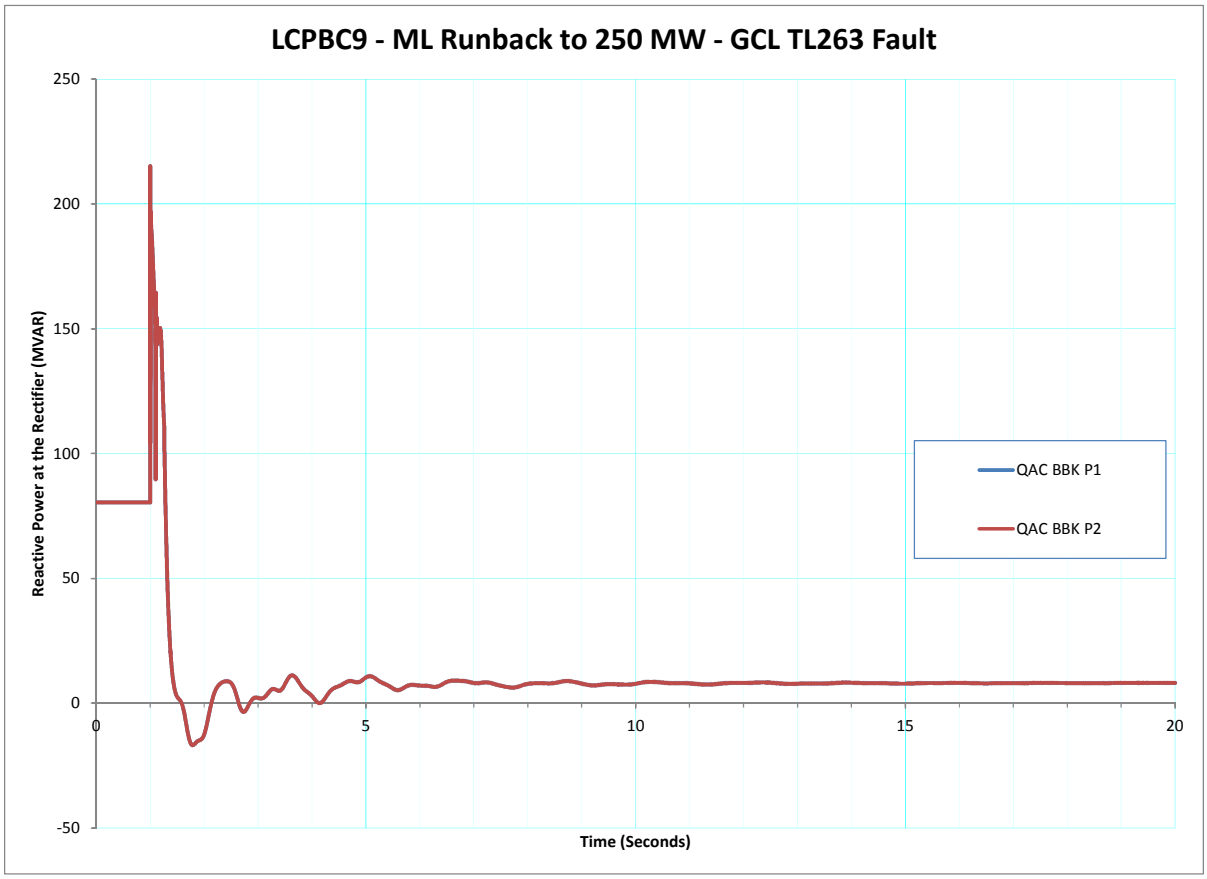

Figure 201 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - Reactive Power at the Rectifier (MVAR)

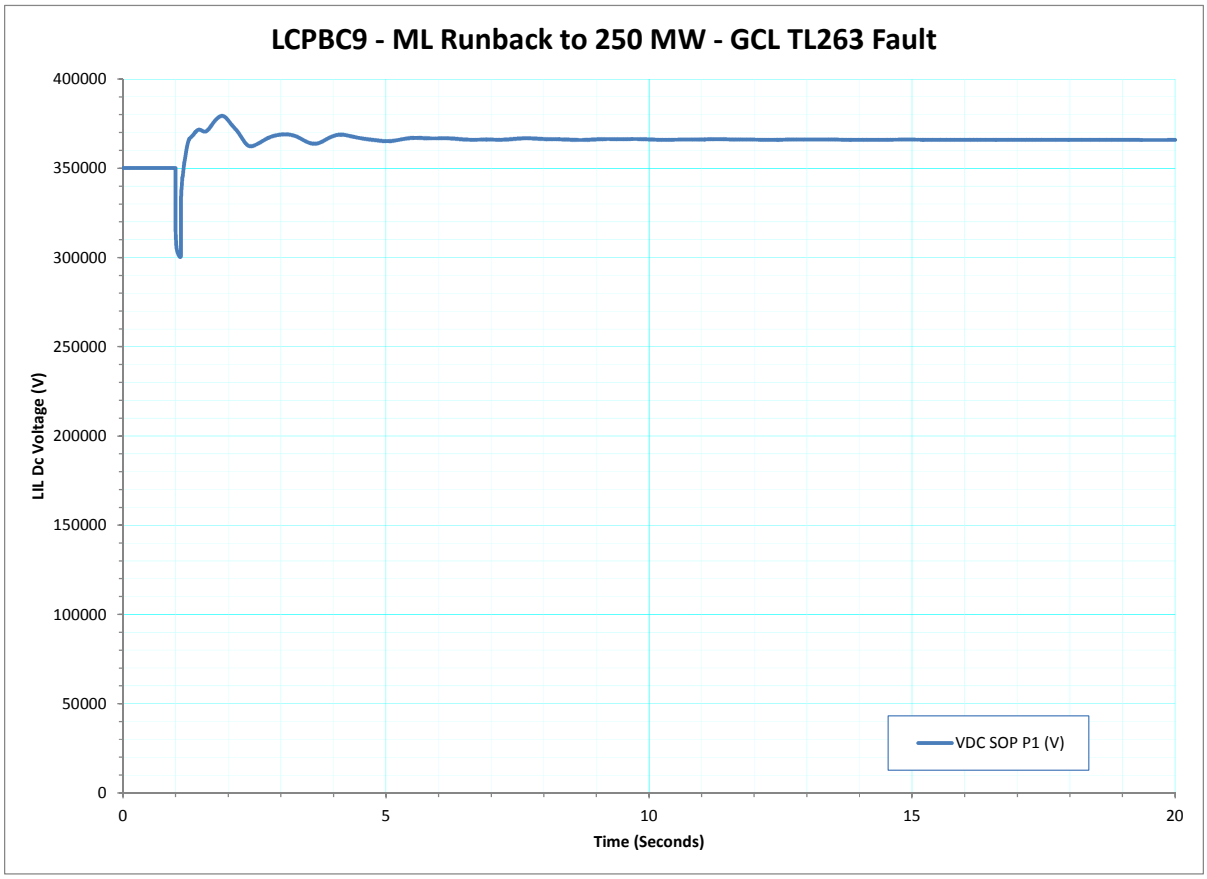

Figure 202 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - LIL Dc Voltage (V)

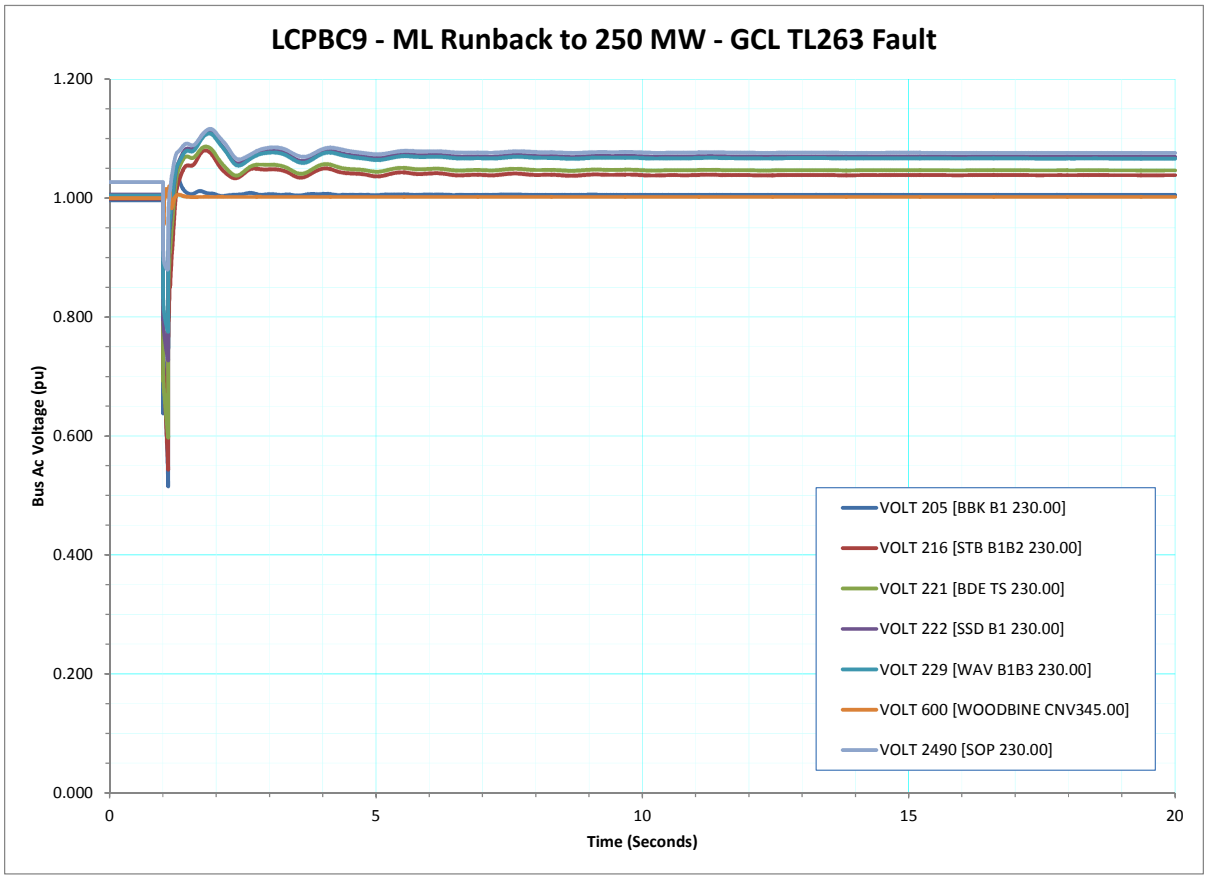

Figure 203 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - Bus Ac Voltage (pu)

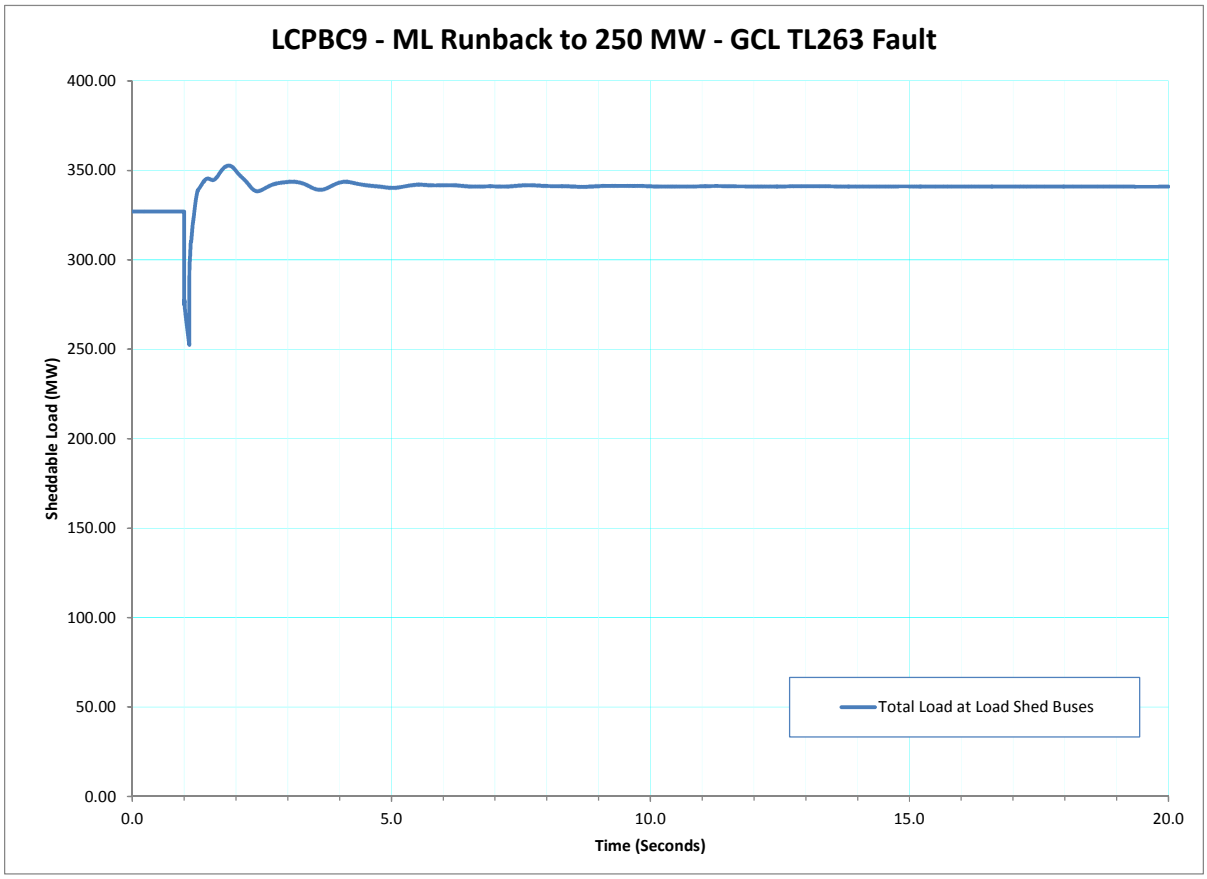

Figure 204 - LCPBC9 - ML Runback to 250 MW - GCL TL263 Fault - Sheddable Load (MW)

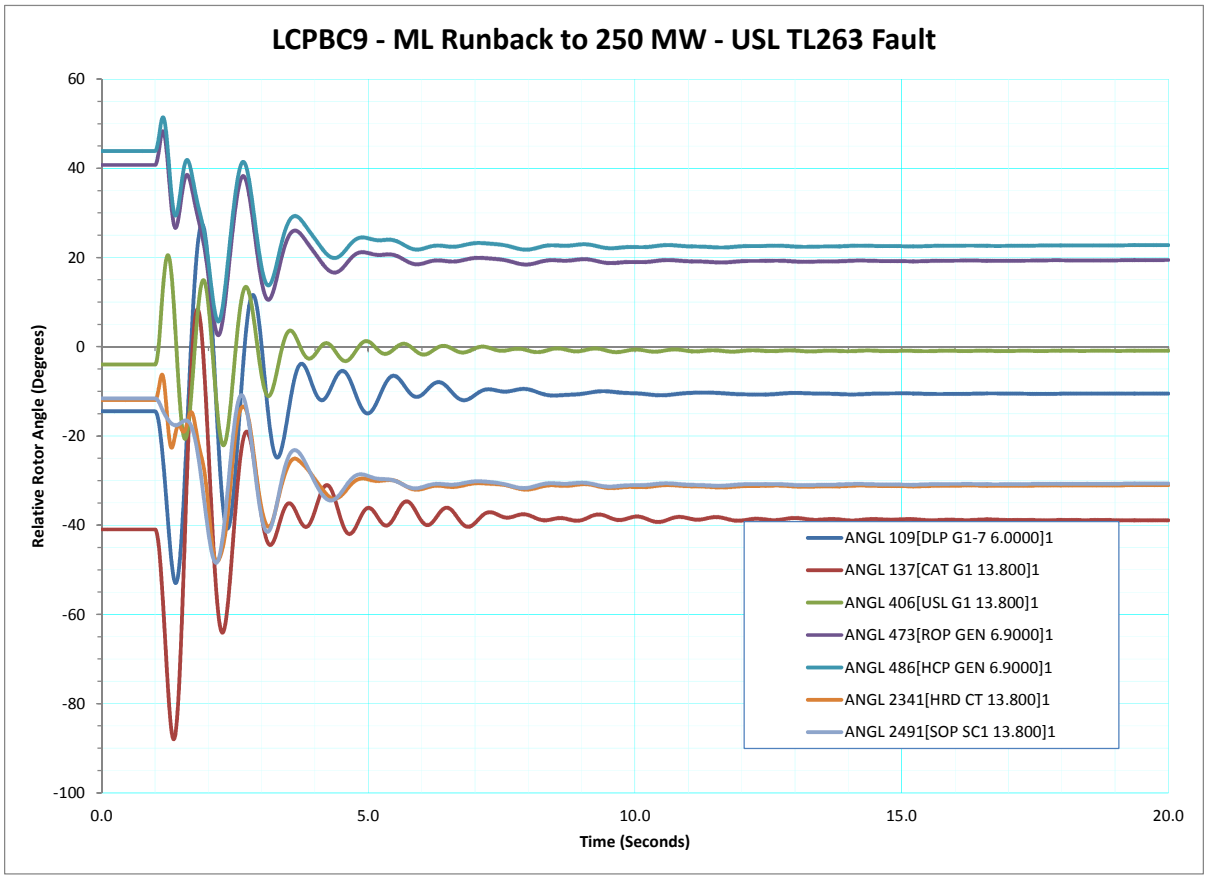

Figure 205 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - Relative Rotor Angle (Degrees)

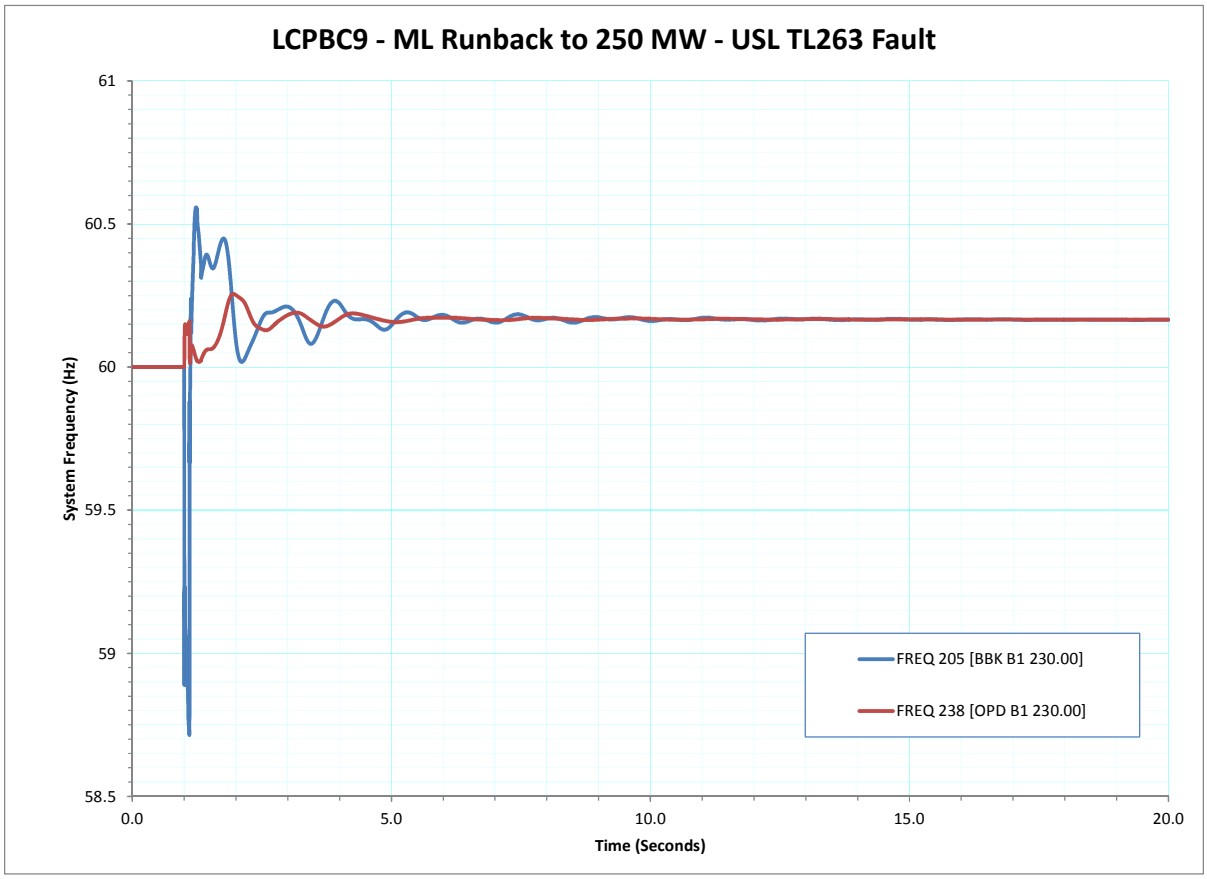

Figure 206 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - System Frequency (Hz)

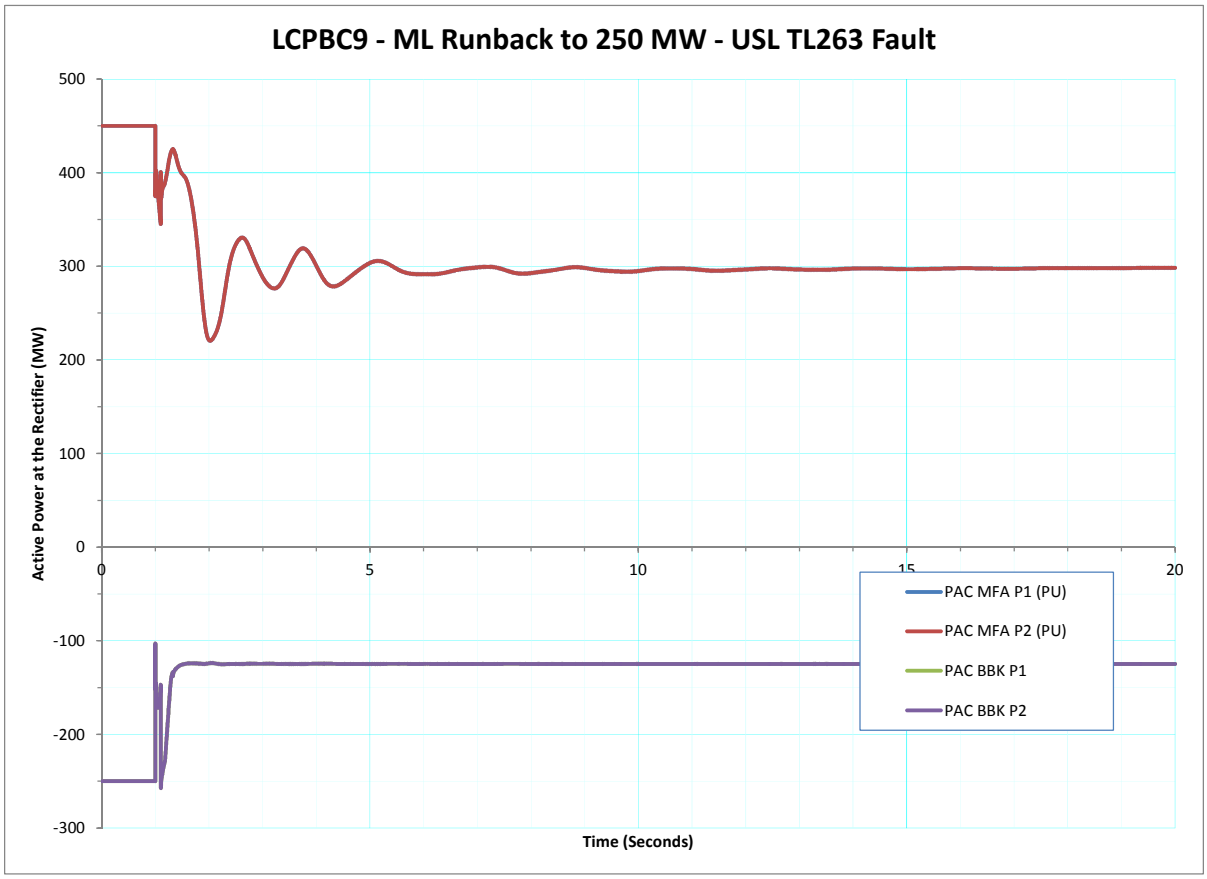

Figure 207 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - Active Power at the Rectifier (MW)

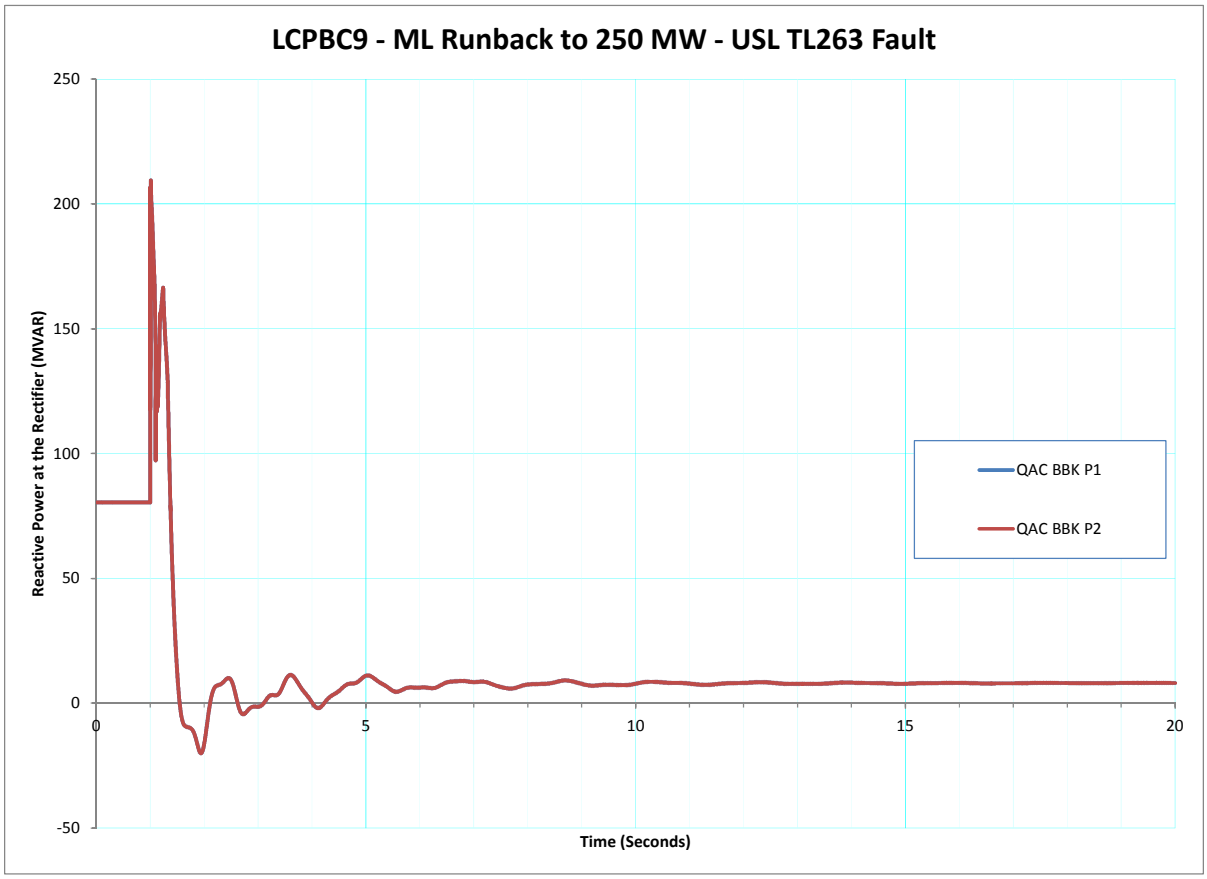

Figure 208 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - Reactive Power at the Rectifier (MVAR)

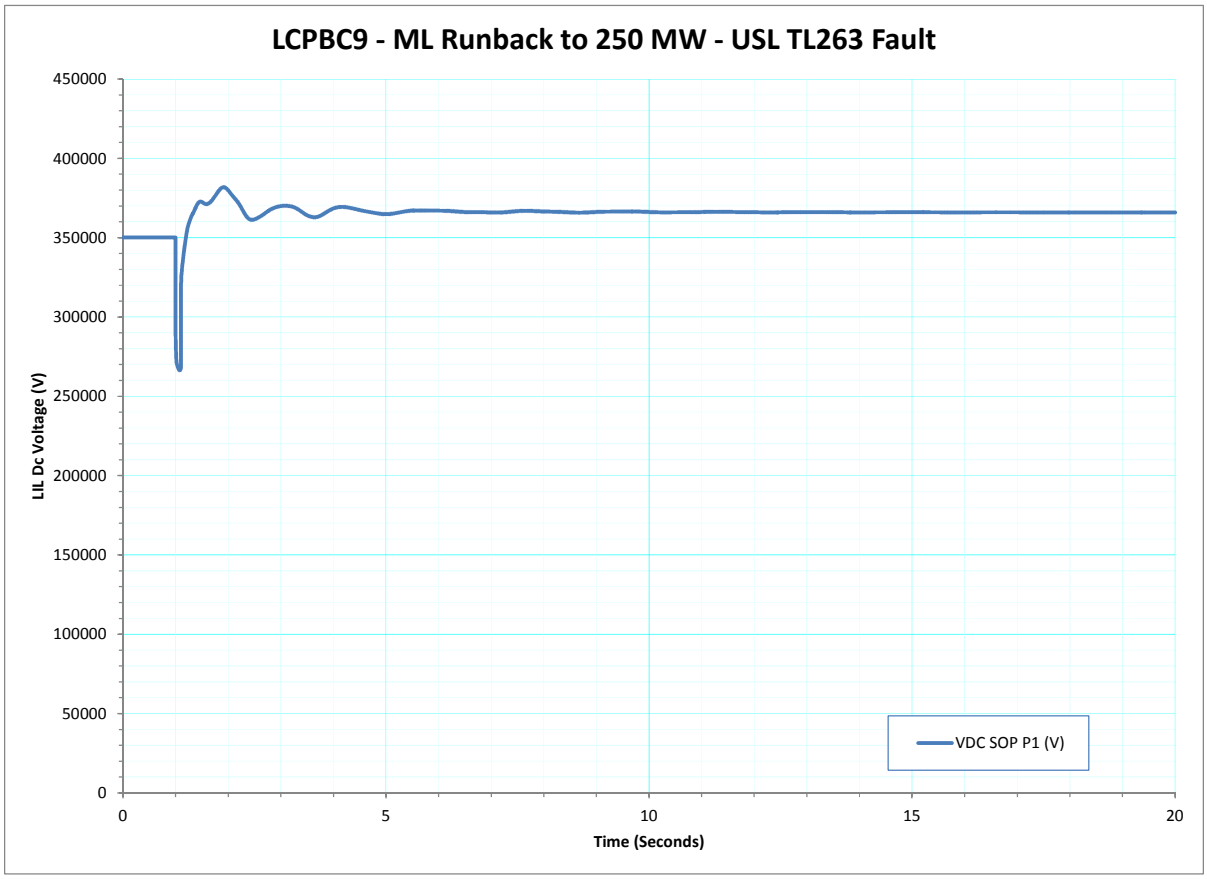

Figure 209 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - LIL Dc Voltage (V)

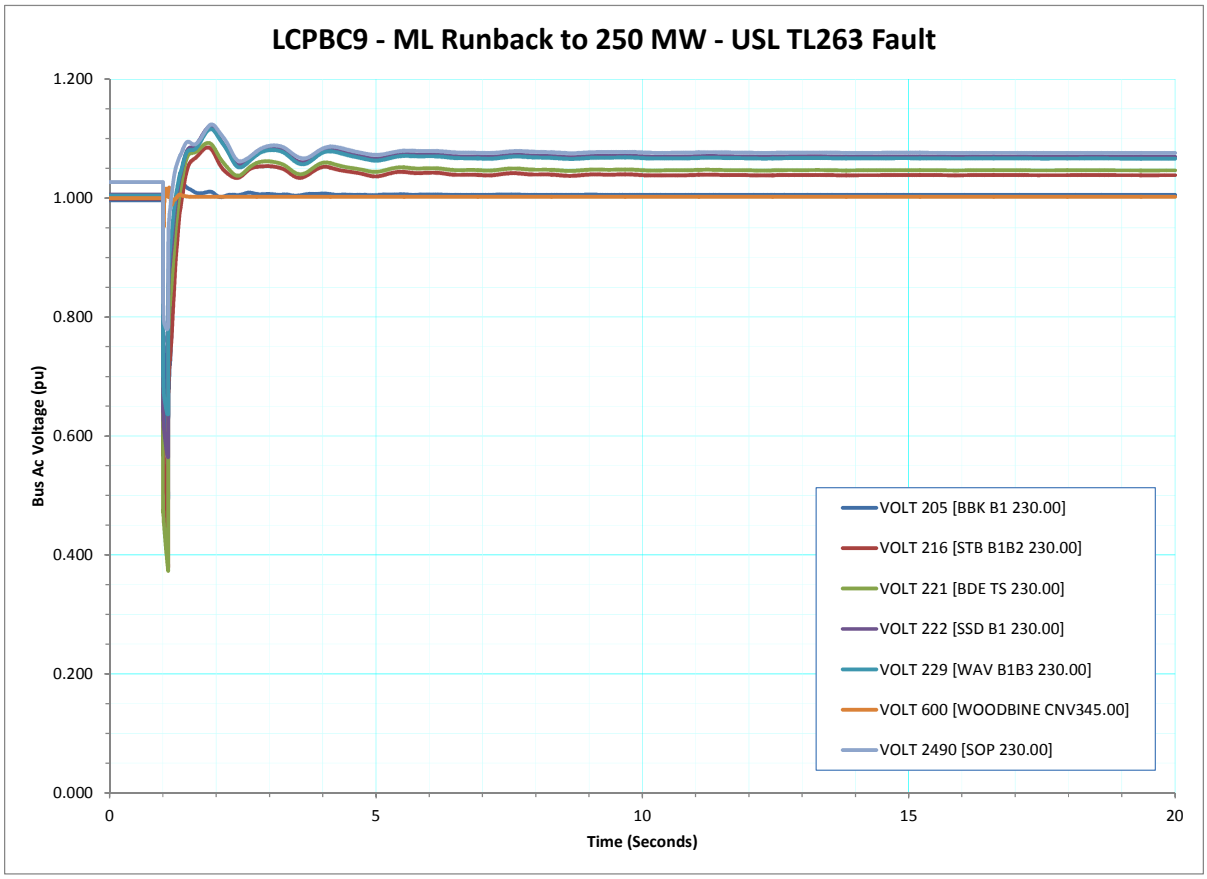

Figure 210 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - Bus Ac Voltage (pu)

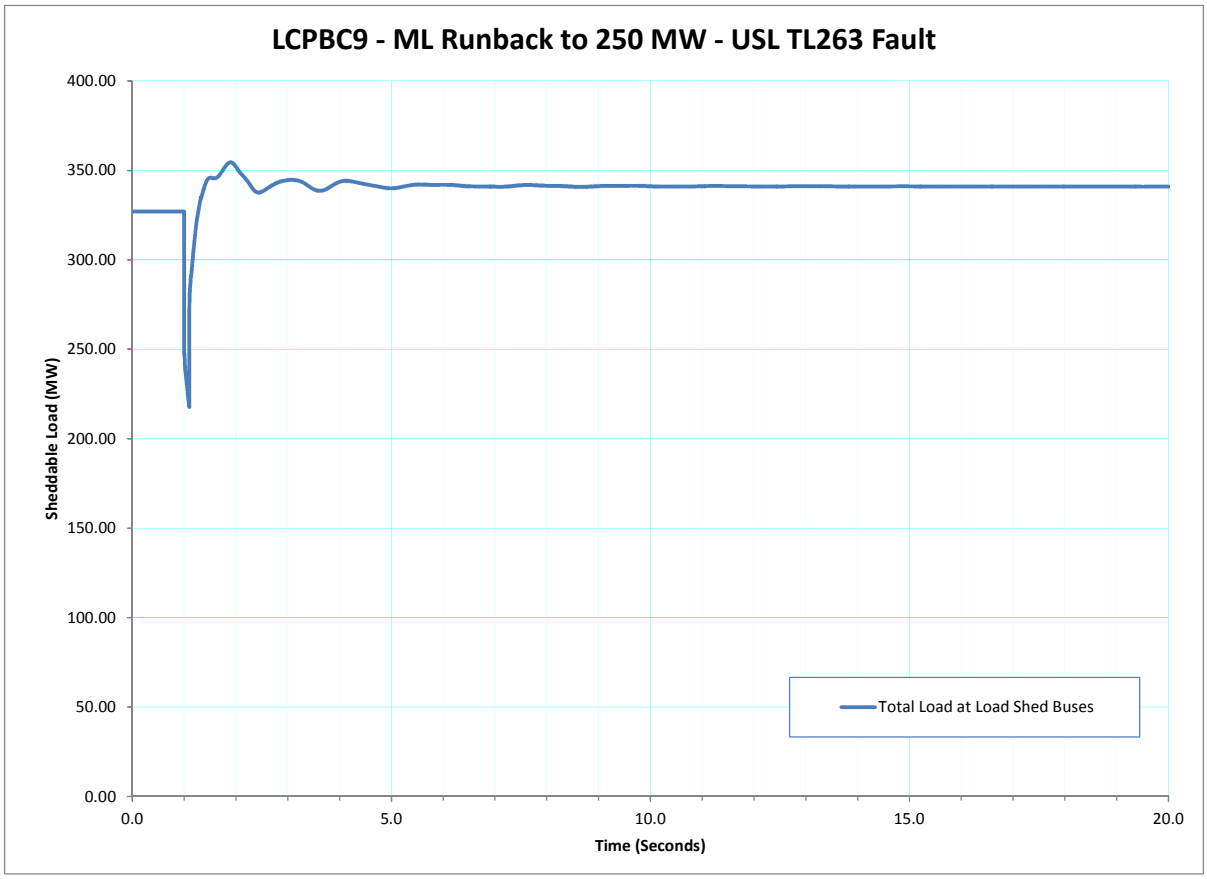

Figure 211 - LCPBC9 - ML Runback to 250 MW - USL TL263 Fault - Sheddable Load (MW)

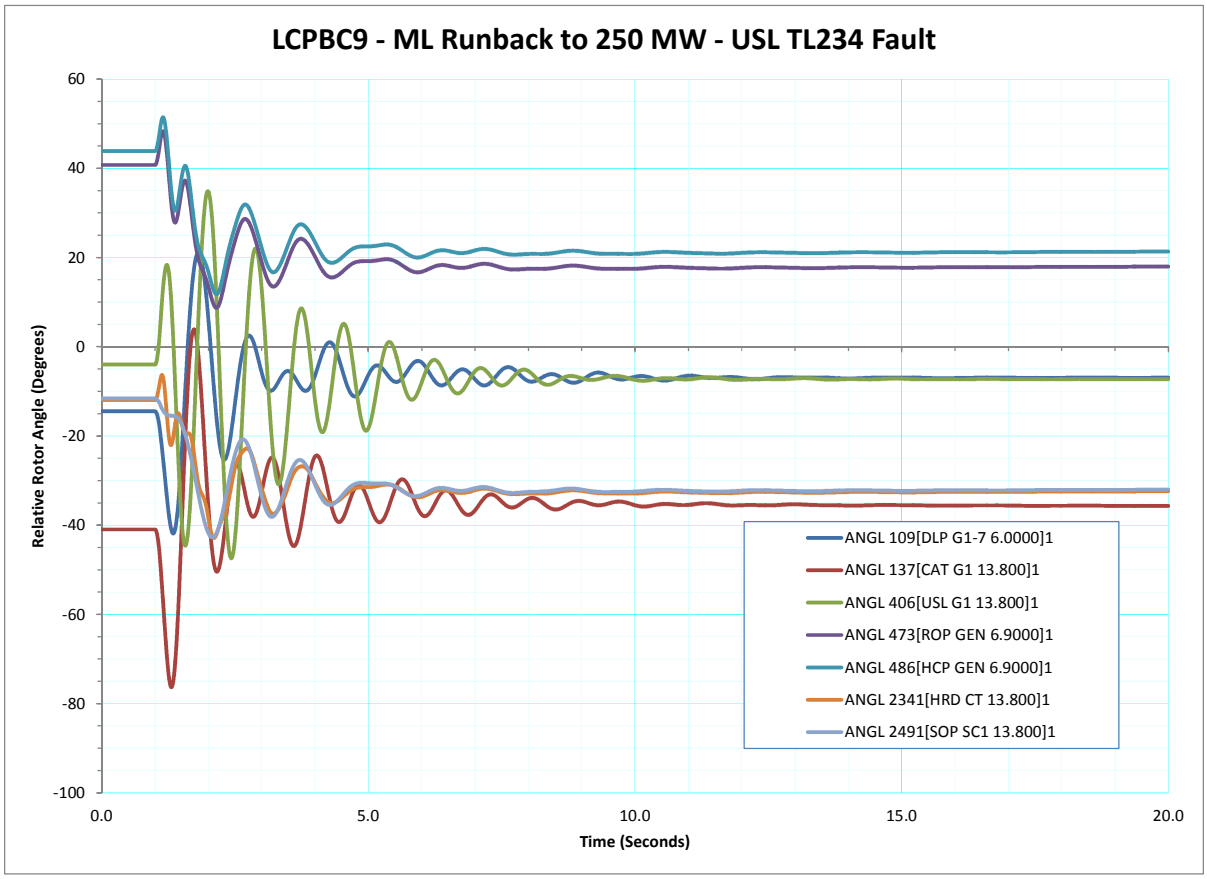

Figure 212 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - Relative Rotor Angle (Degrees)

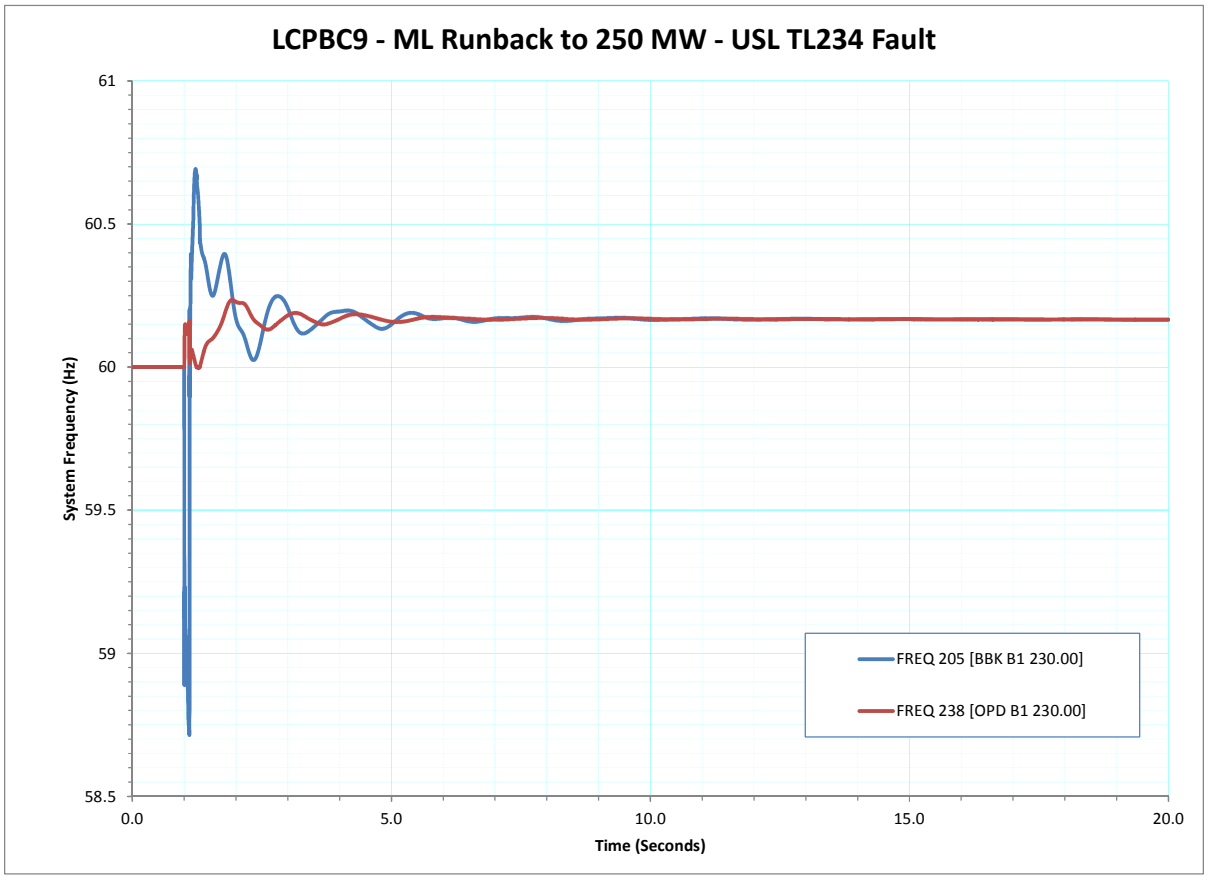

Figure 213 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - System Frequency (Hz)

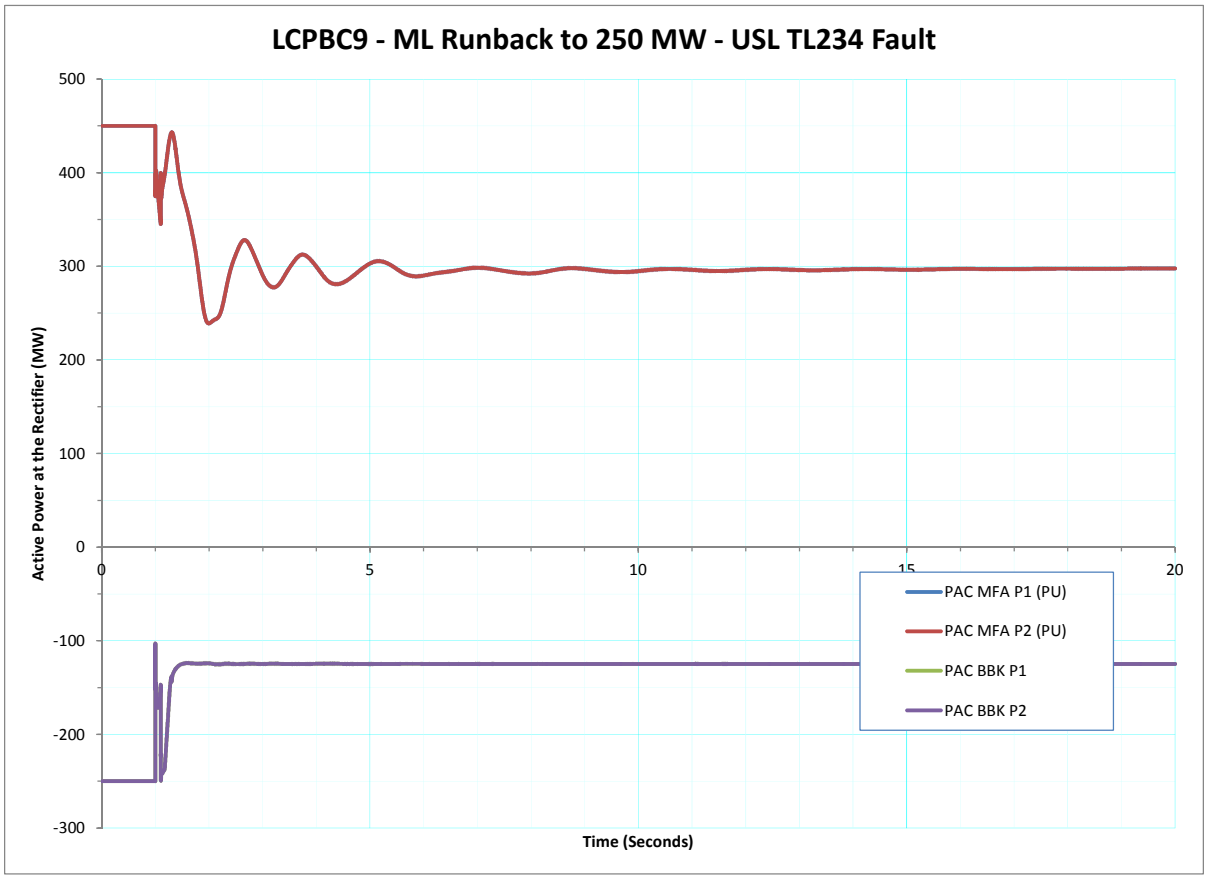

Figure 214 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - Active Power at the Rectifier (MW)

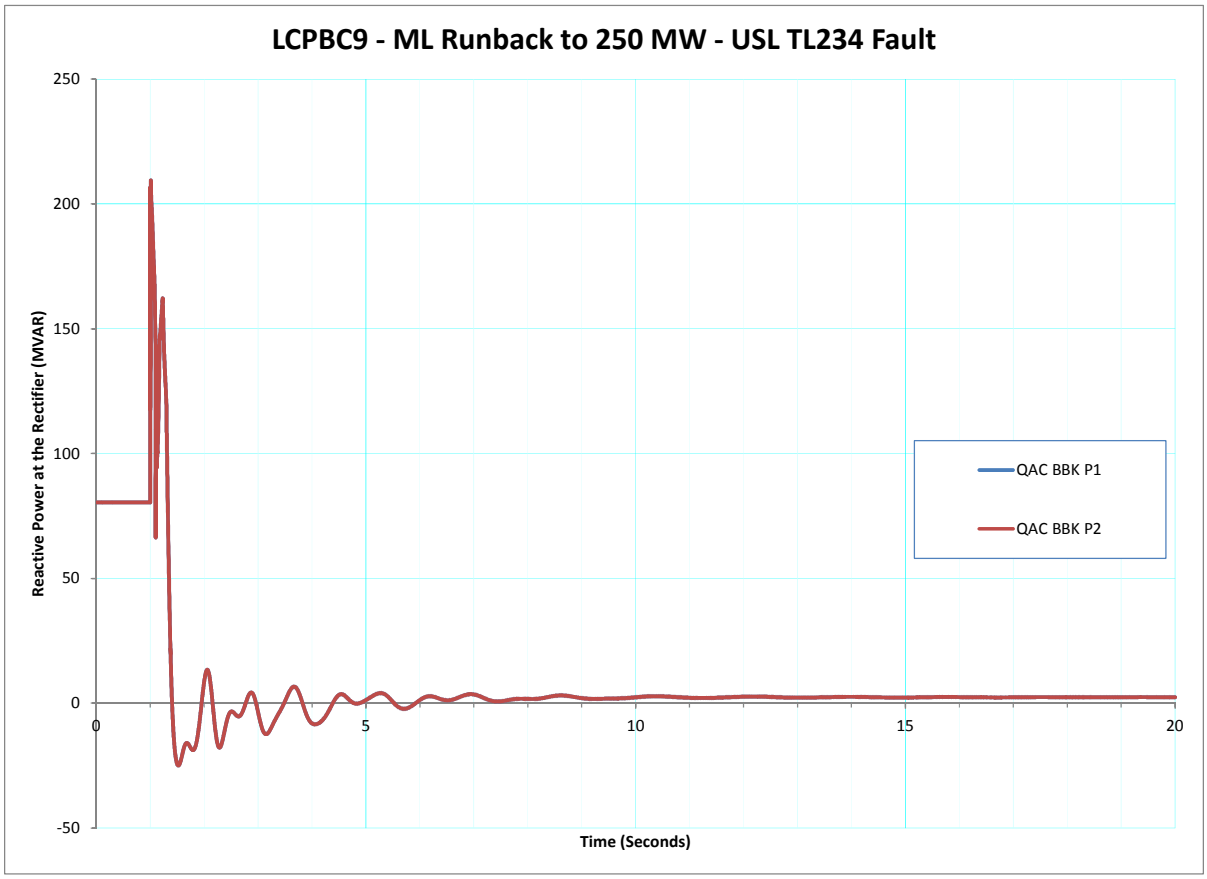

Figure 215 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - Reactive Power at the Rectifier (MVAR)

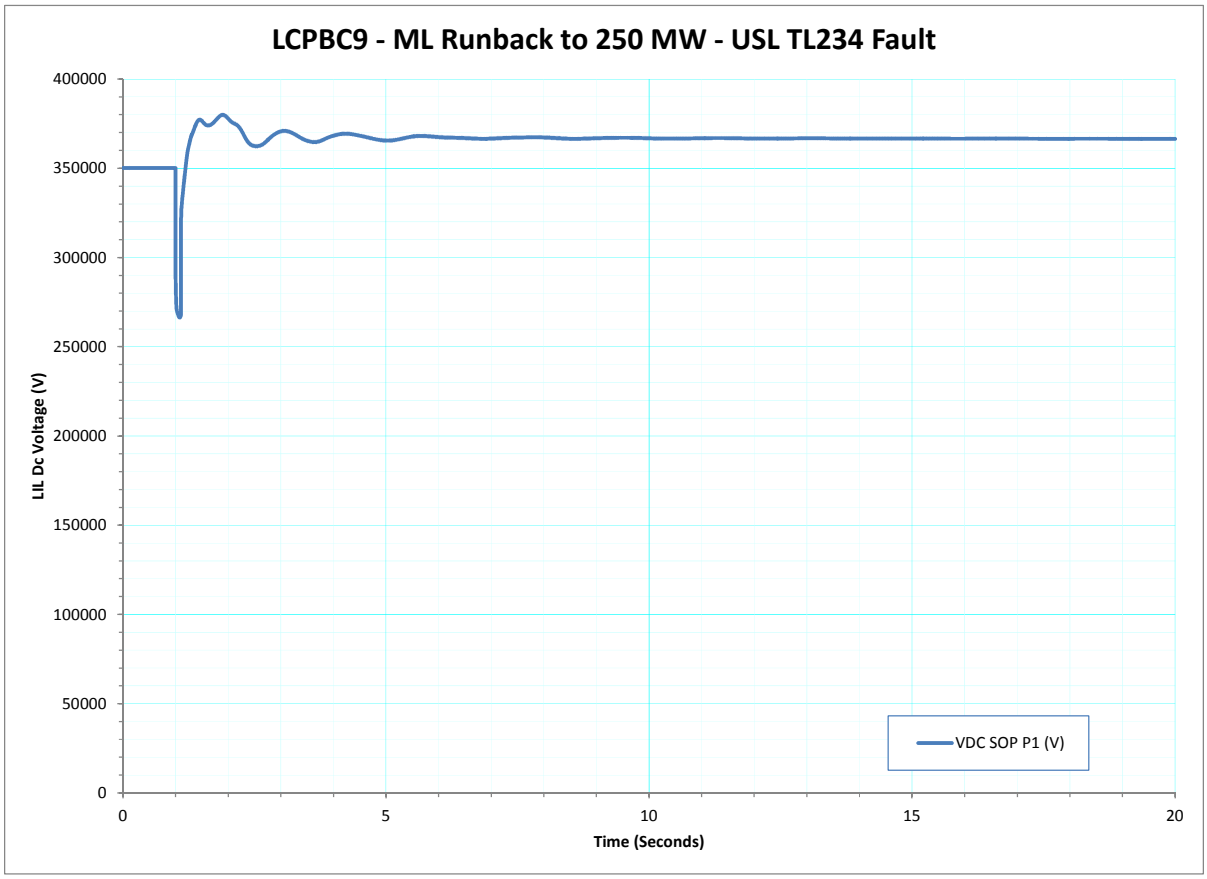

Figure 216 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - LIL Dc Voltage (V)

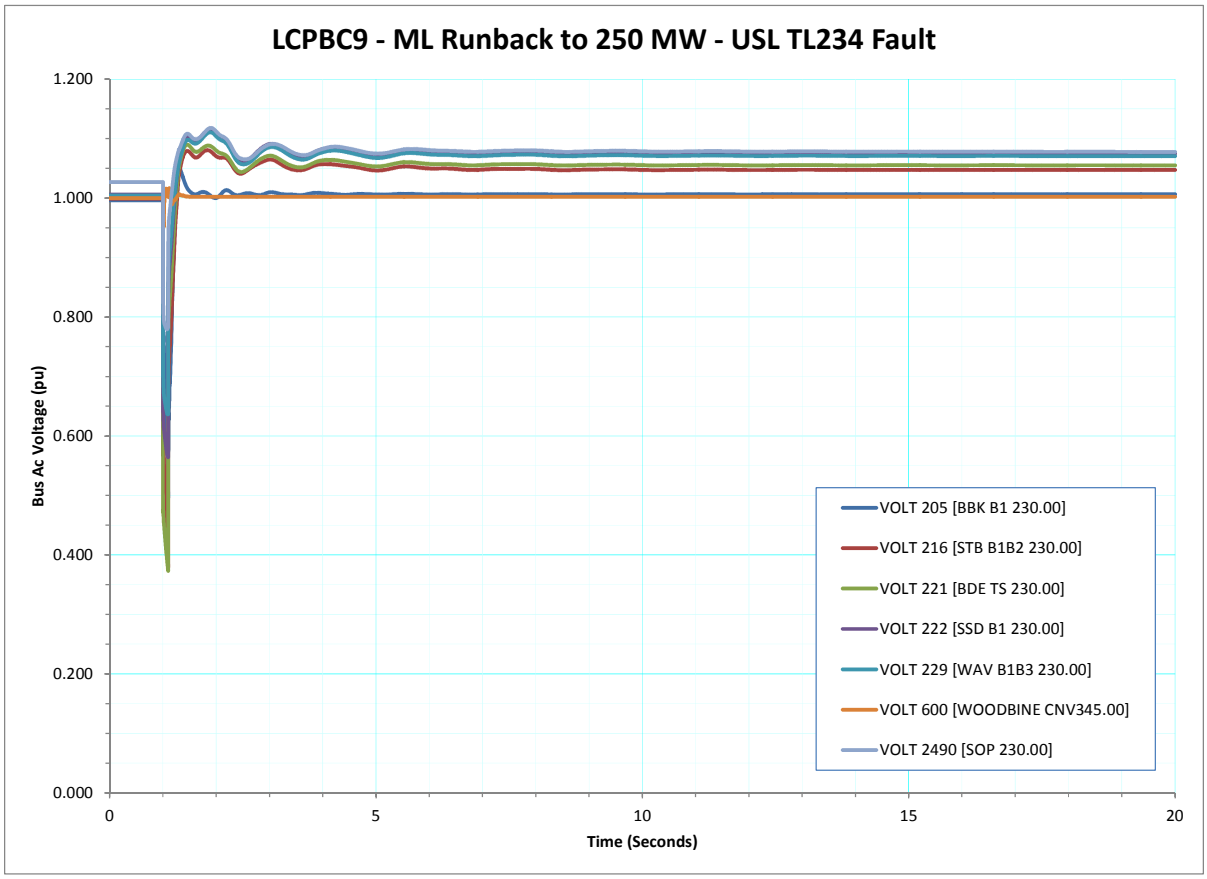

Figure 217 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - Bus Ac Voltage (pu)

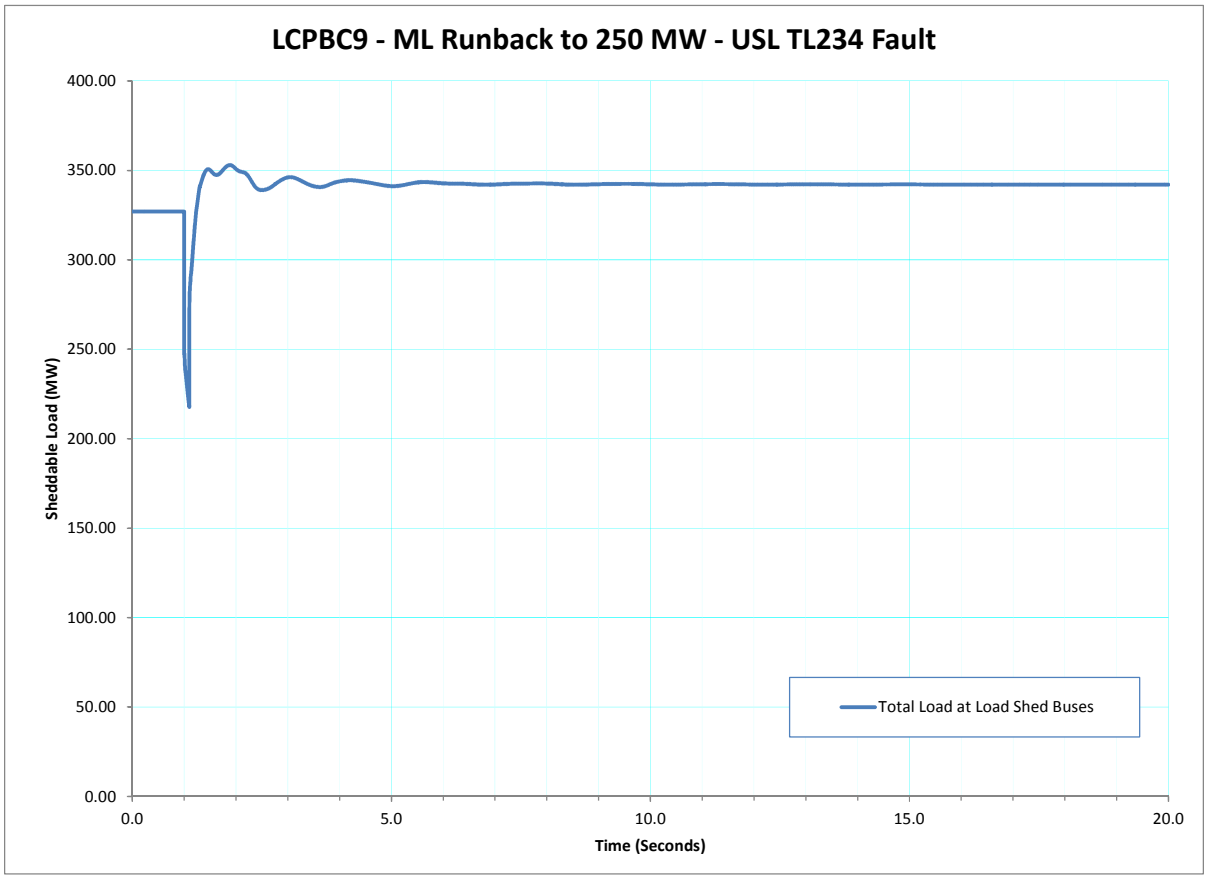

Figure 218 - LCPBC9 - ML Runback to 250 MW - USL TL234 Fault - Sheddable Load (MW)

APPENDIX D Remedial ML Curtailment for Temporary Bipole Faults

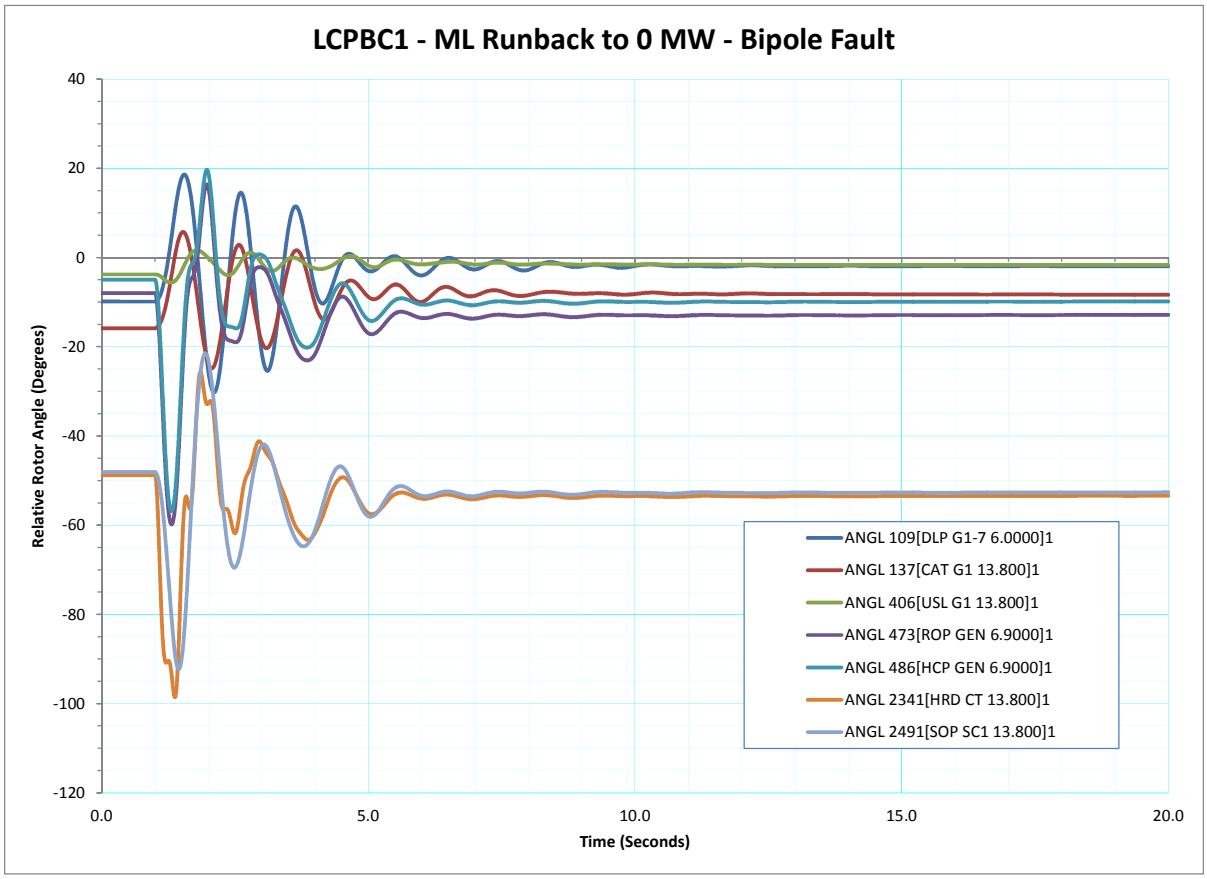

Figure 219 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - Relative Rotor Angle (Degrees)

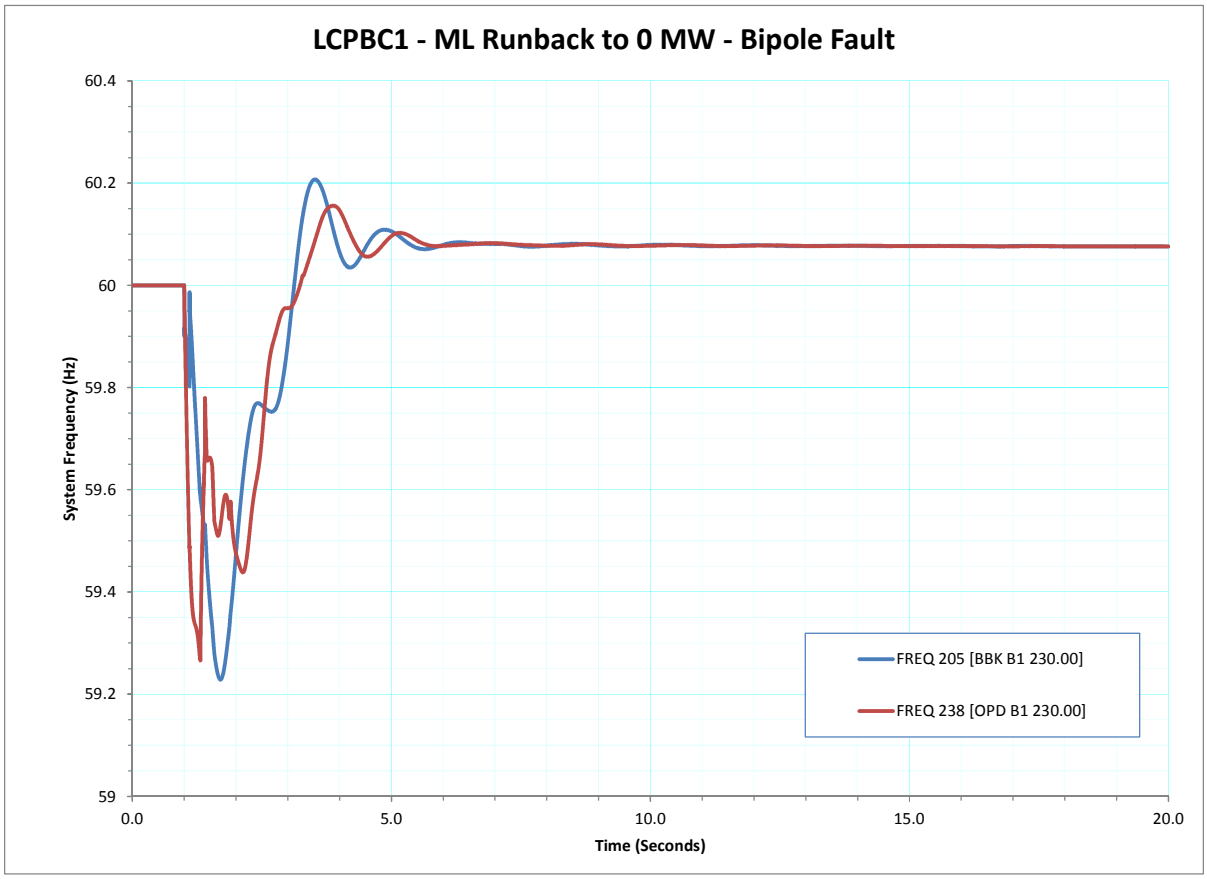

Figure 220 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - System Frequency (Hz)

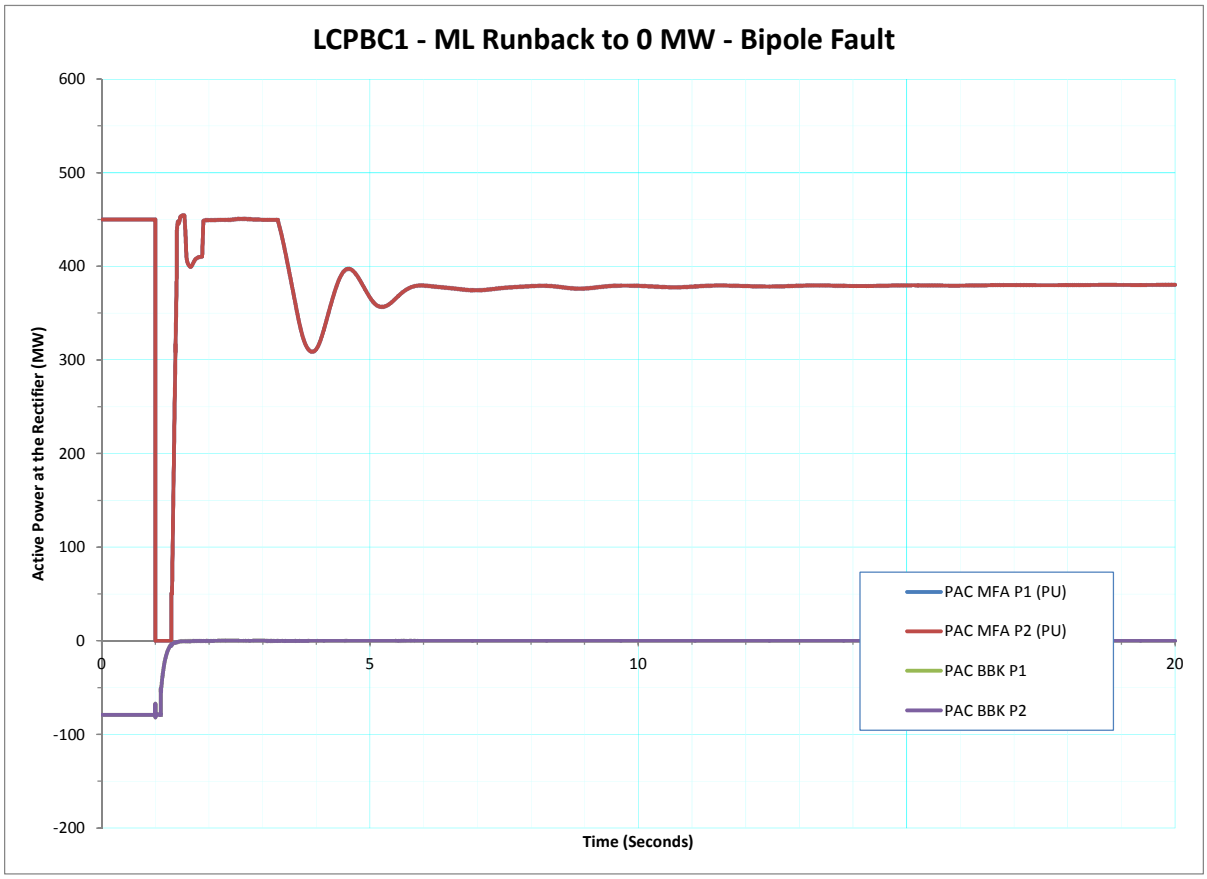

Figure 221 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - Active Power at the Rectifier (MW)

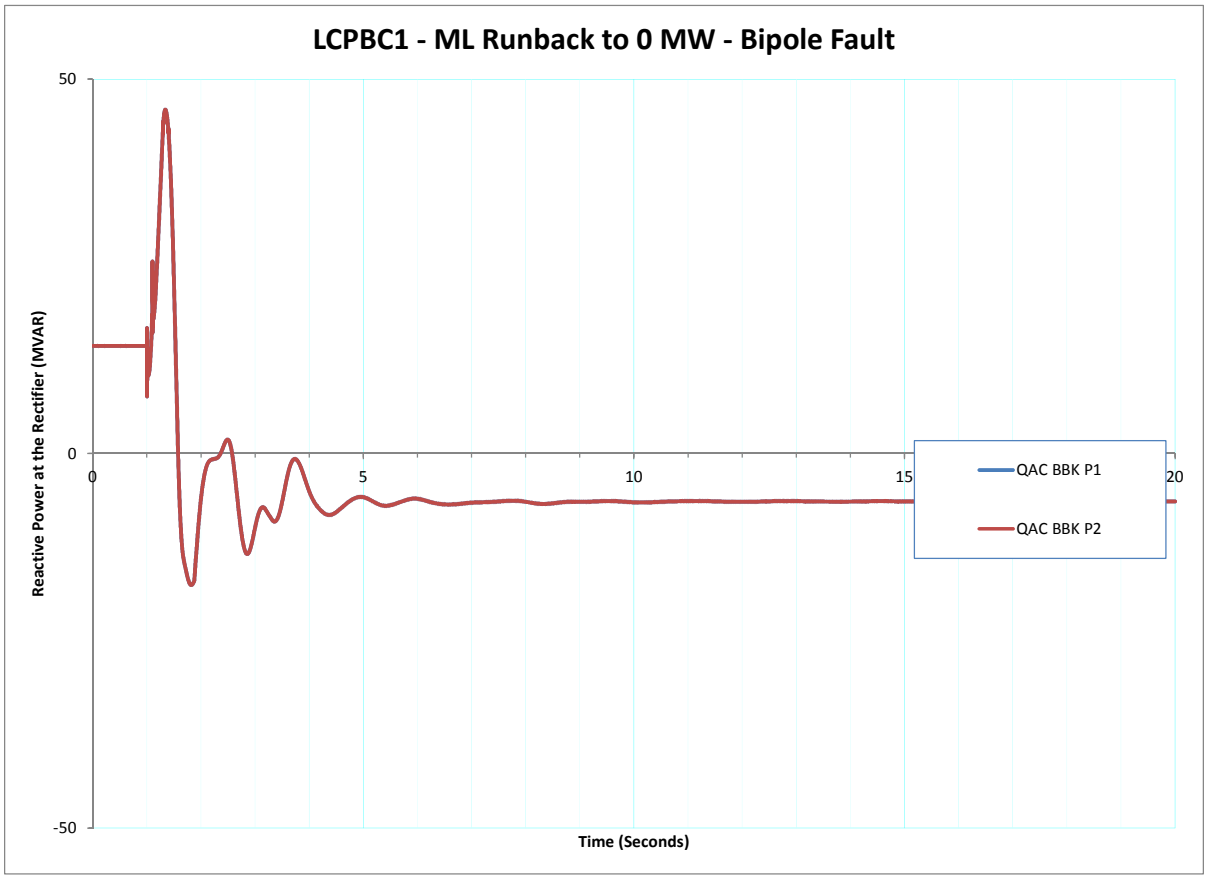

Figure 222 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

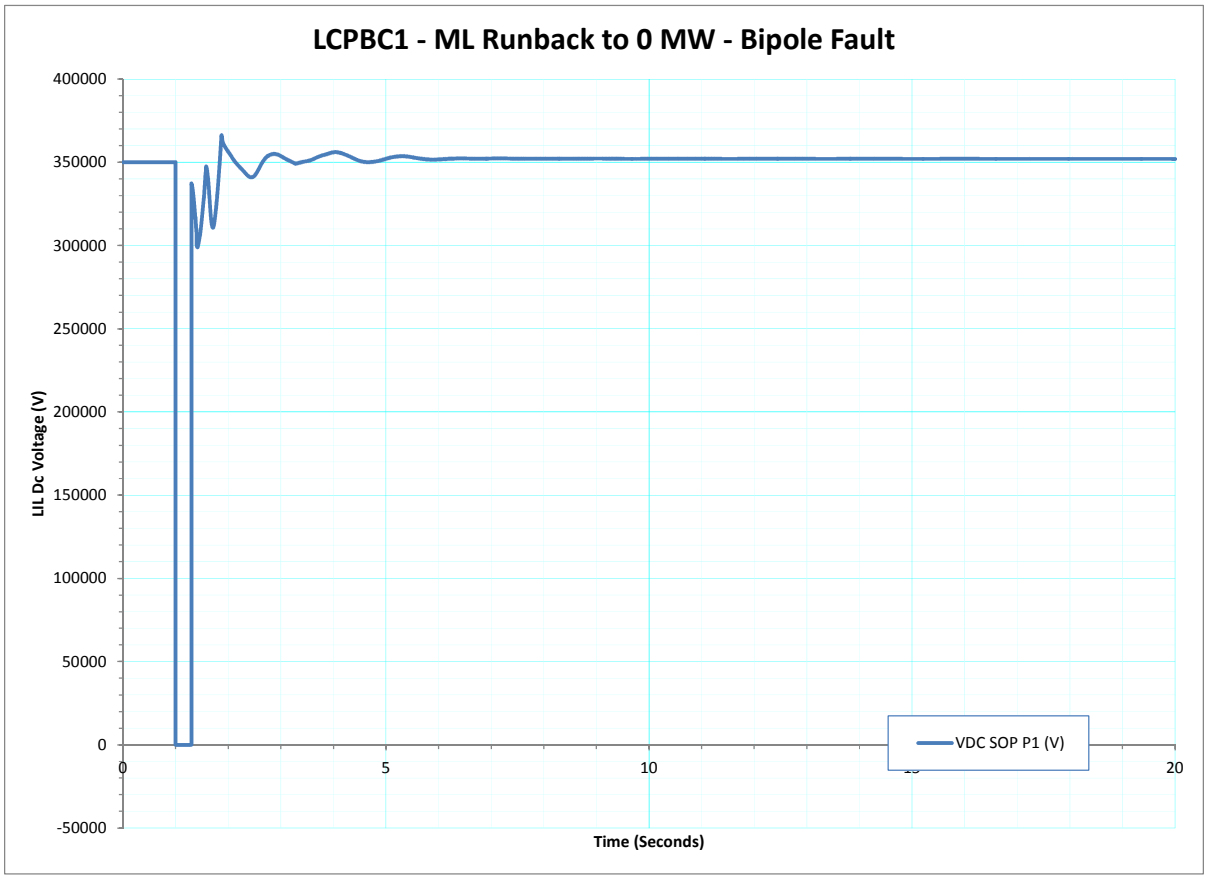

Figure 223 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - LIL Dc Voltage (V)

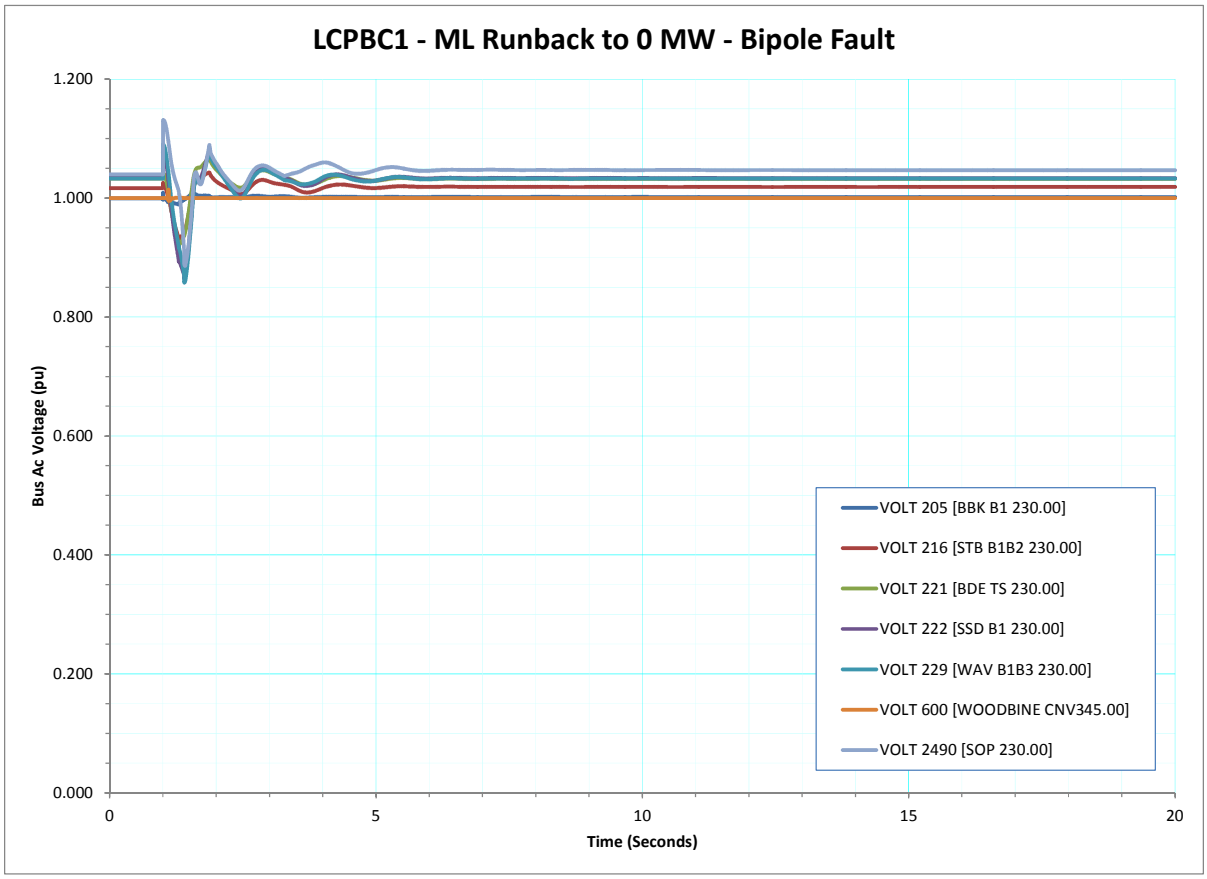

Figure 224 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - Bus Ac Voltage (pu)

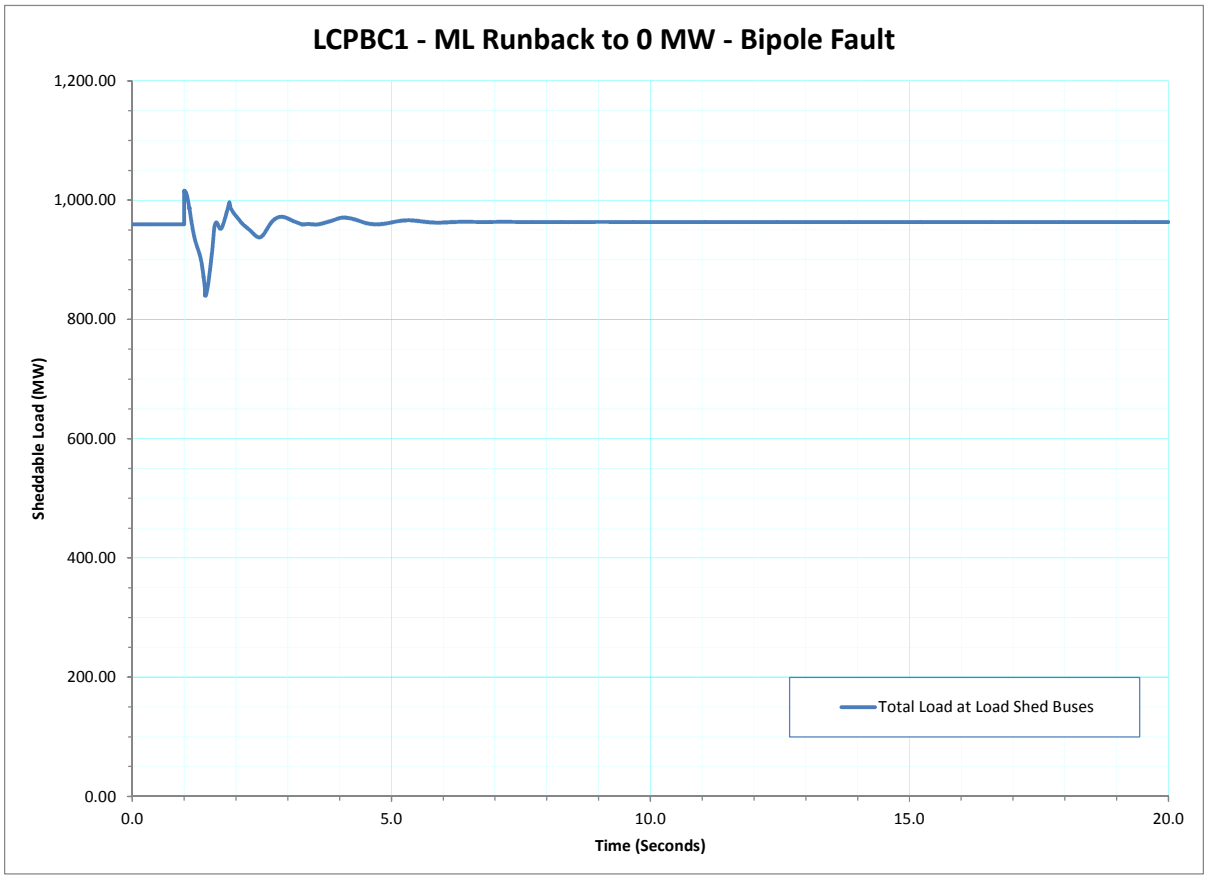

Figure 225 - LCPBC1 - ML Runback to 0 MW - Bipole Fault - Sheddable Load (MW)

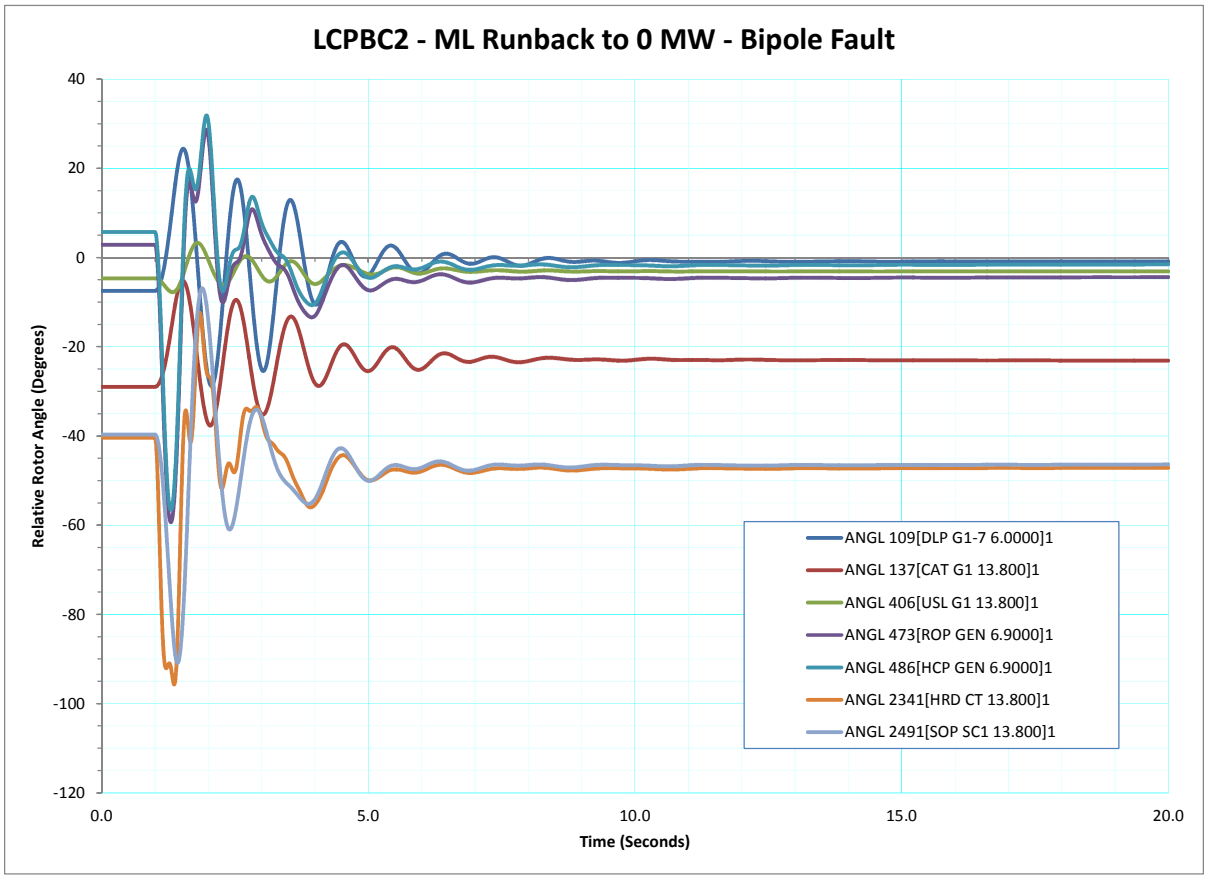

Figure 226 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - Relative Rotor Angle (Degrees)

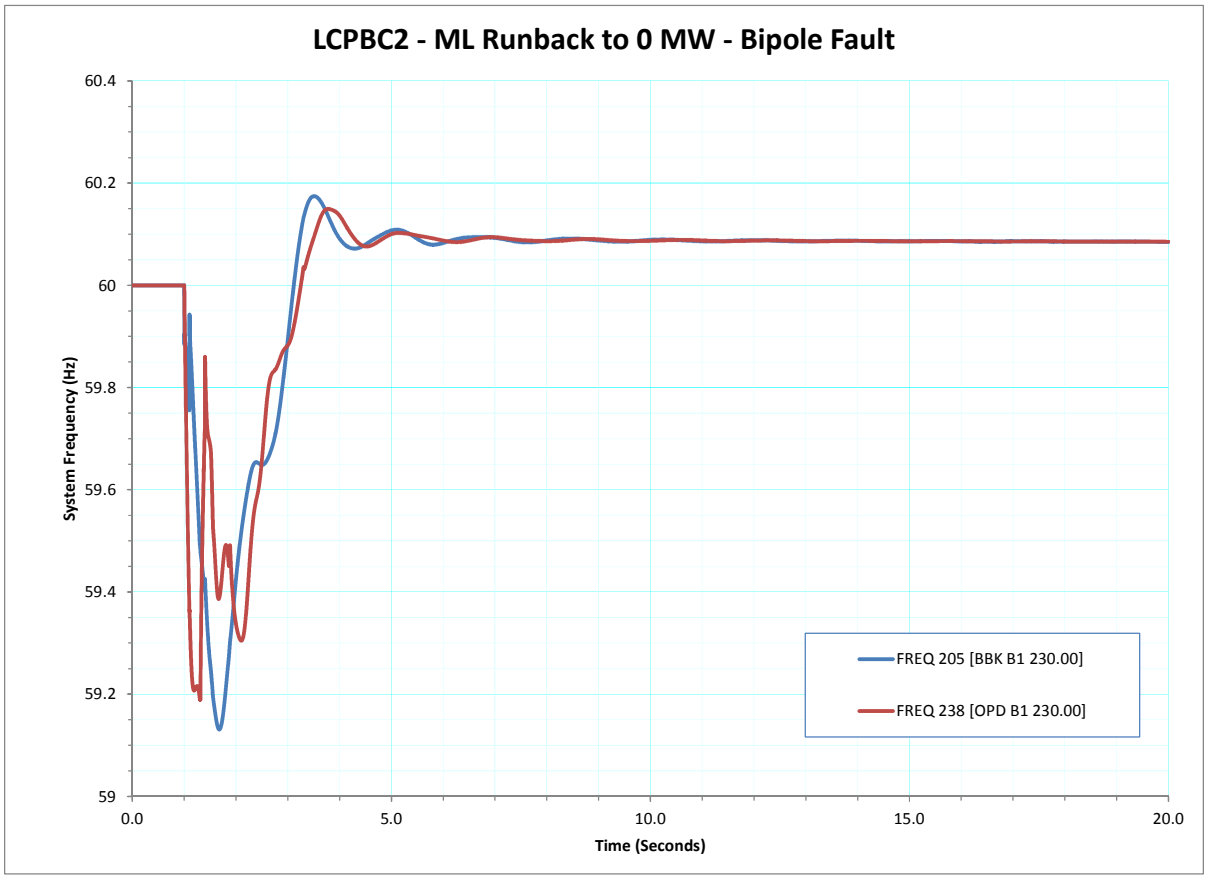

Figure 227 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - System Frequency (Hz)

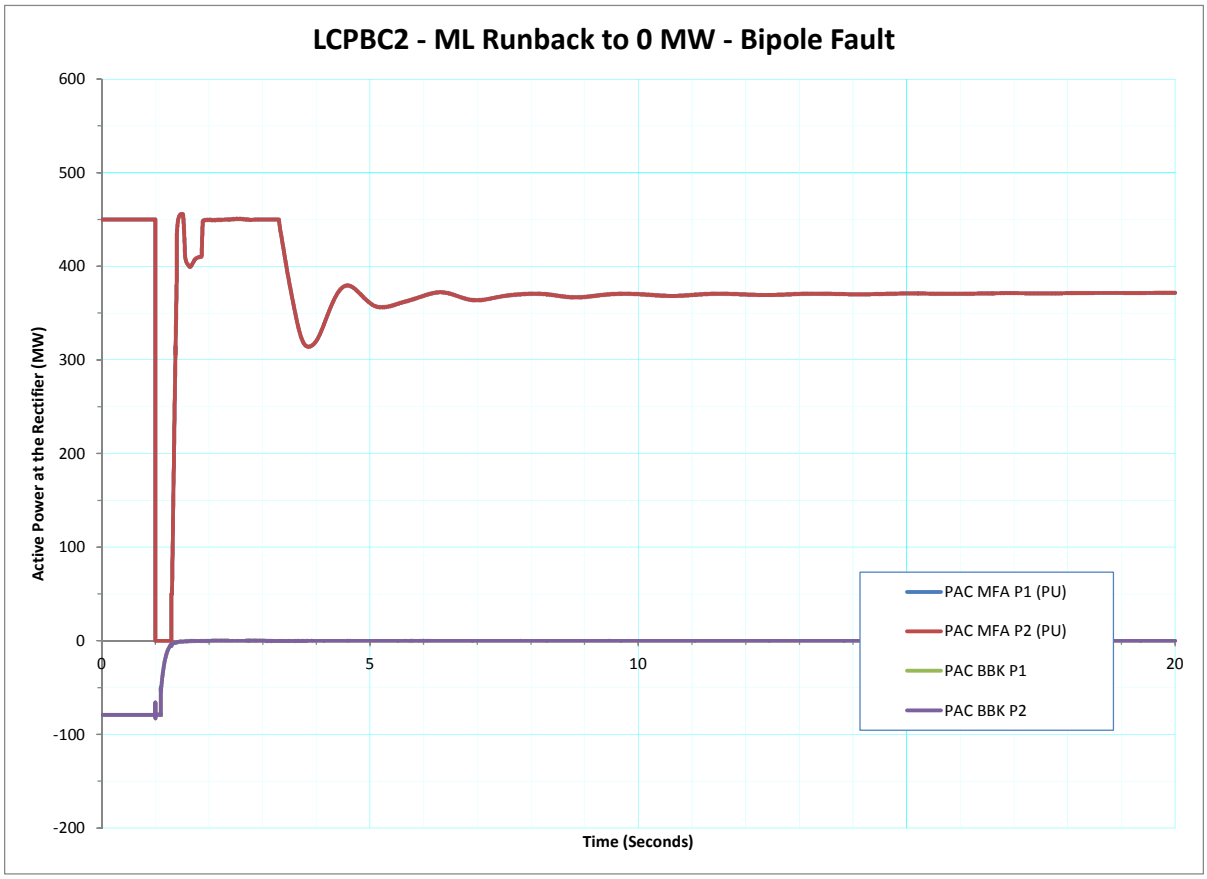

Figure 228 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - Active Power at the Rectifier (MW)

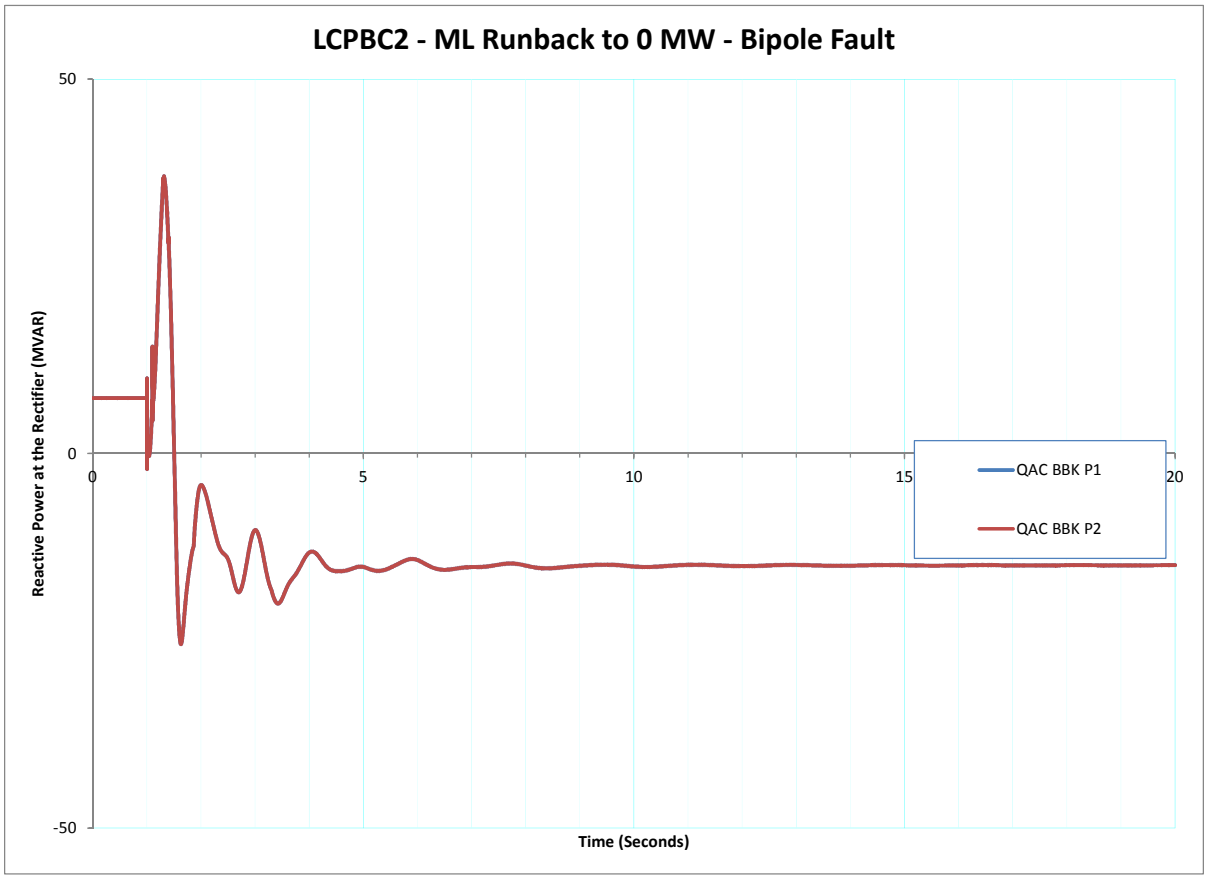

Figure 229 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

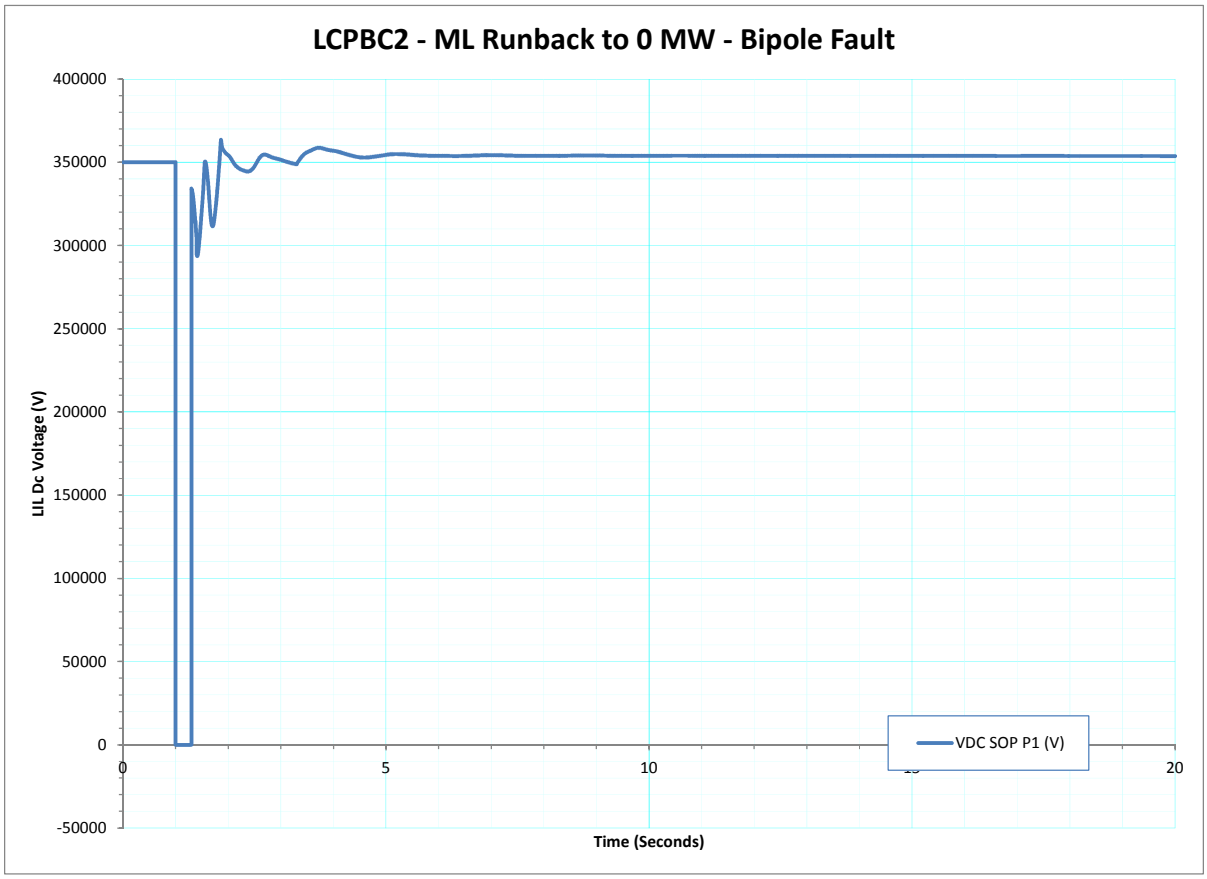

Figure 230 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - LIL Dc Voltage (V)

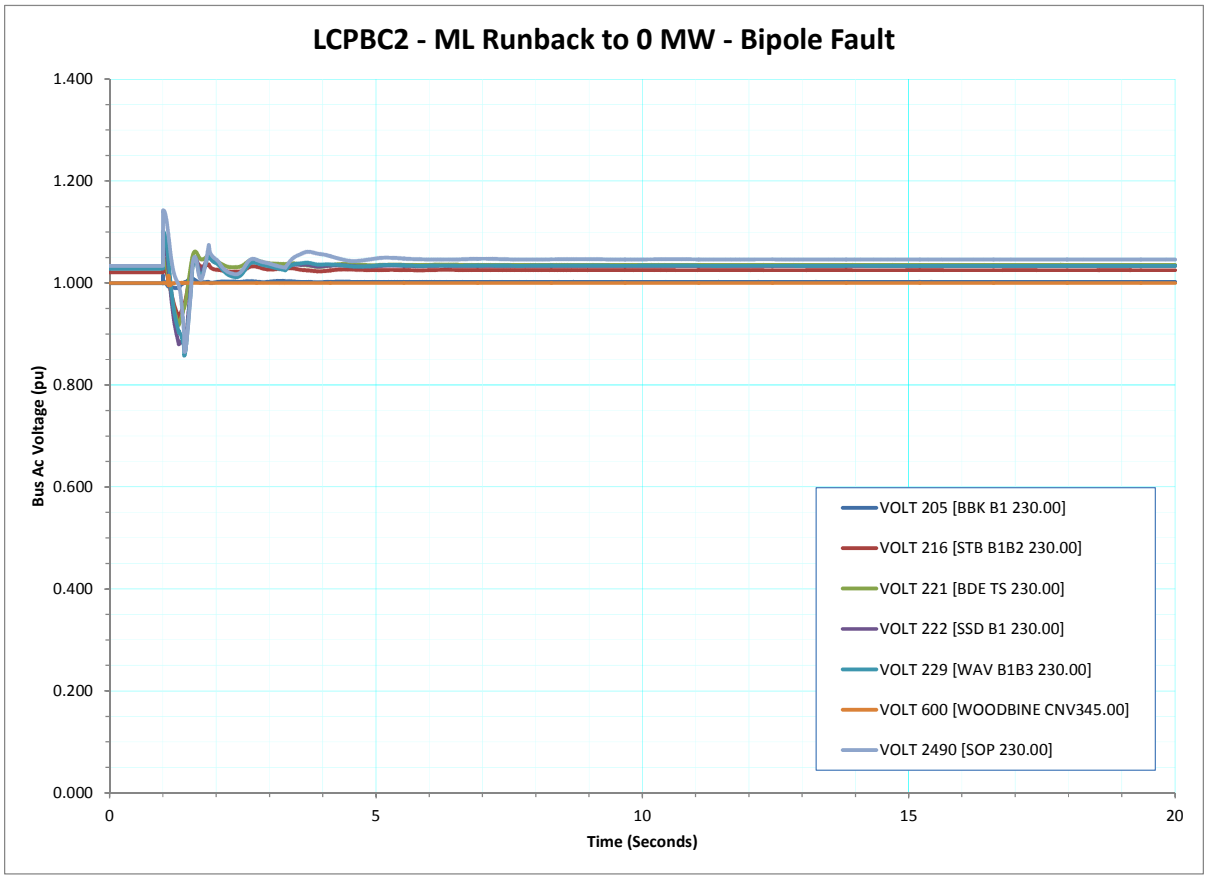

Figure 231 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - Bus Ac Voltage (pu)

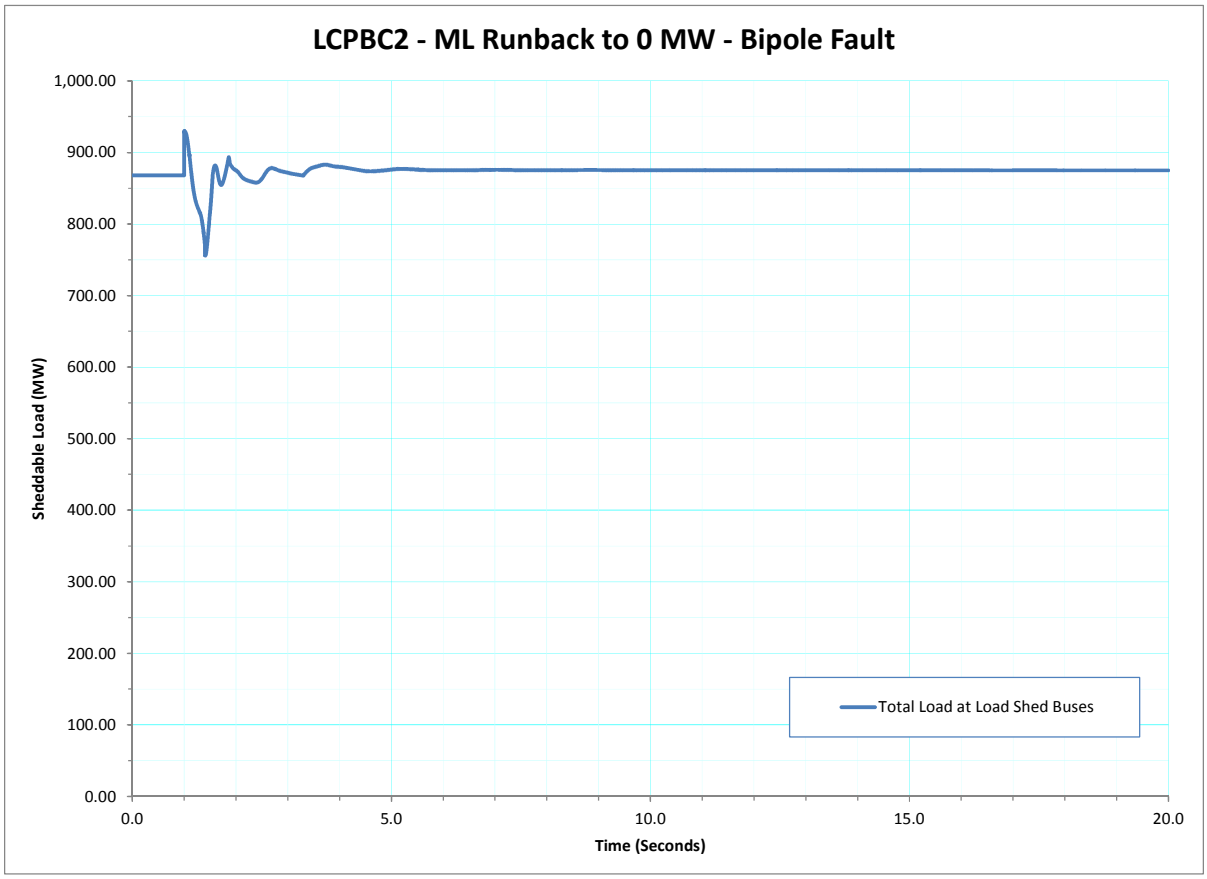

Figure 232 - LCPBC2 - ML Runback to 0 MW - Bipole Fault - Sheddable Load (MW)

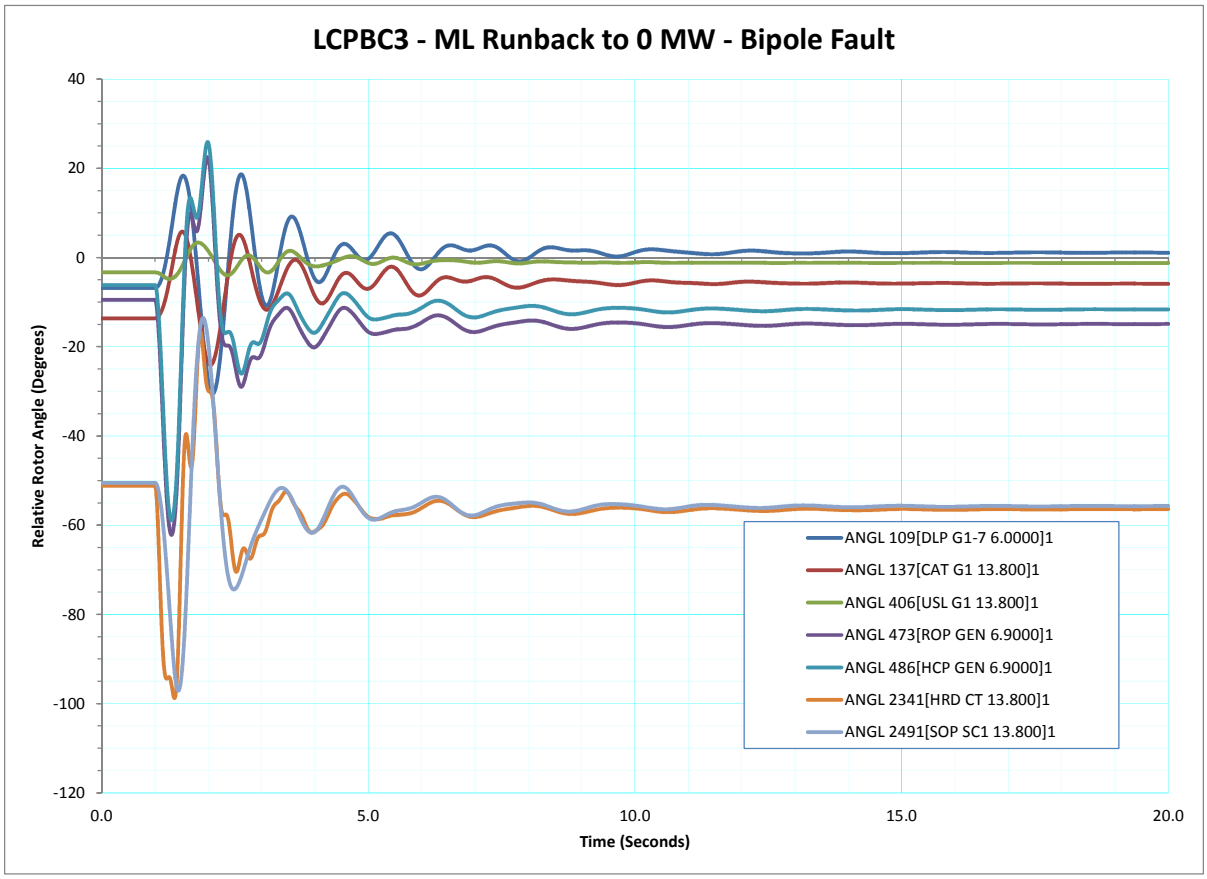

Figure 233 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - Relative Rotor Angle (Degrees)

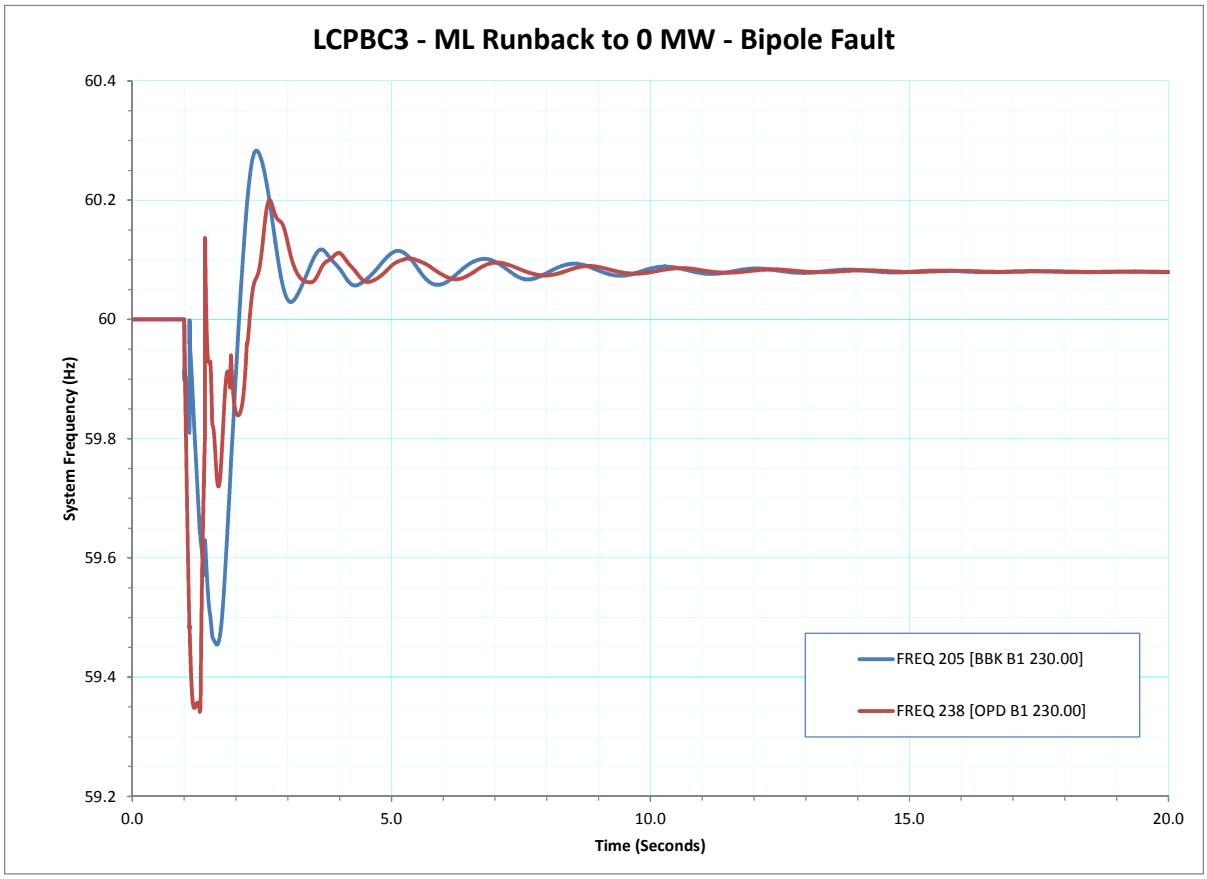

Figure 234 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - System Frequency (Hz)

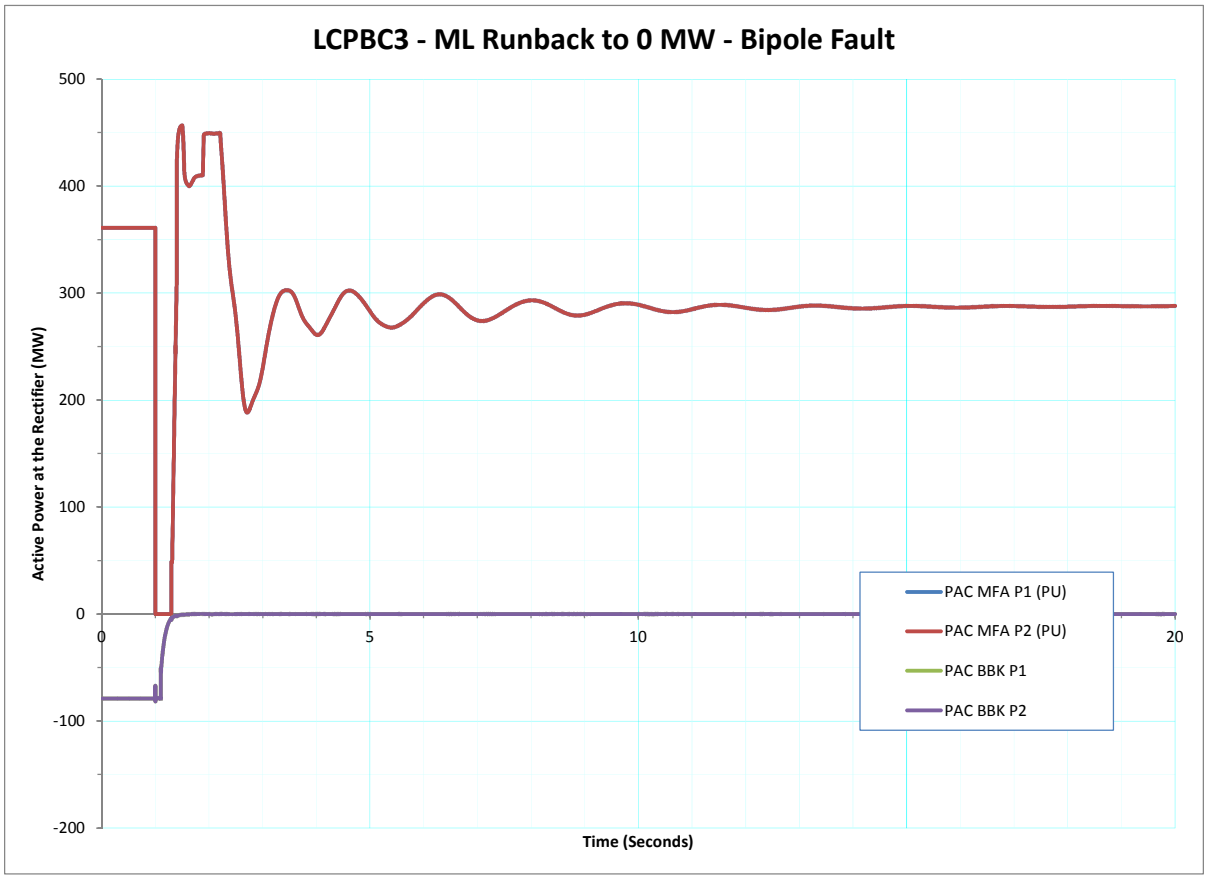

Figure 235 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - Active Power at the Rectifier (MW)

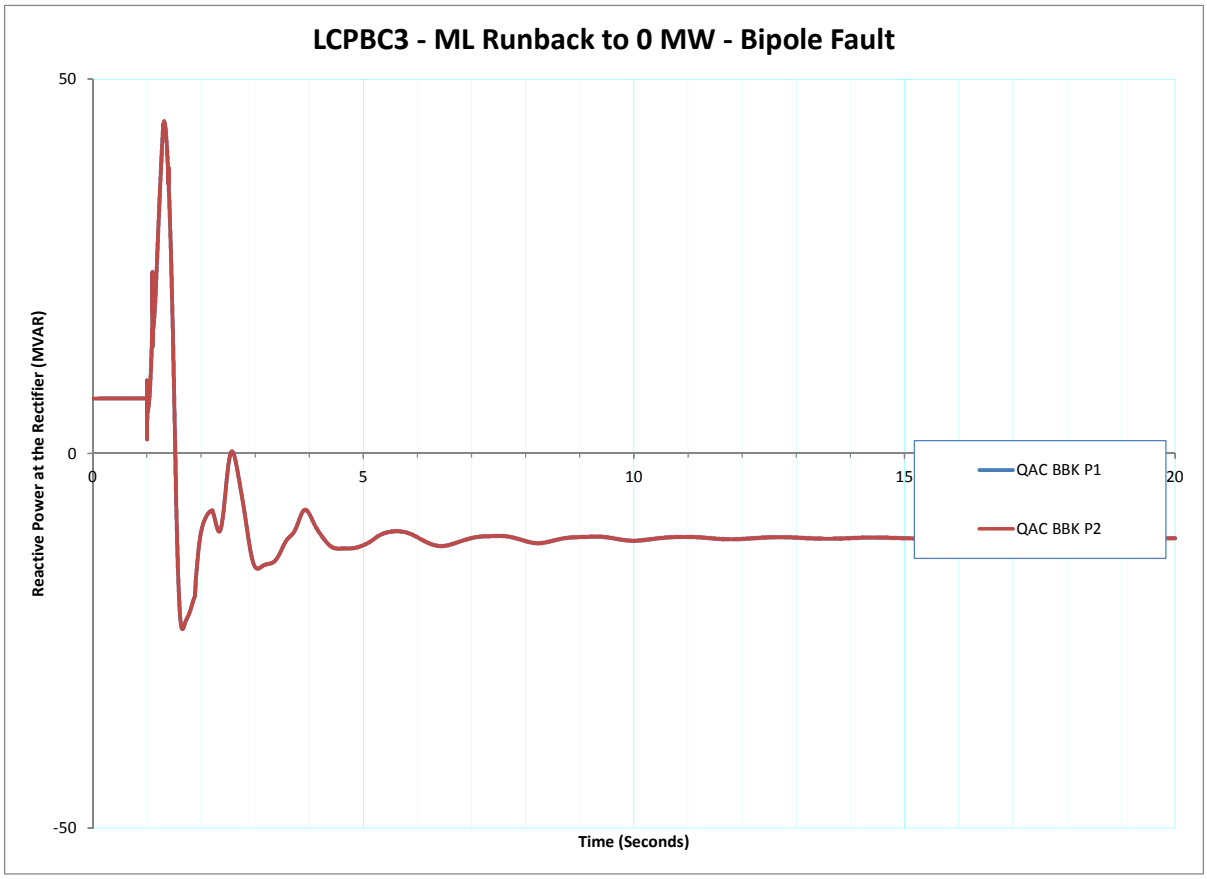

Figure 236 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

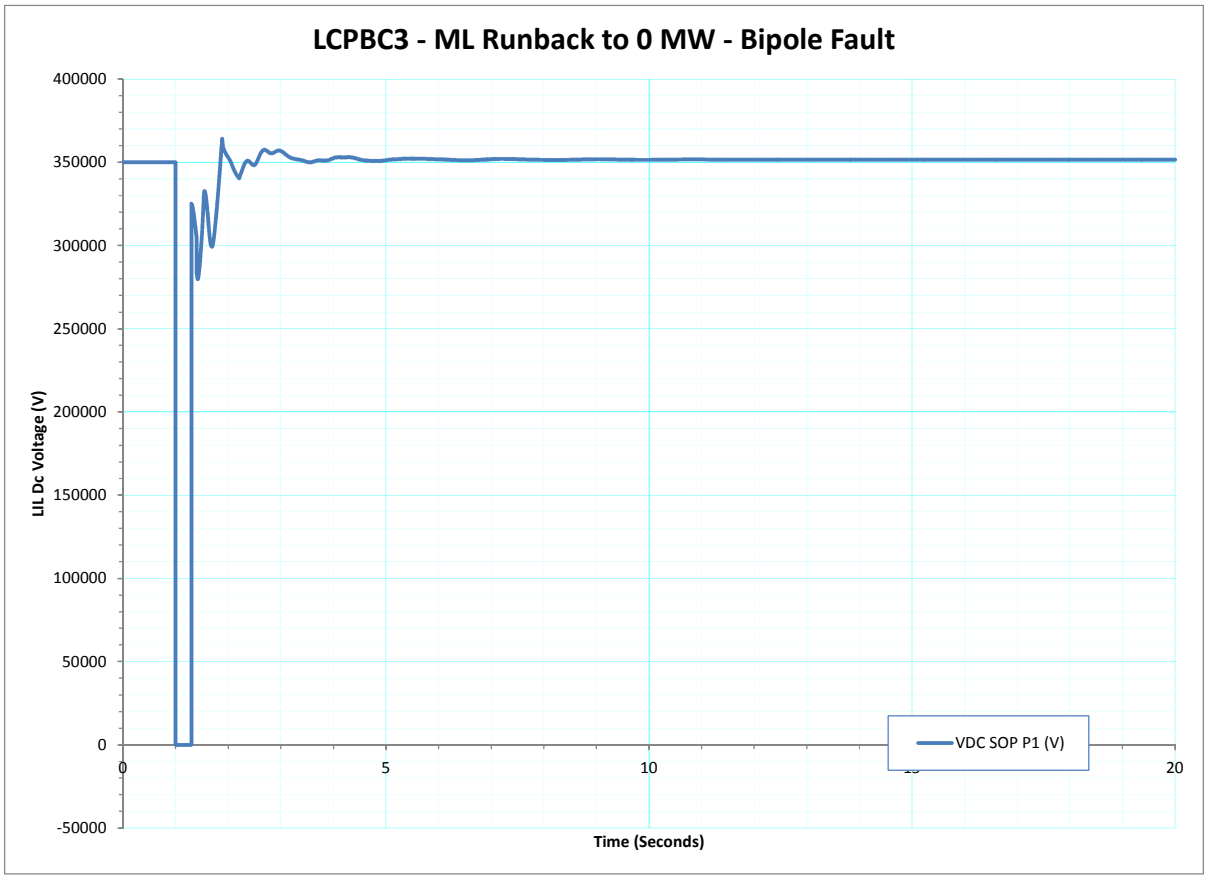

Figure 237 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - LIL Dc Voltage (V)

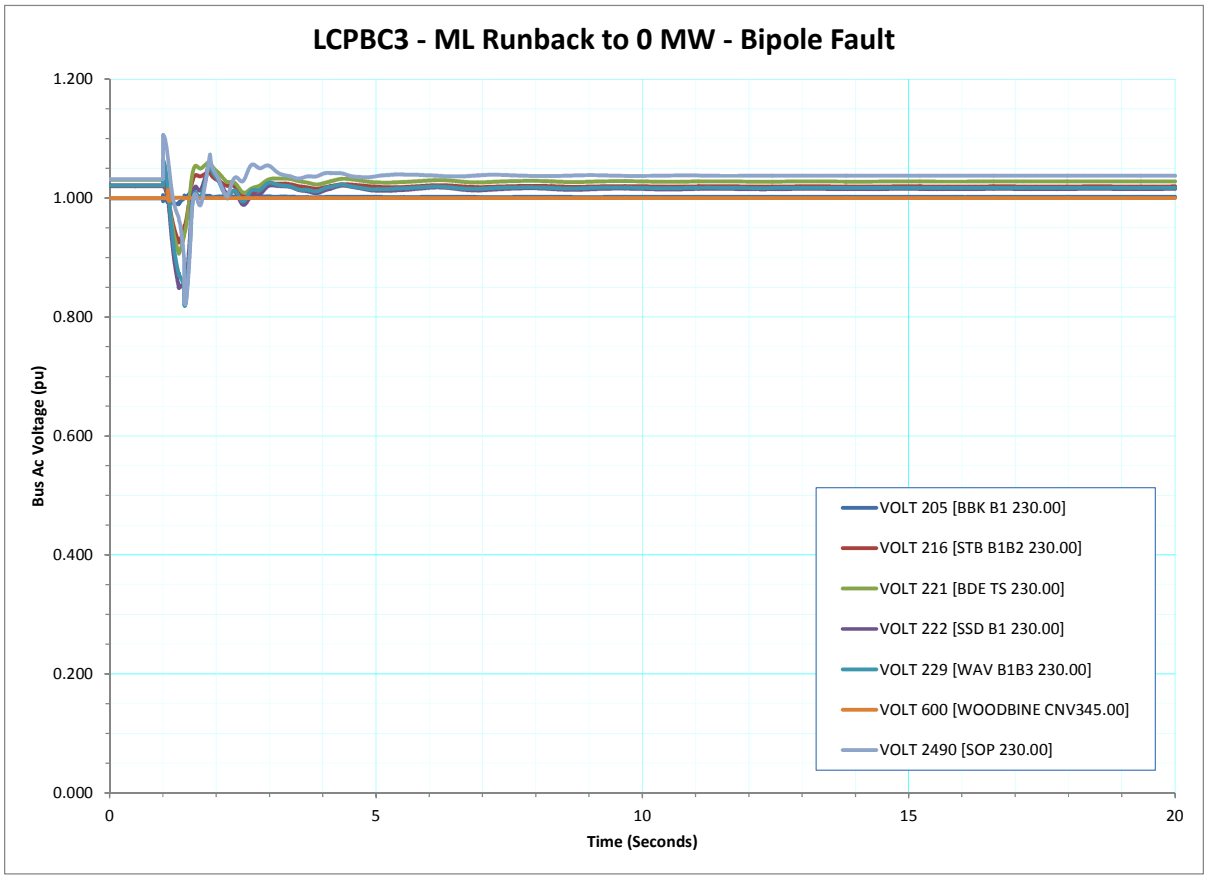

Figure 238 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - Bus Ac Voltage (pu)

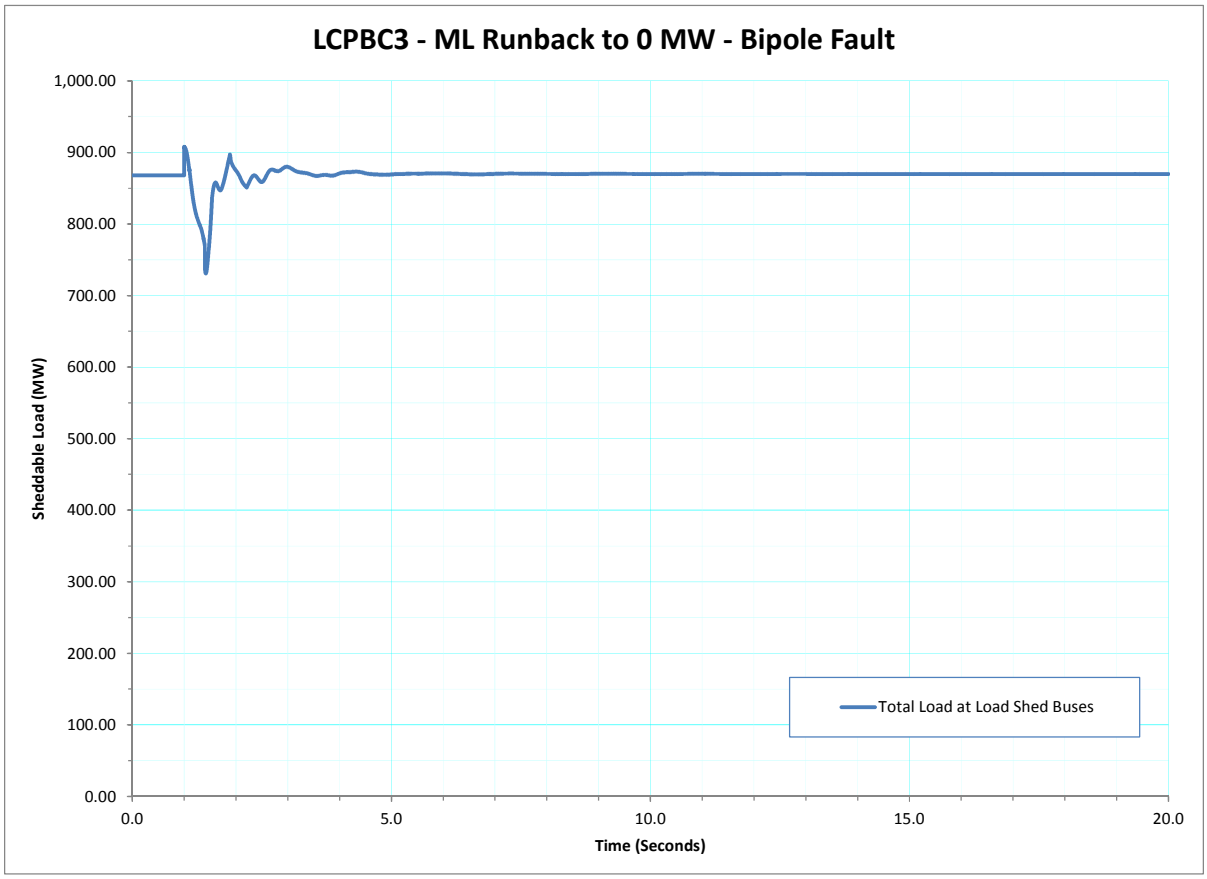

Figure 239 - LCPBC3 - ML Runback to 0 MW - Bipole Fault - Sheddable Load (MW)

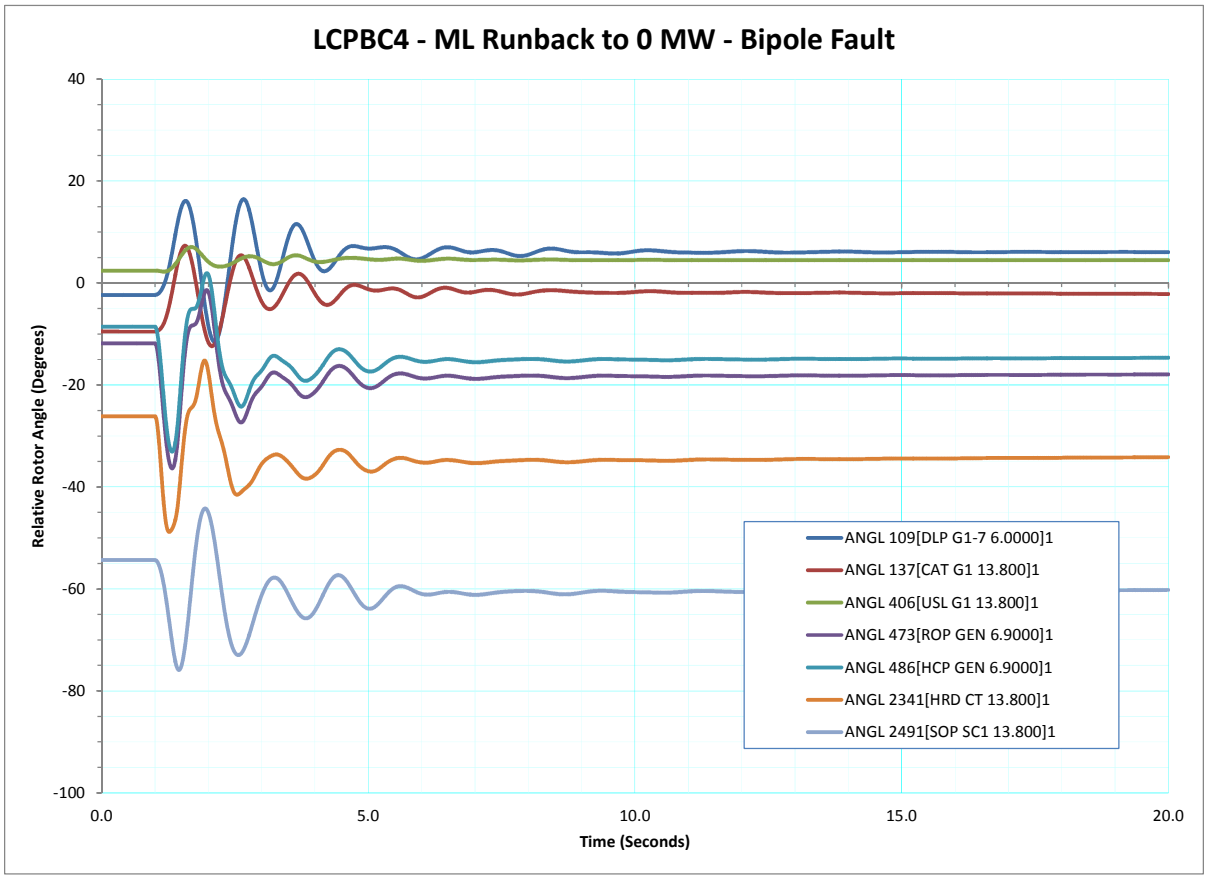

Figure 240 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - Relative Rotor Angle (Degrees)

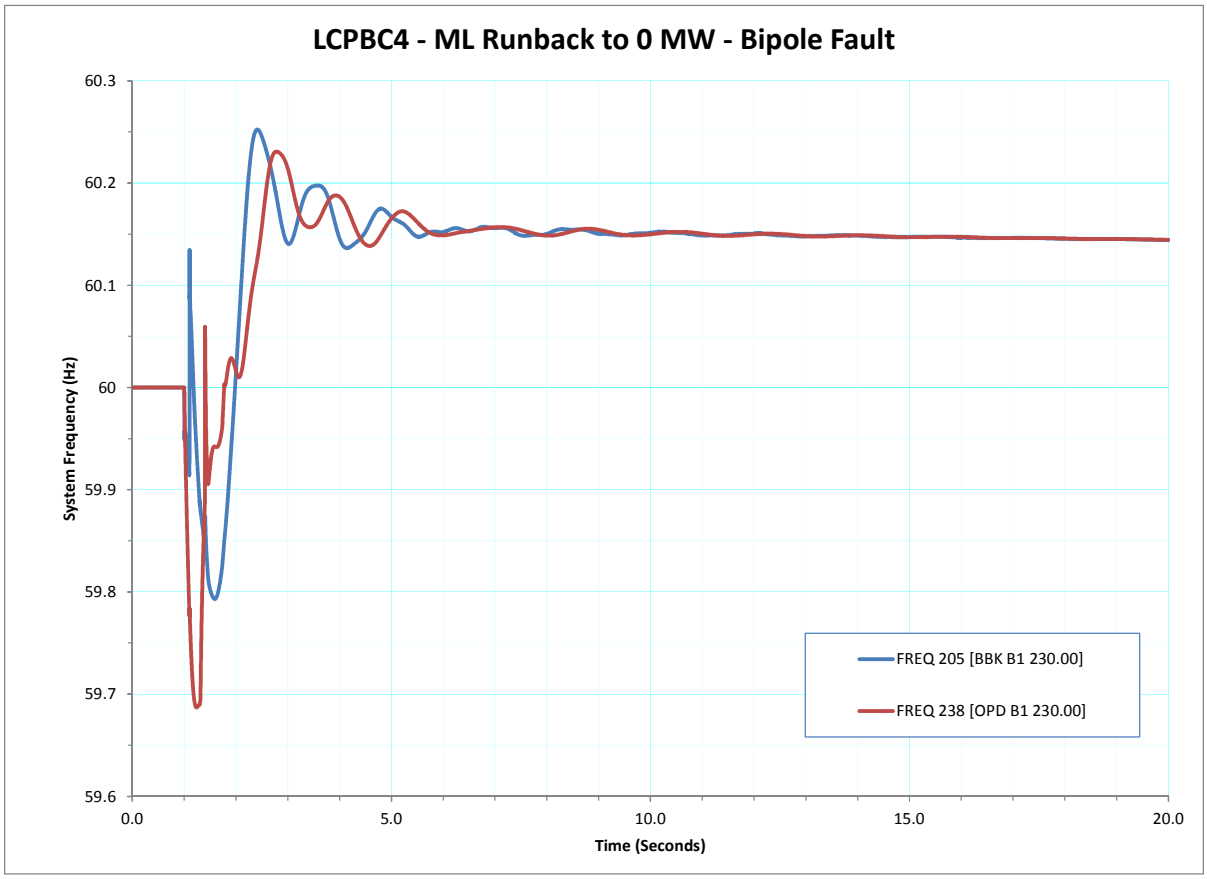

Figure 241 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - System Frequency (Hz)

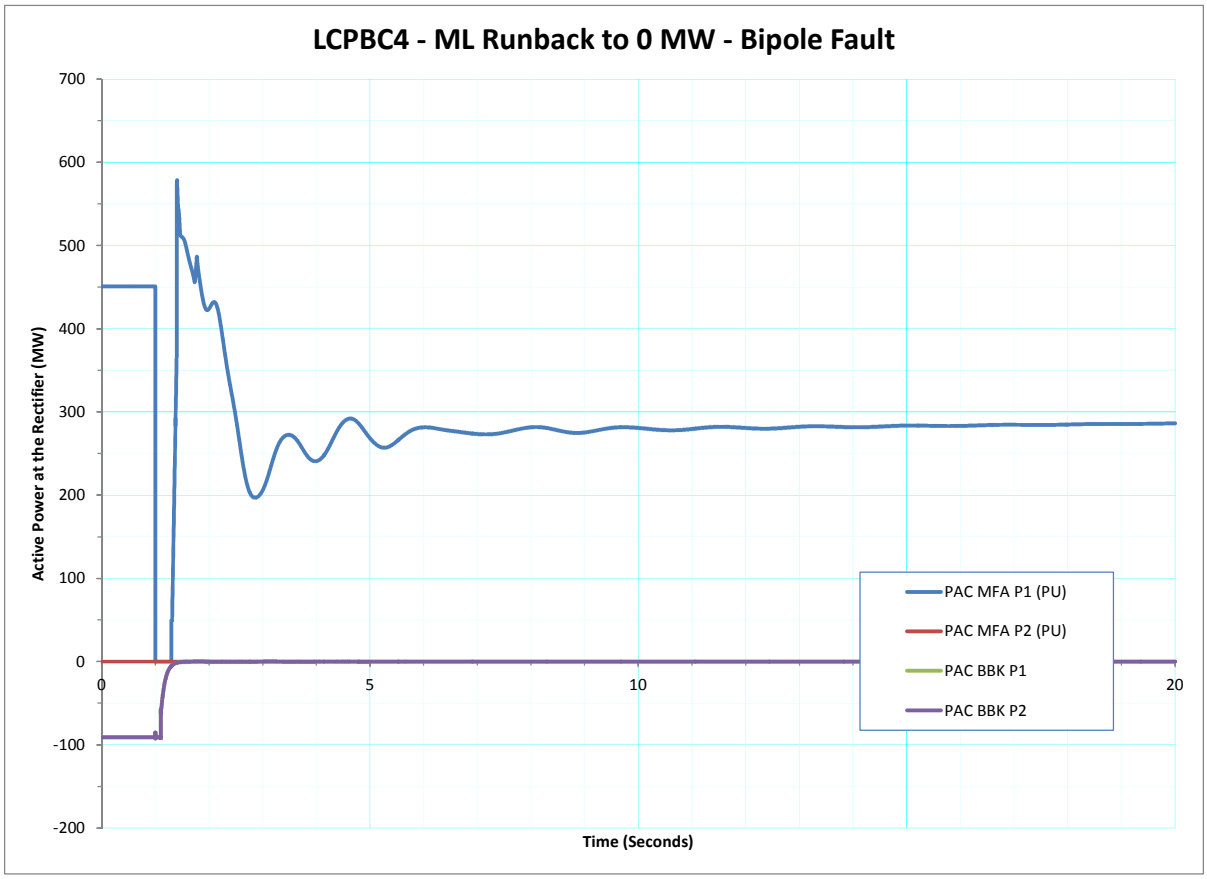

Figure 242 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - Active Power at the Rectifier (MW)

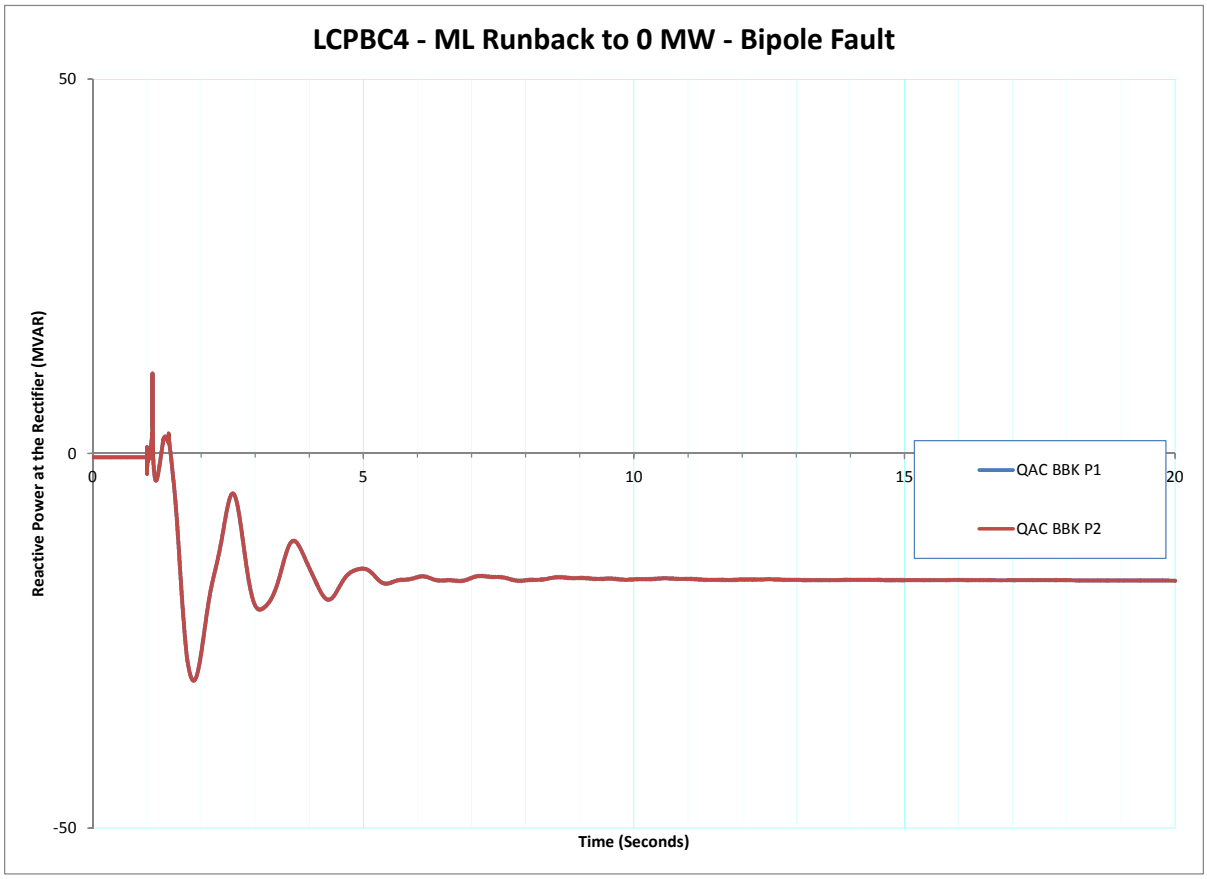

Figure 243 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

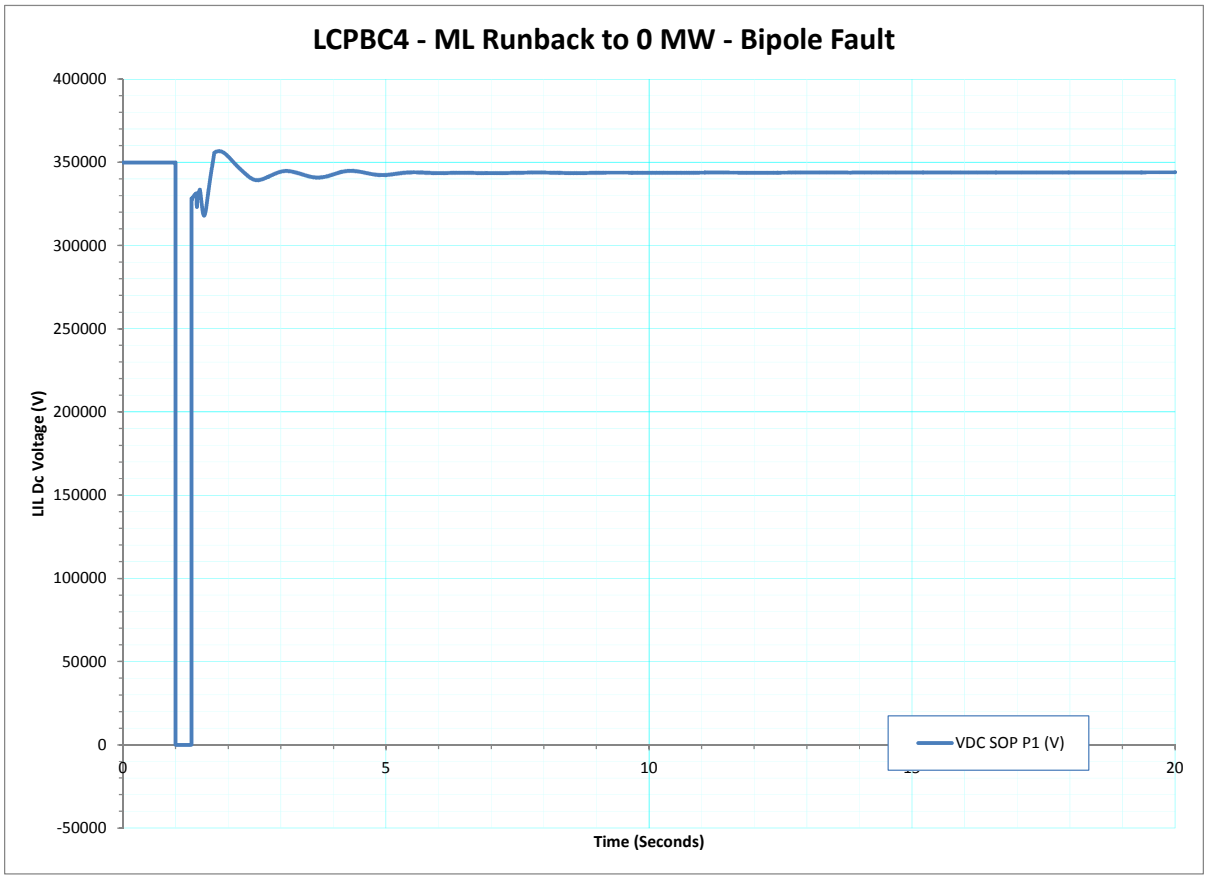

Figure 244 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - LIL Dc Voltage (V)

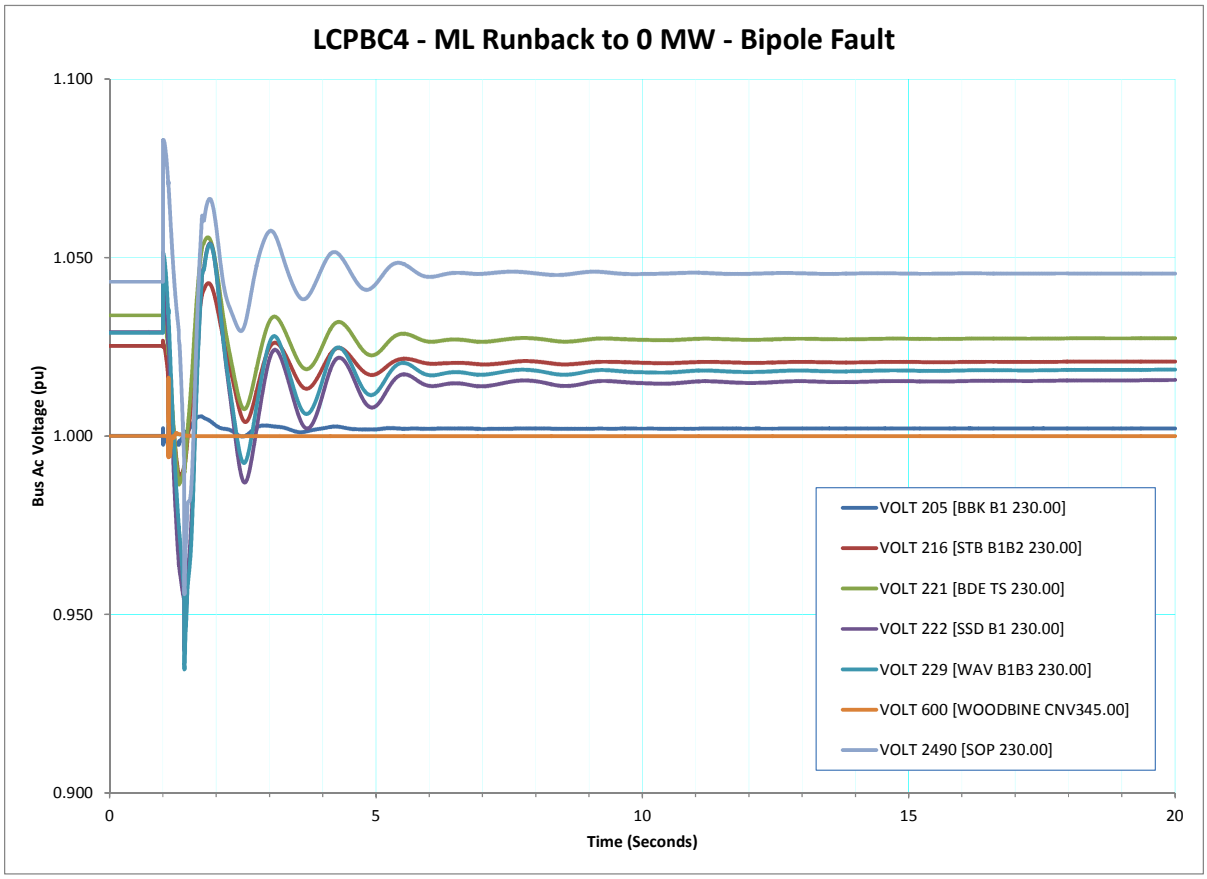

Figure 245 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - Bus Ac Voltage (pu)

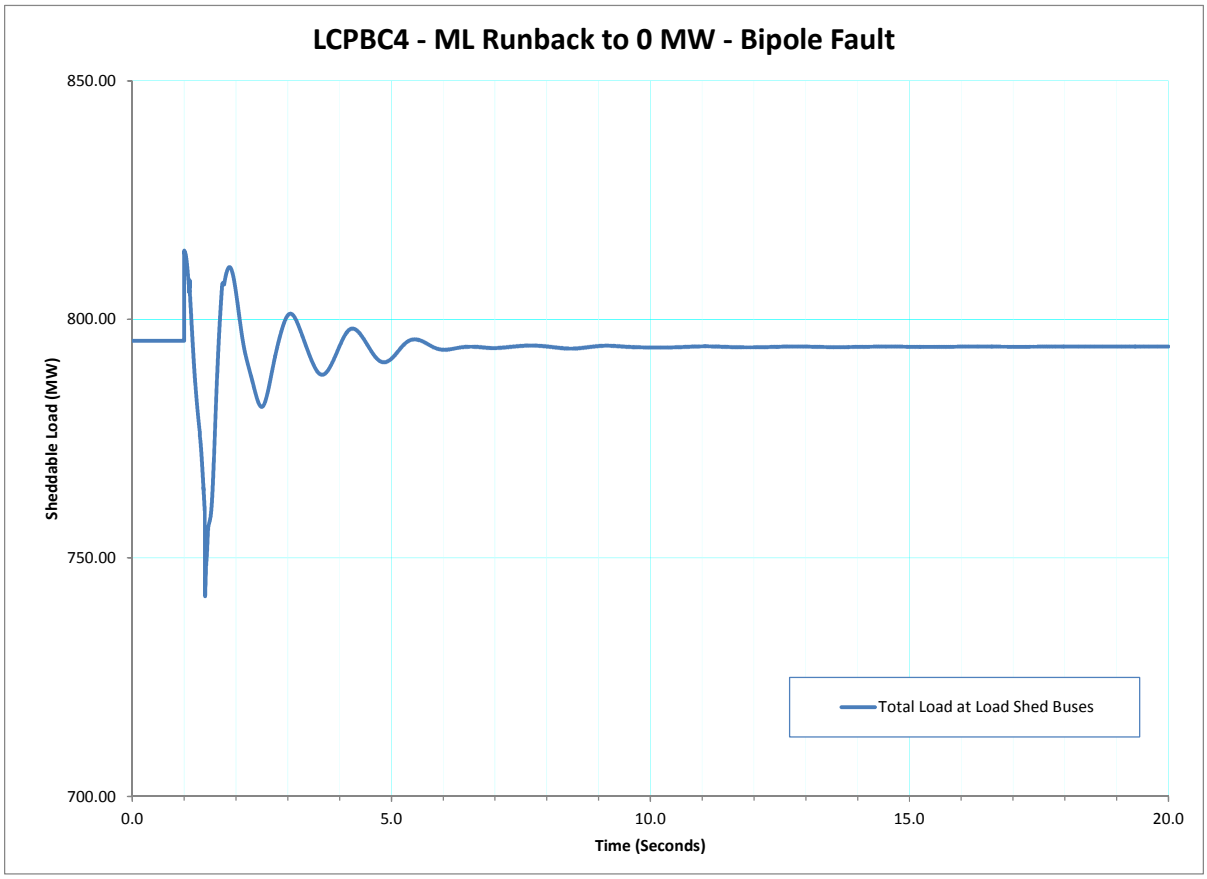

Figure 246 - LCPBC4 - ML Runback to 0 MW - Bipole Fault - Sheddable Load (MW)

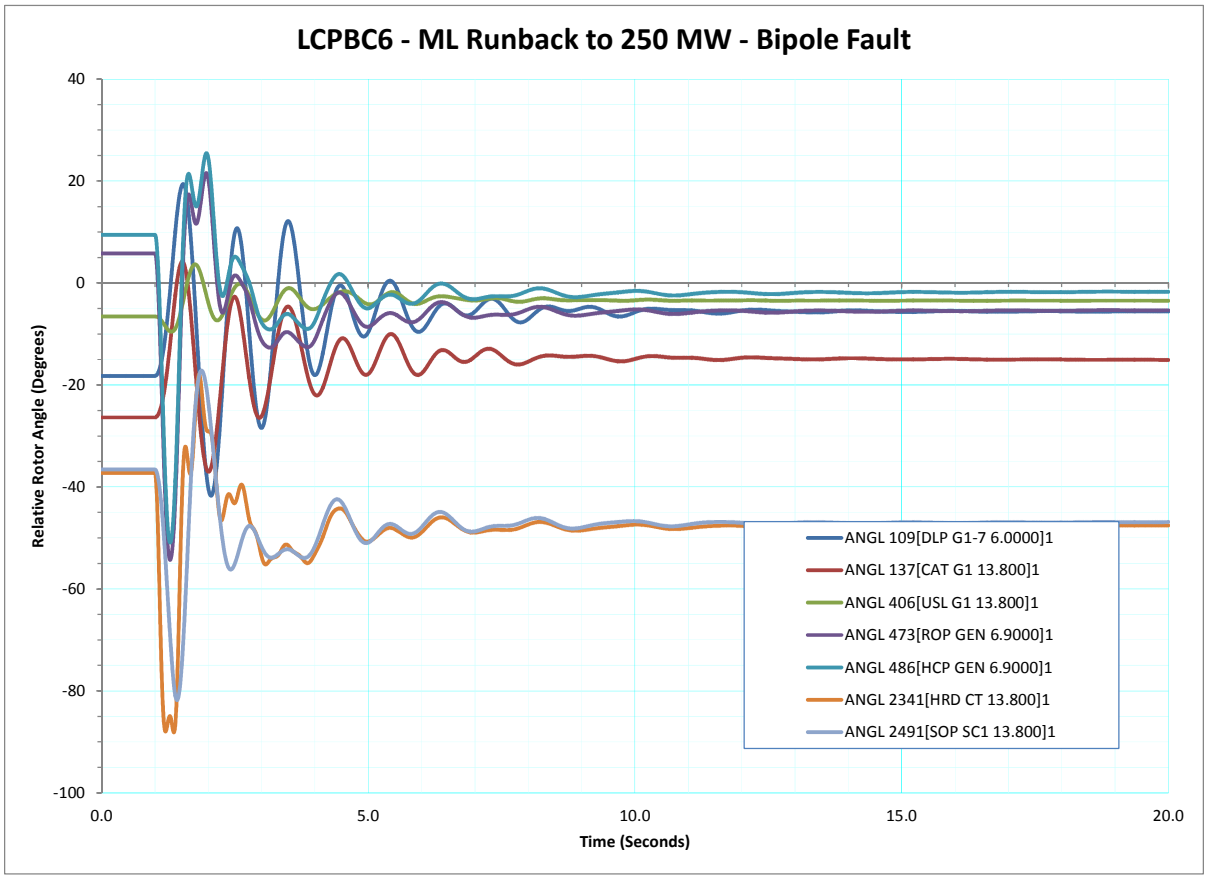

Figure 247 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - Relative Rotor Angle (Degrees)

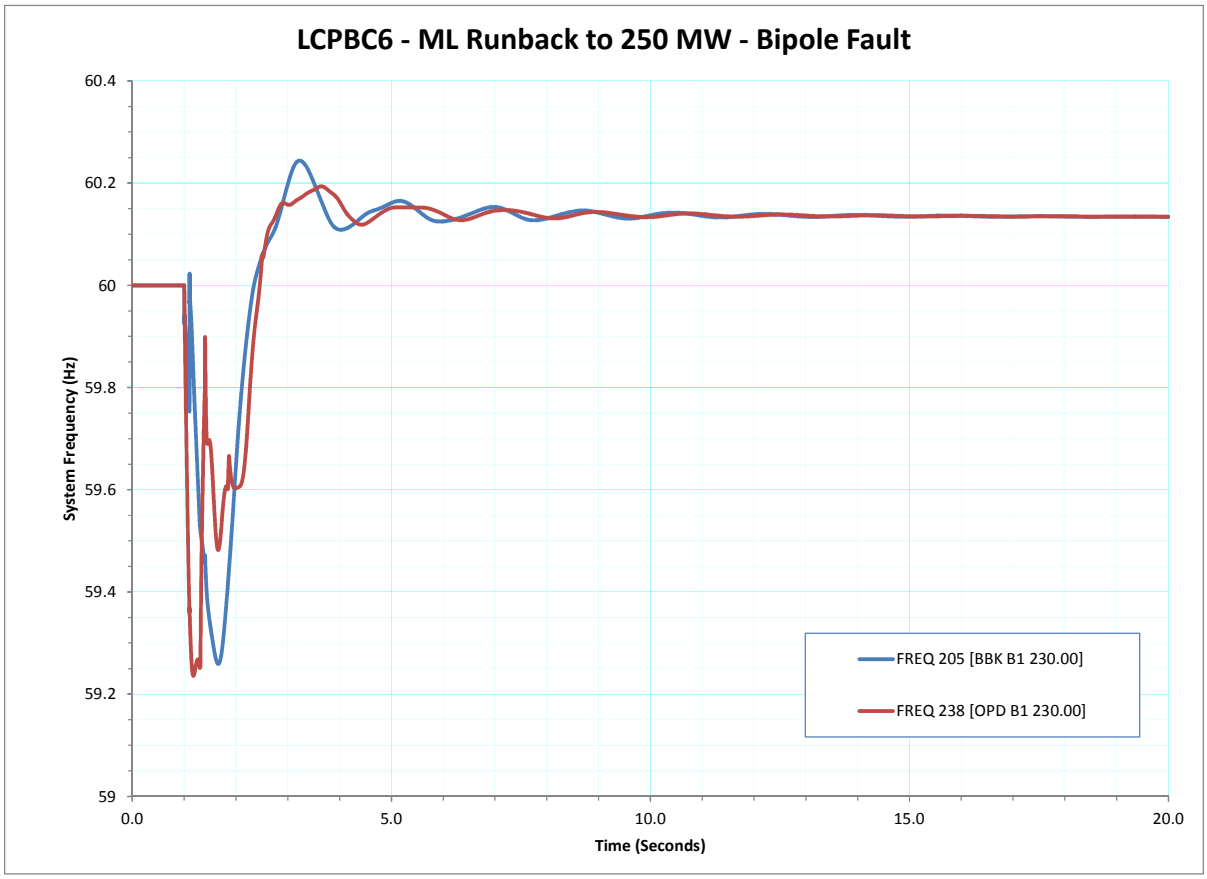

Figure 248 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - System Frequency (Hz)

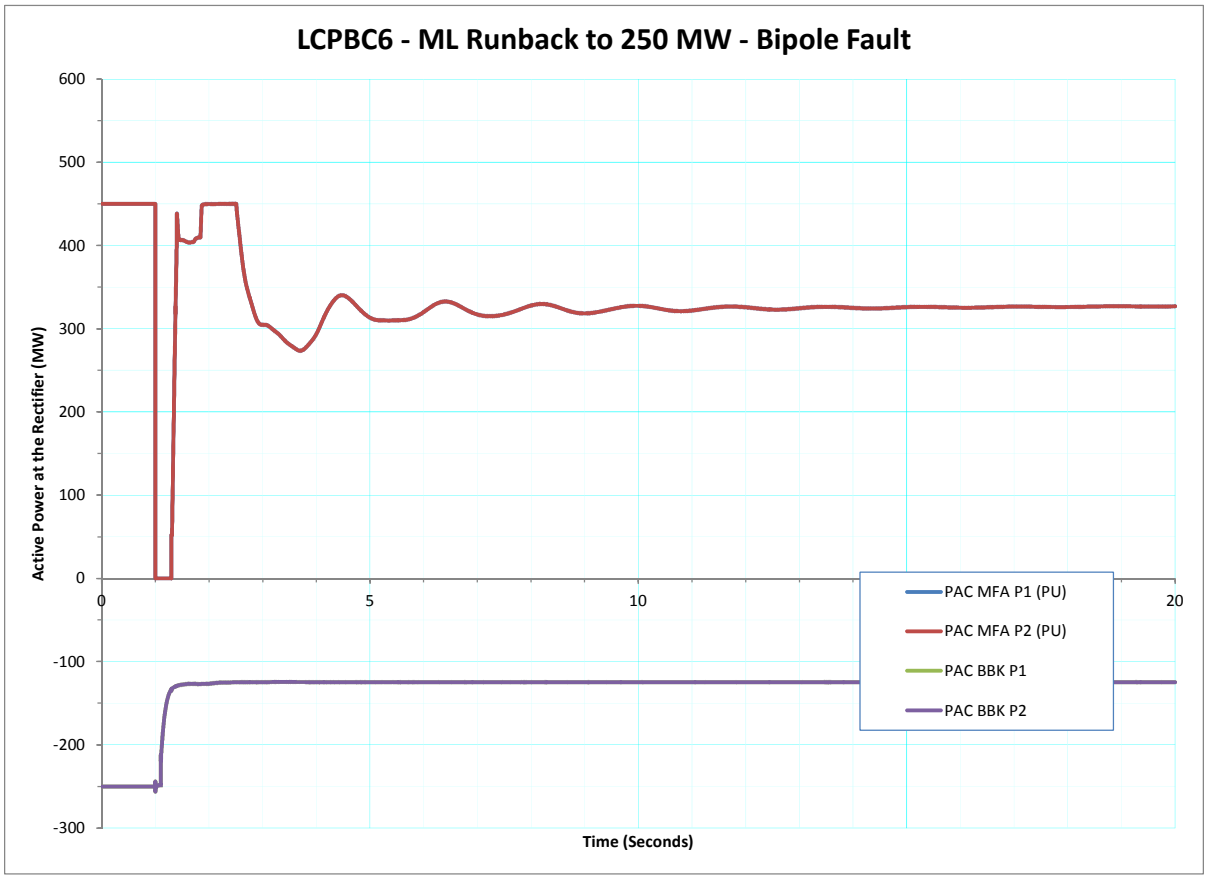

Figure 249 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - Active Power at the Rectifier (MW)

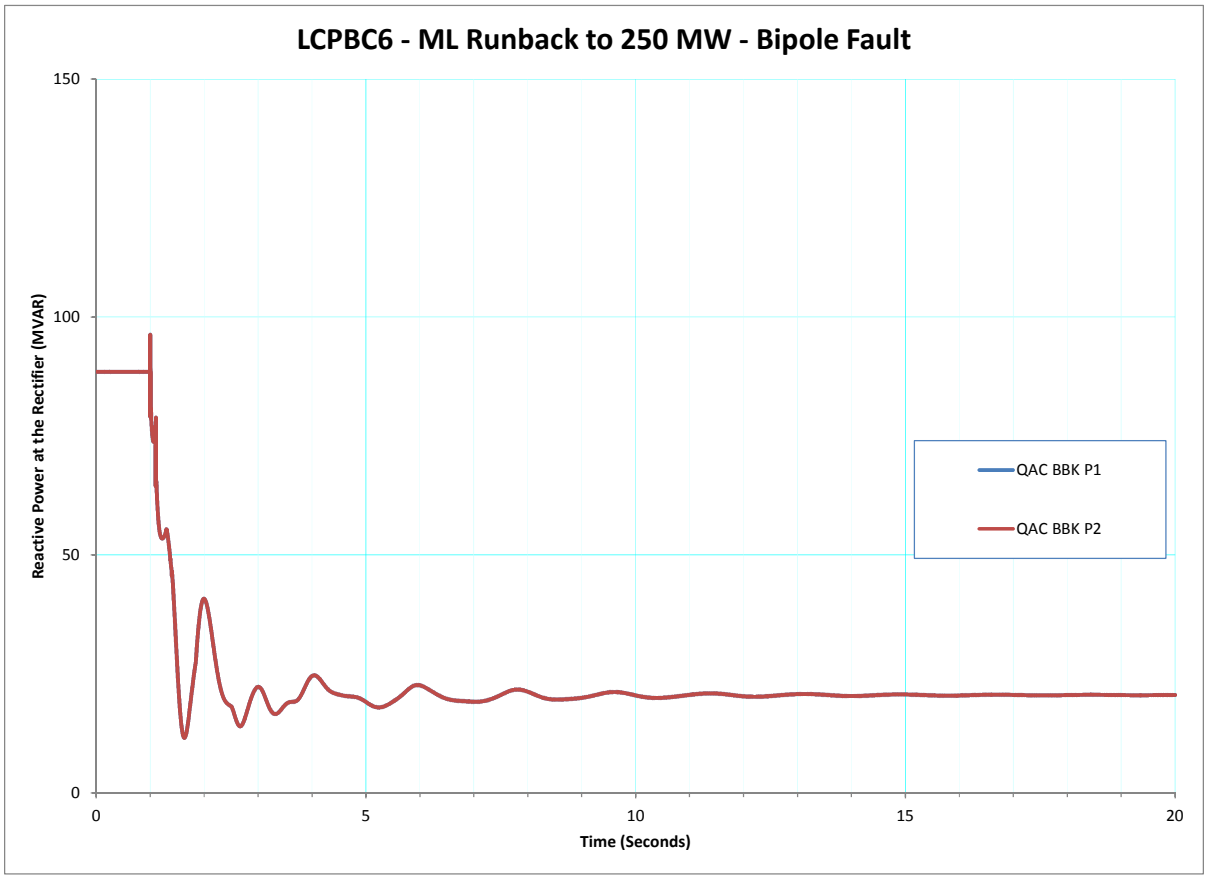

Figure 250 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

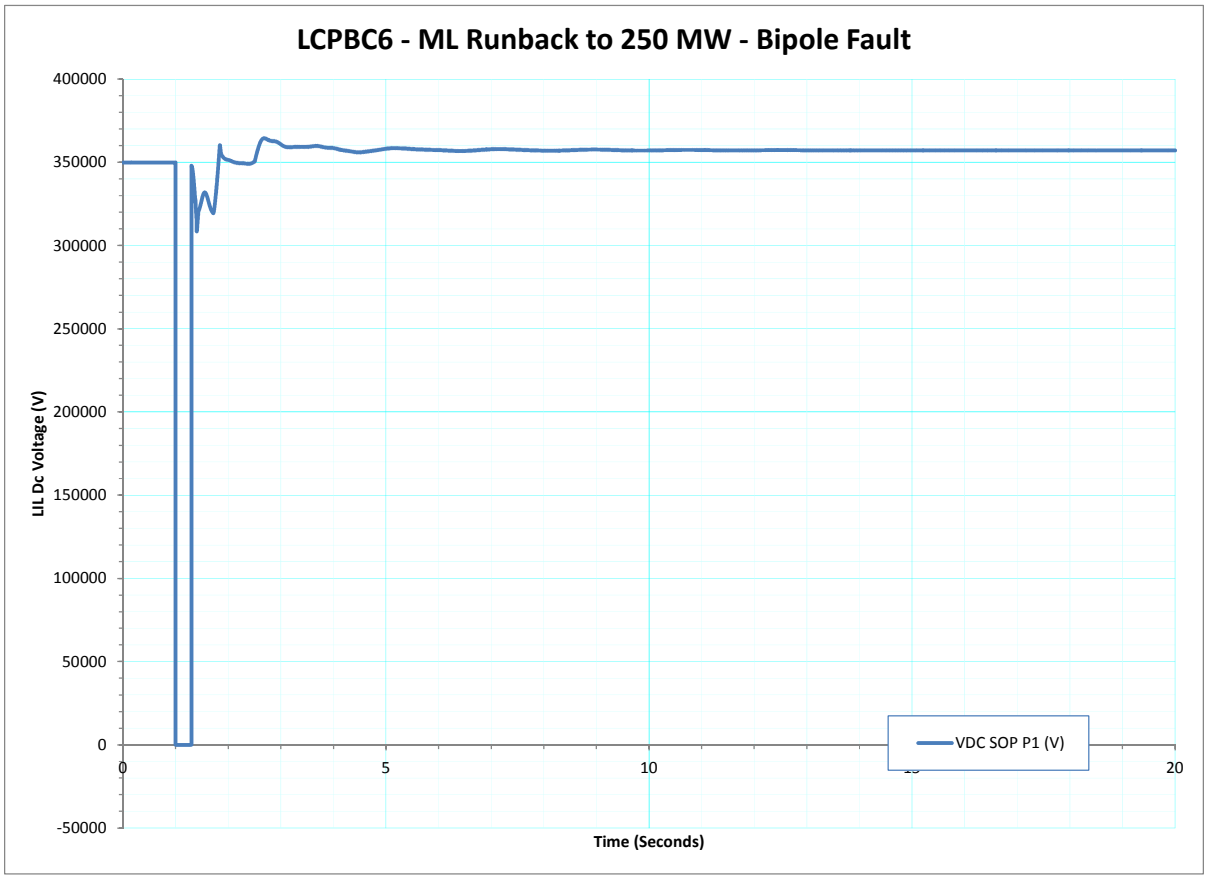

Figure 251 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - LIL Dc Voltage (V)

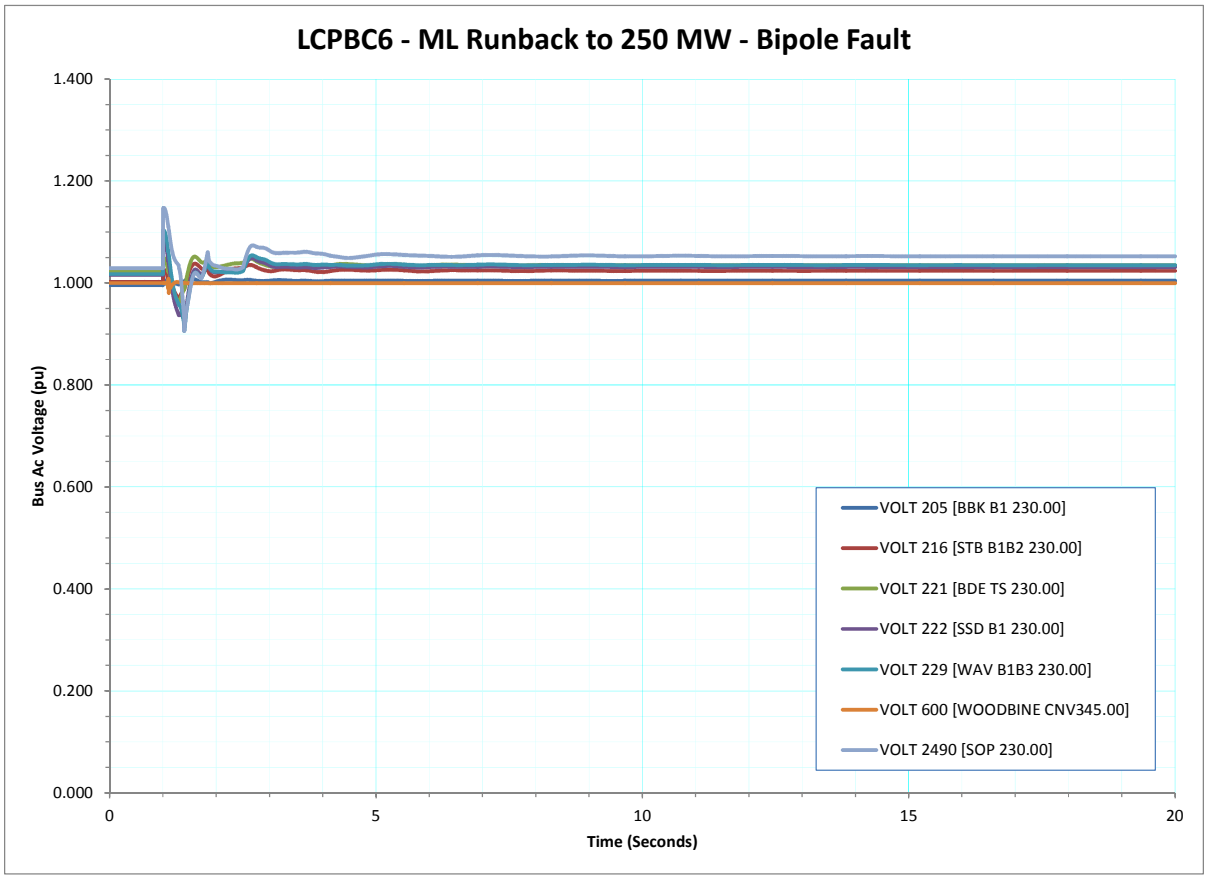

Figure 252 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - Bus Ac Voltage (pu)

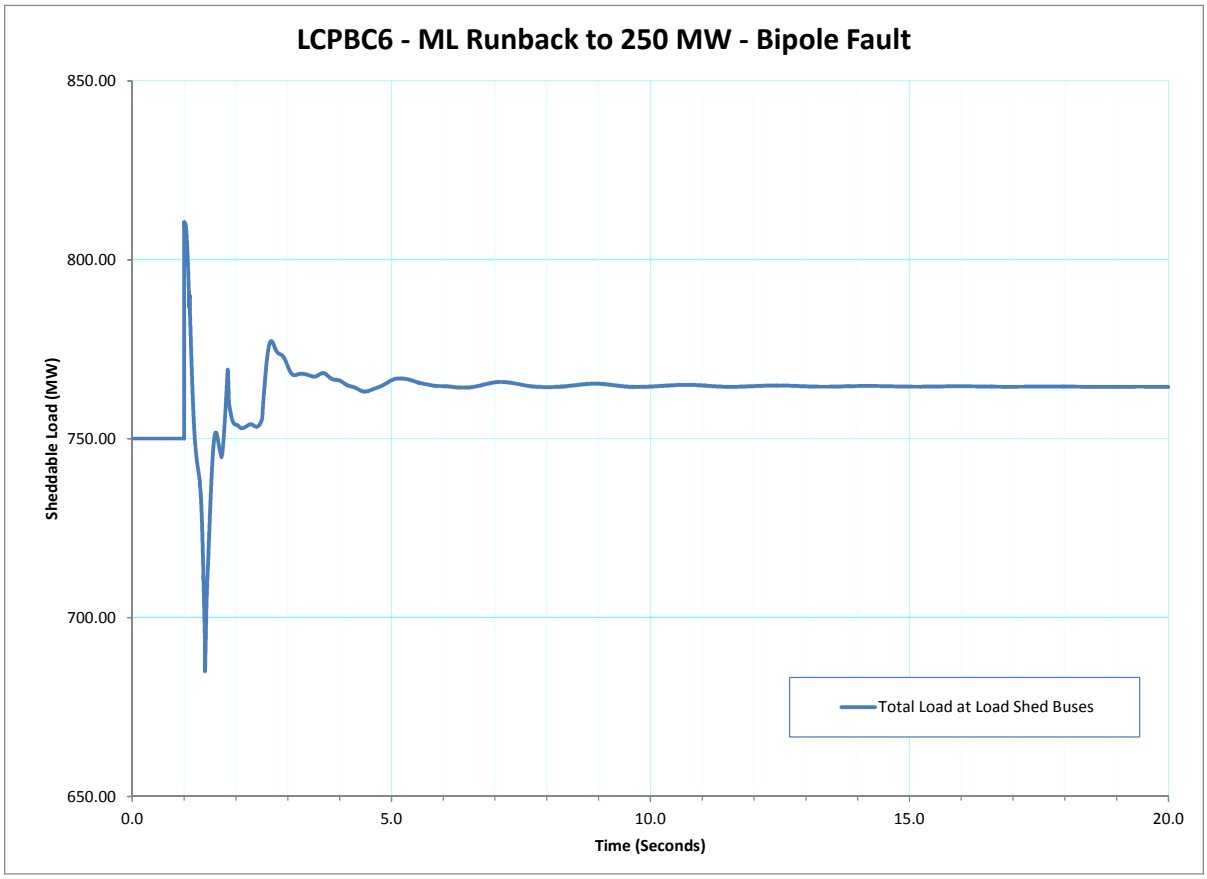

Figure 253 - LCPBC6 - ML Runback to 250 MW - Bipole Fault - Sheddable Load (MW)

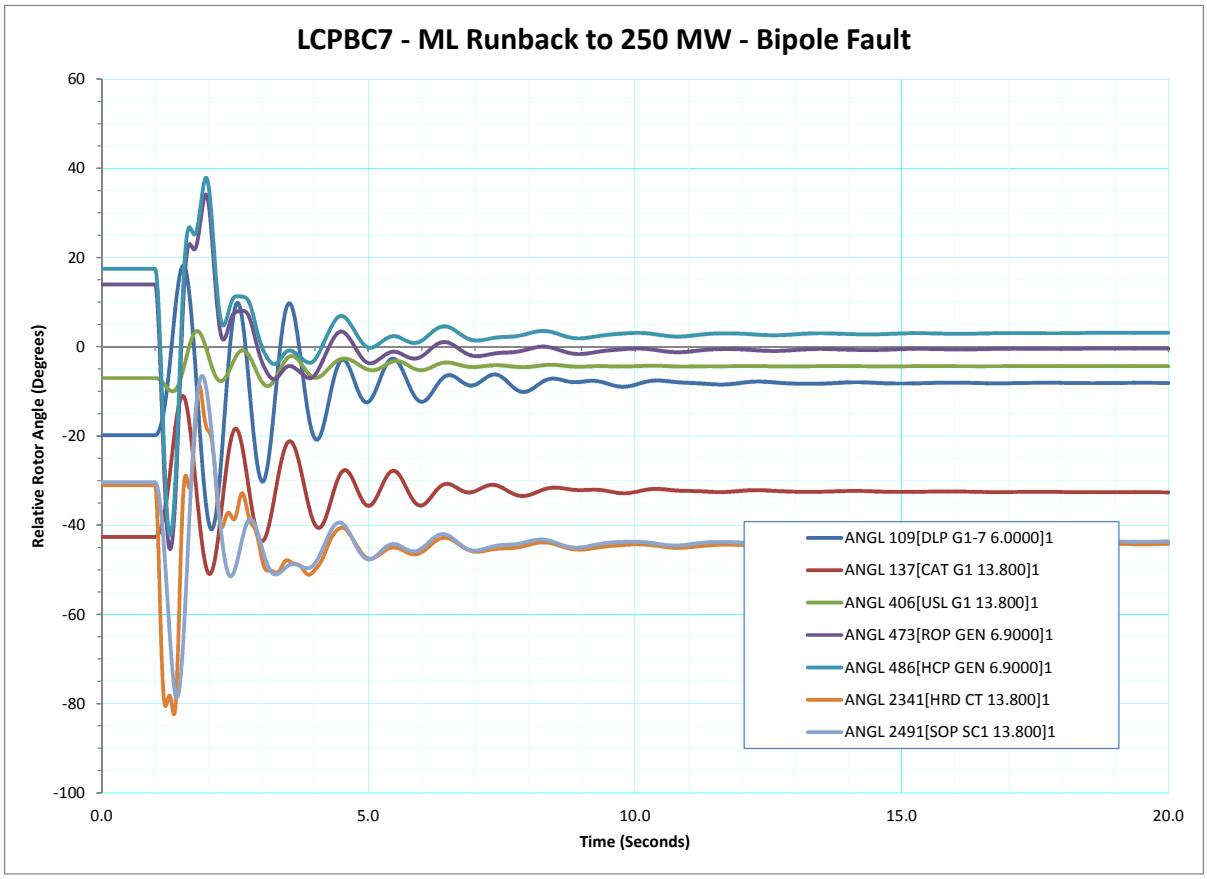

Figure 254 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - Relative Rotor Angle (Degrees)

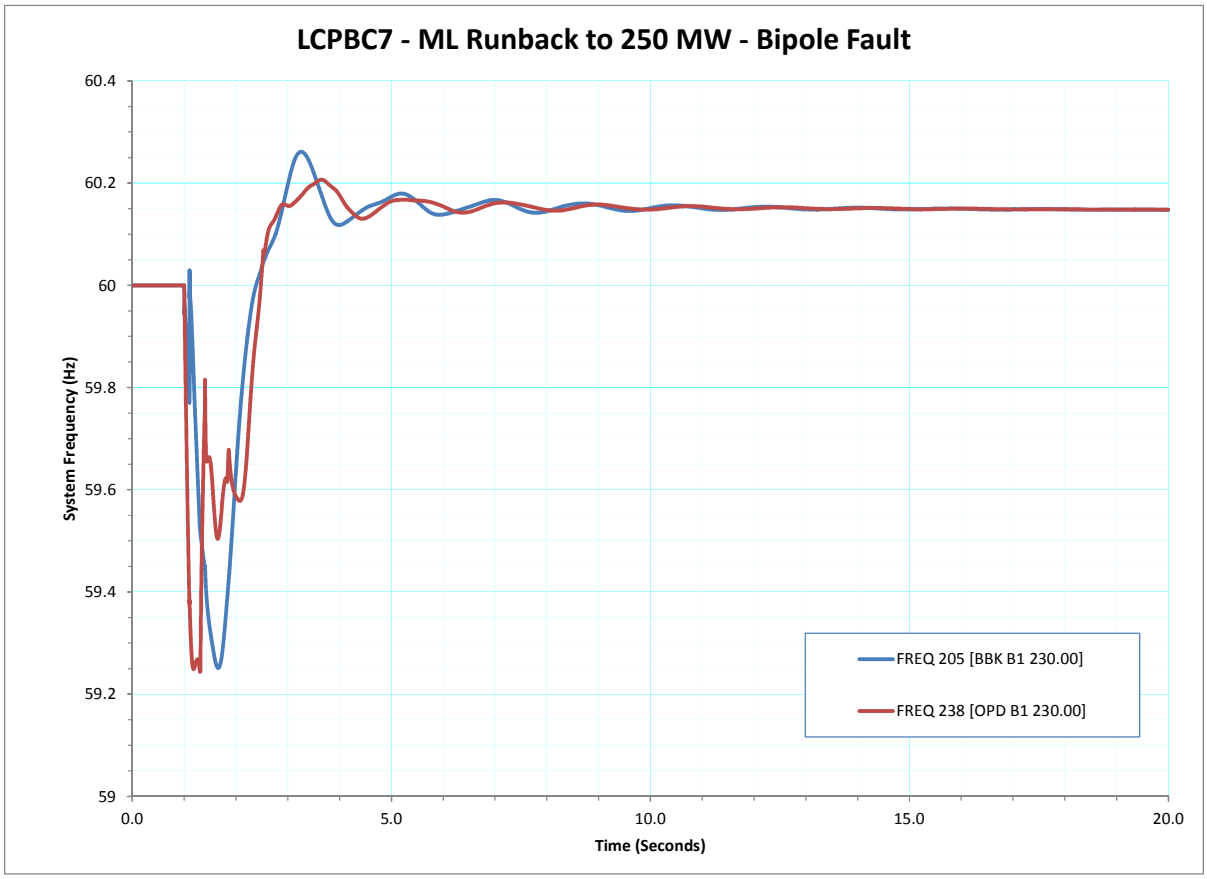

Figure 255 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - System Frequency (Hz)

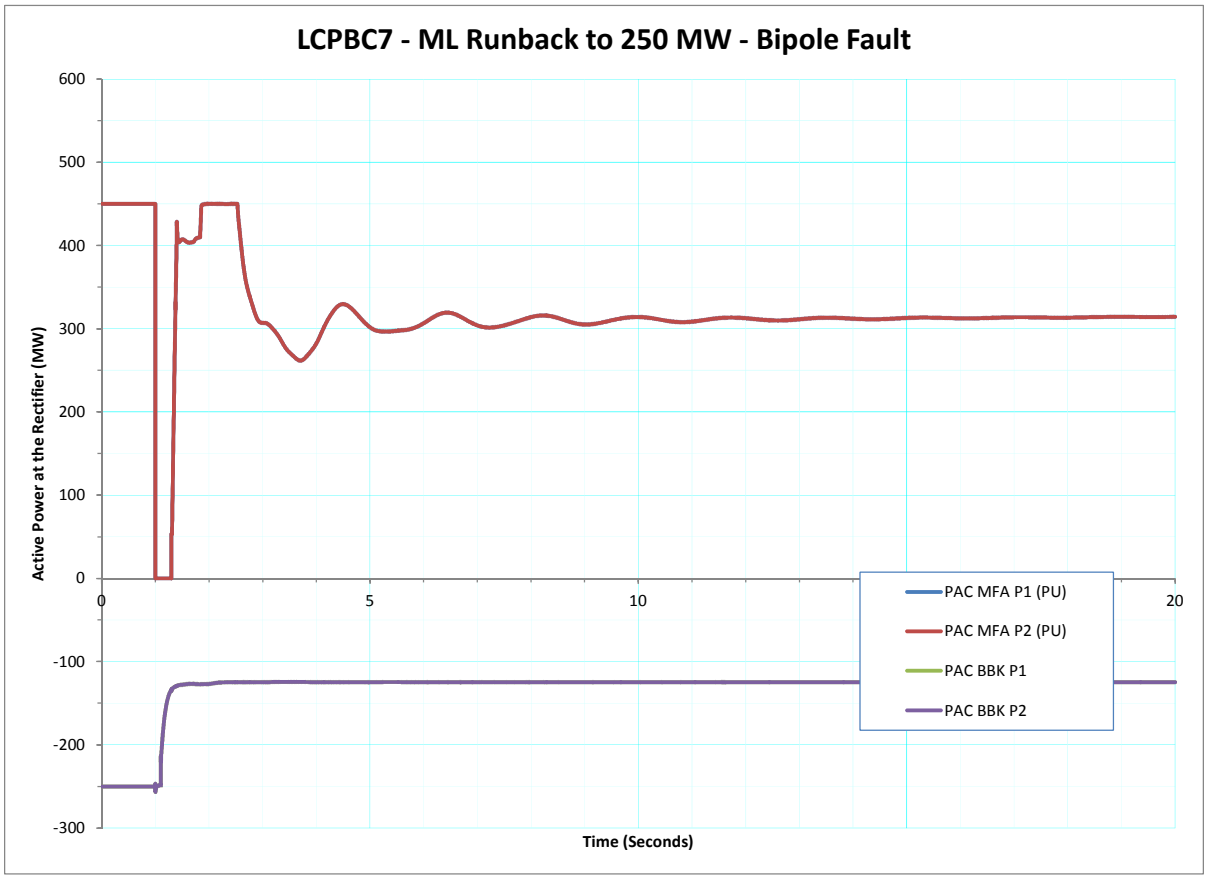

Figure 256 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - Active Power at the Rectifier (MW)

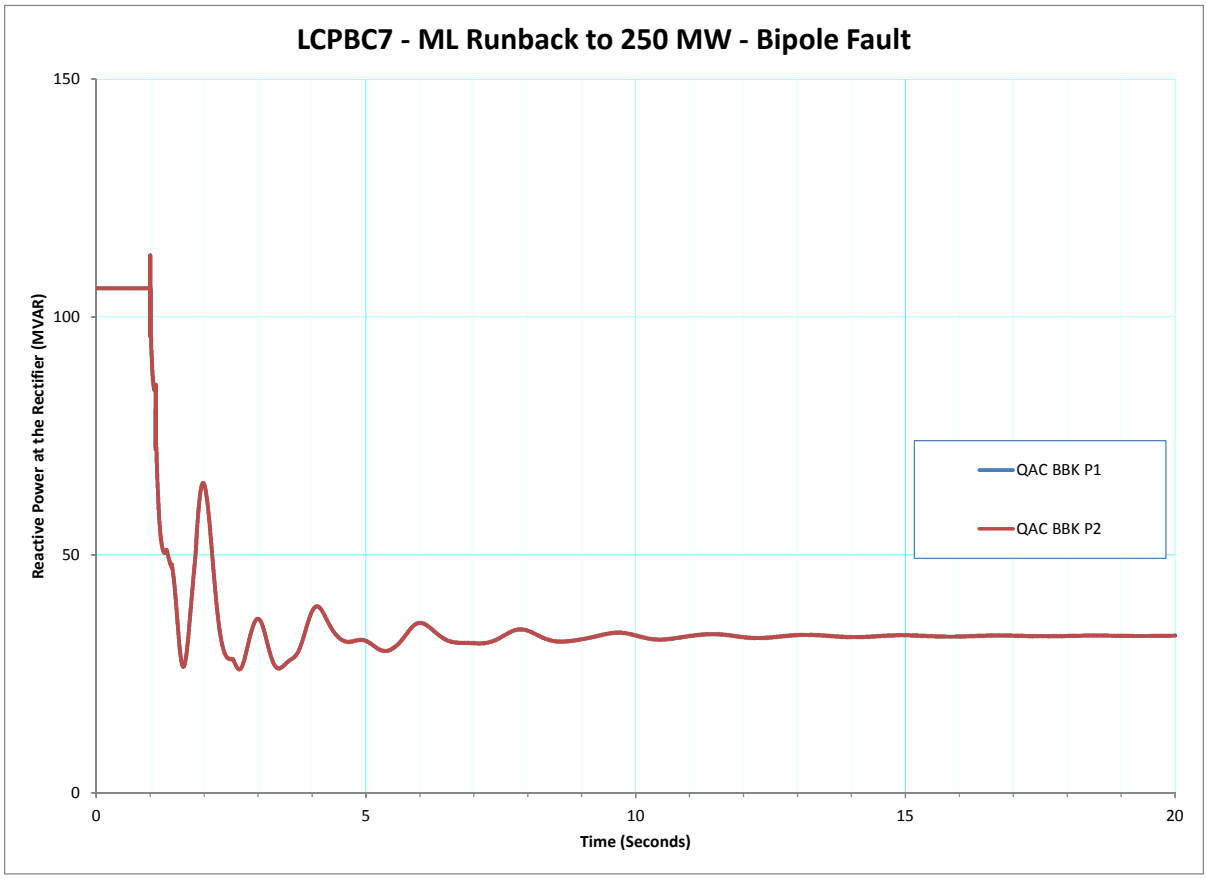

Figure 257 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

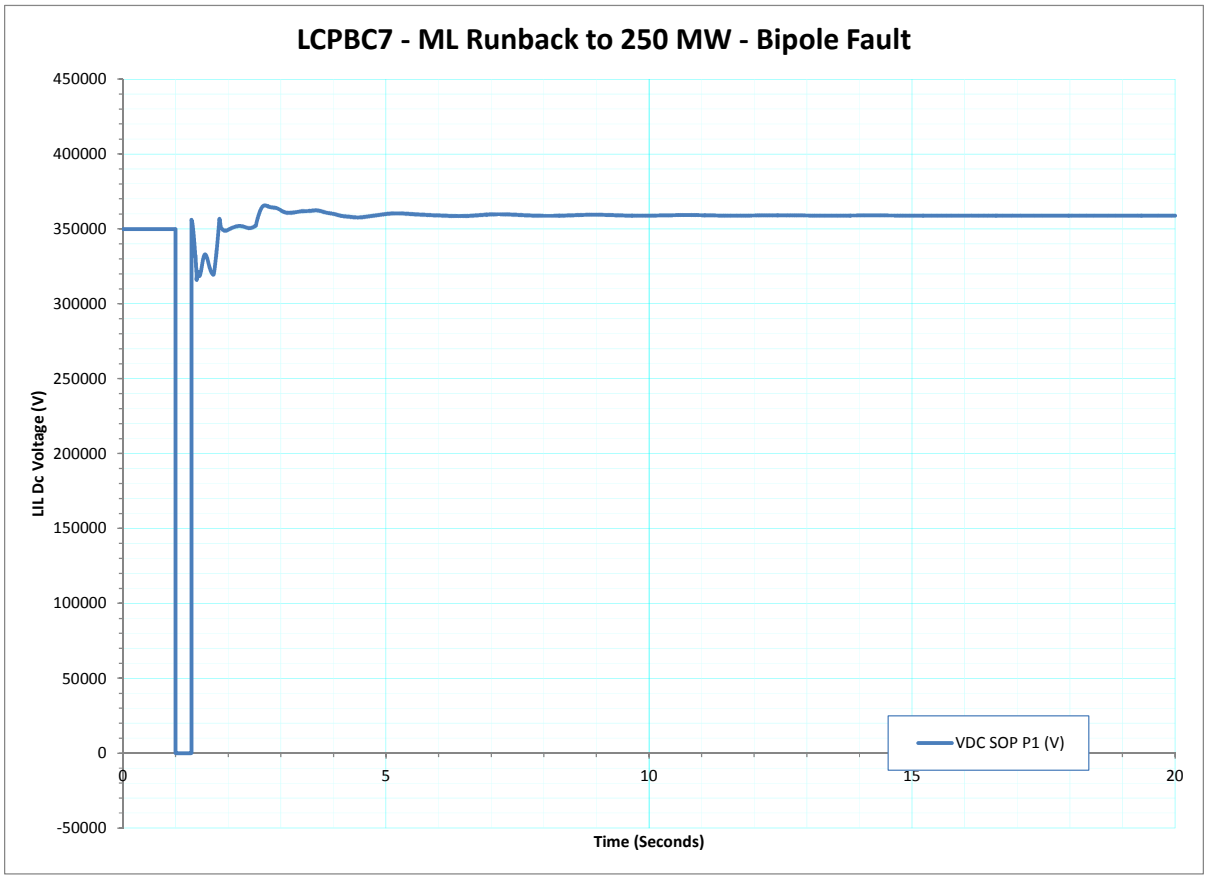

Figure 258 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - LIL Dc Voltage (V)

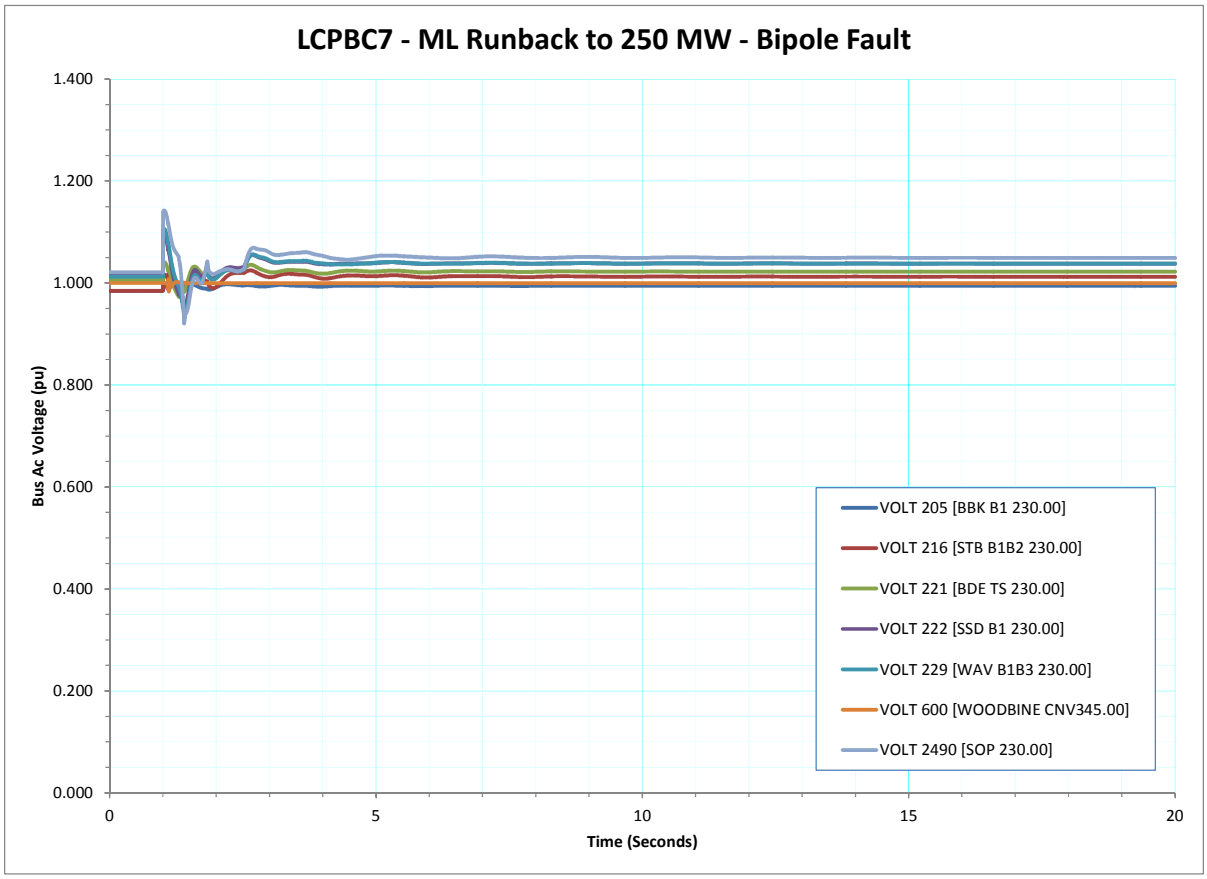

Figure 259 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - Bus Ac Voltage (pu)

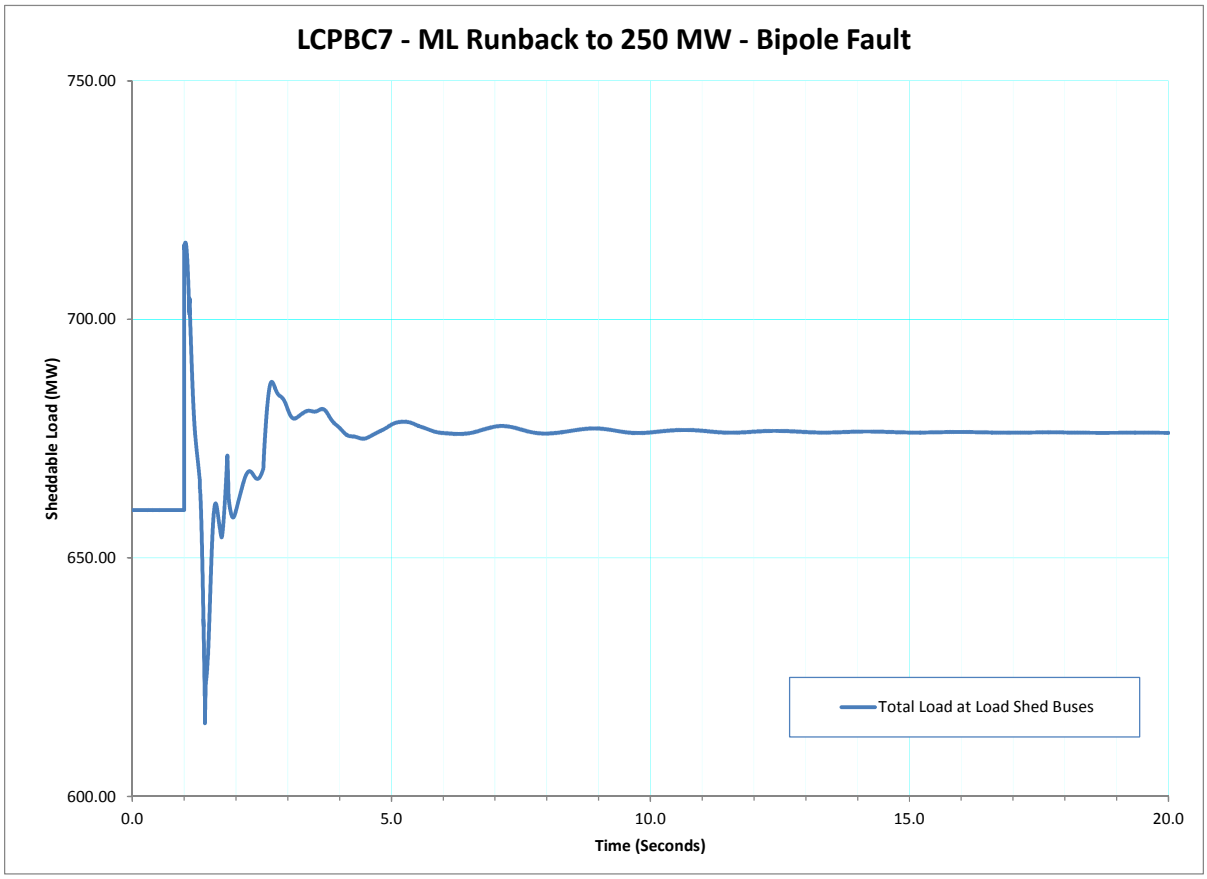

Figure 260 - LCPBC7 - ML Runback to 250 MW - Bipole Fault - Sheddable Load (MW)

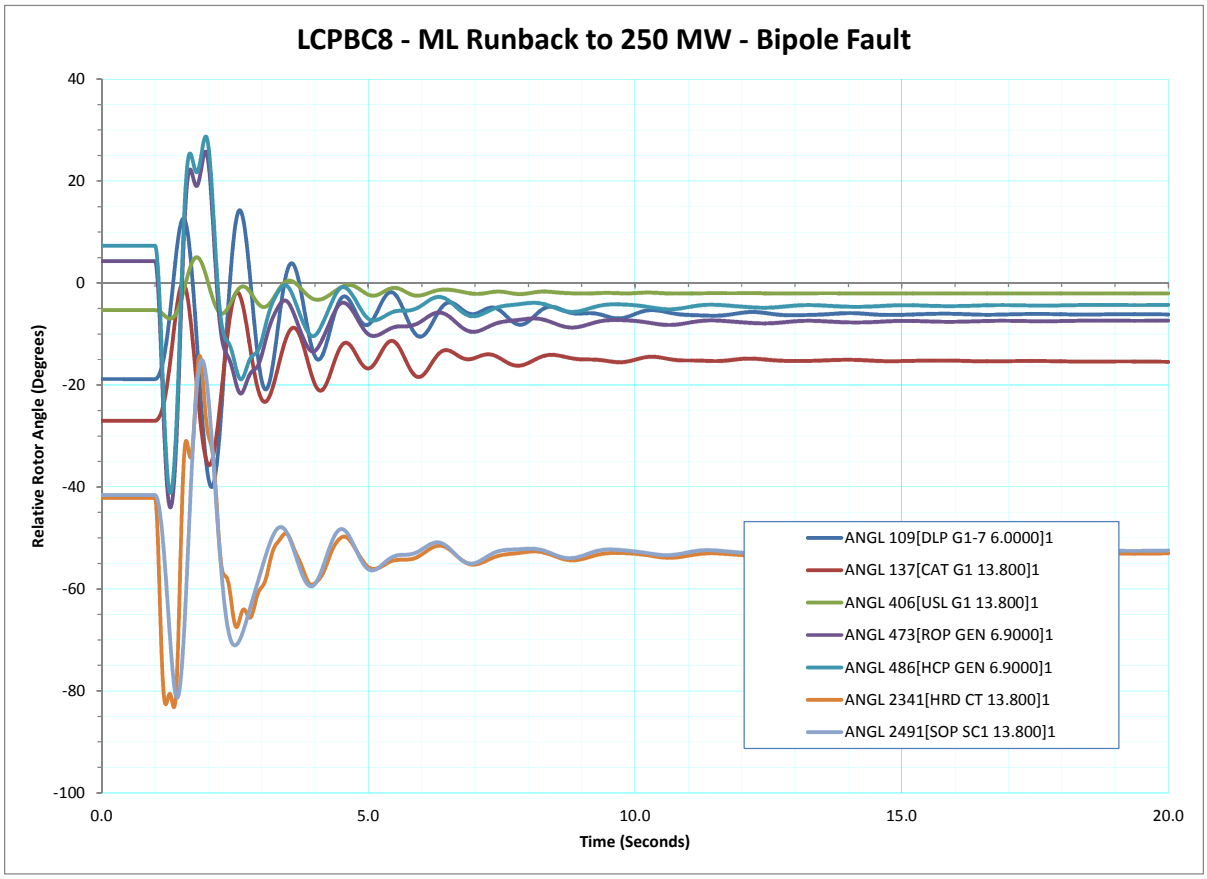

Figure 261 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - Relative Rotor Angle (Degrees)

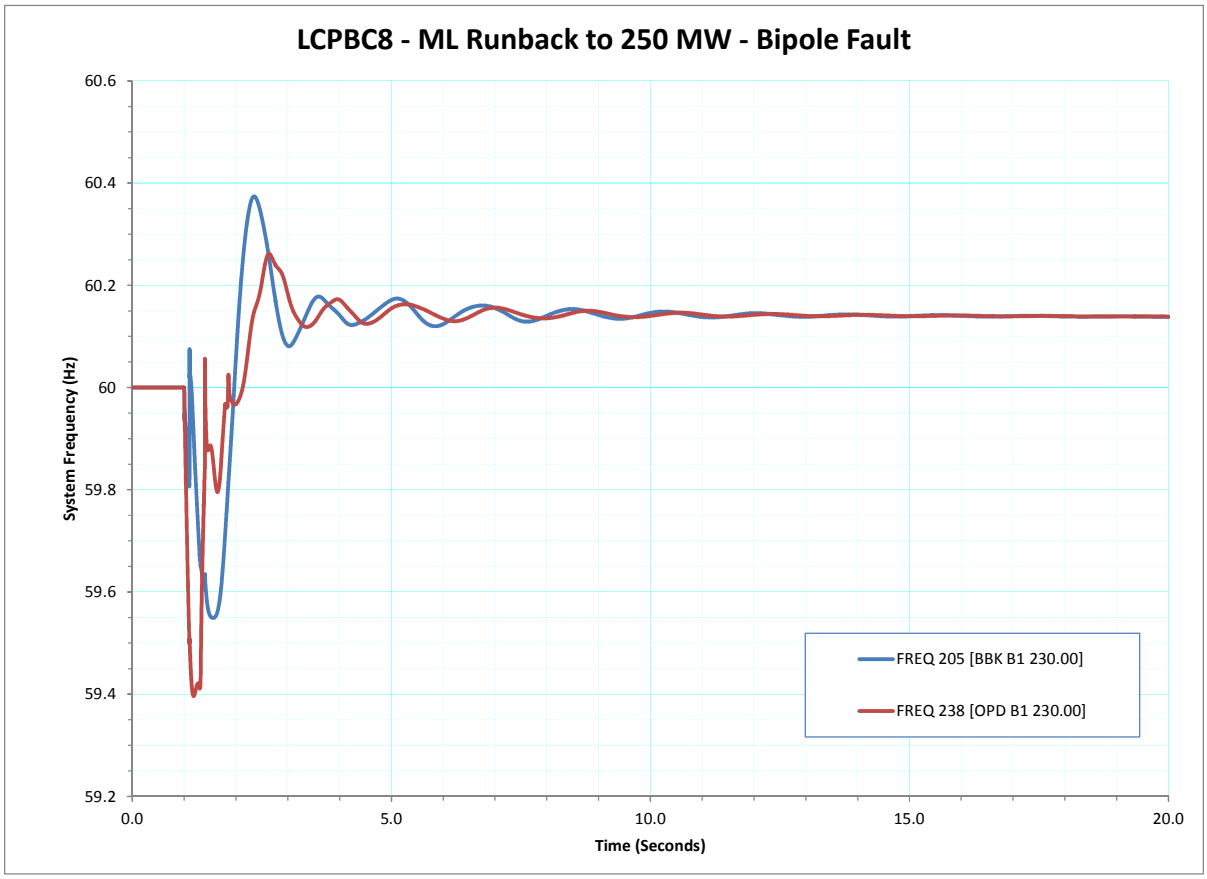

Figure 262 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - System Frequency (Hz)

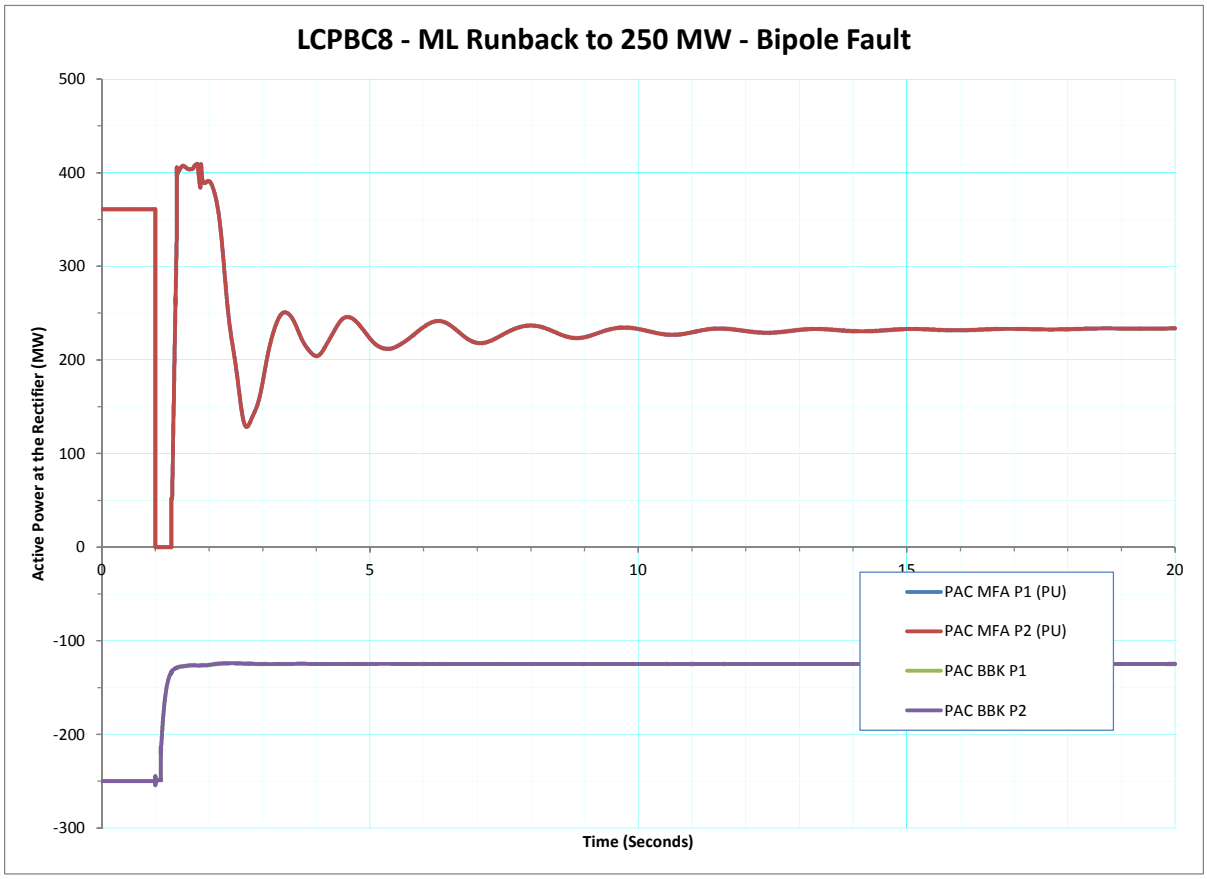

Figure 263 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - Active Power at the Rectifier (MW)

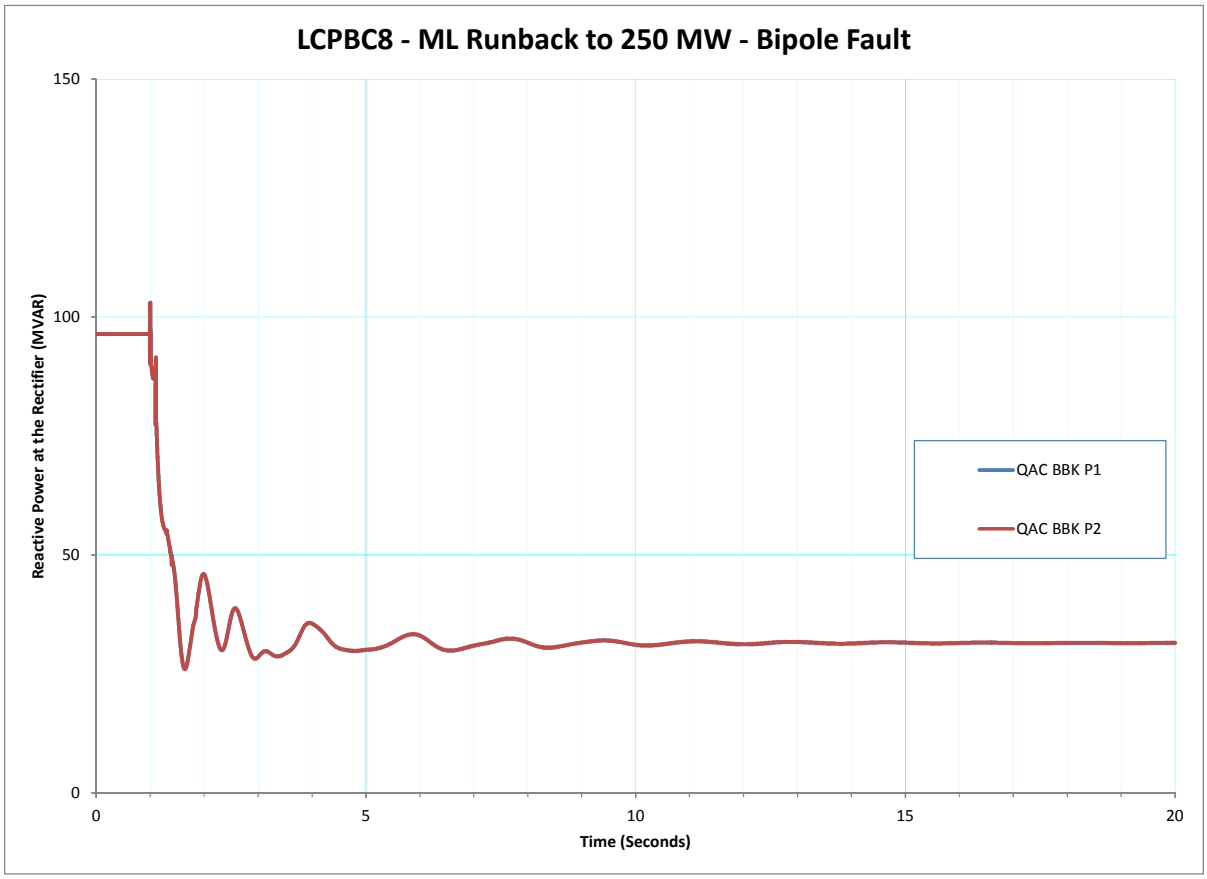

Figure 264 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

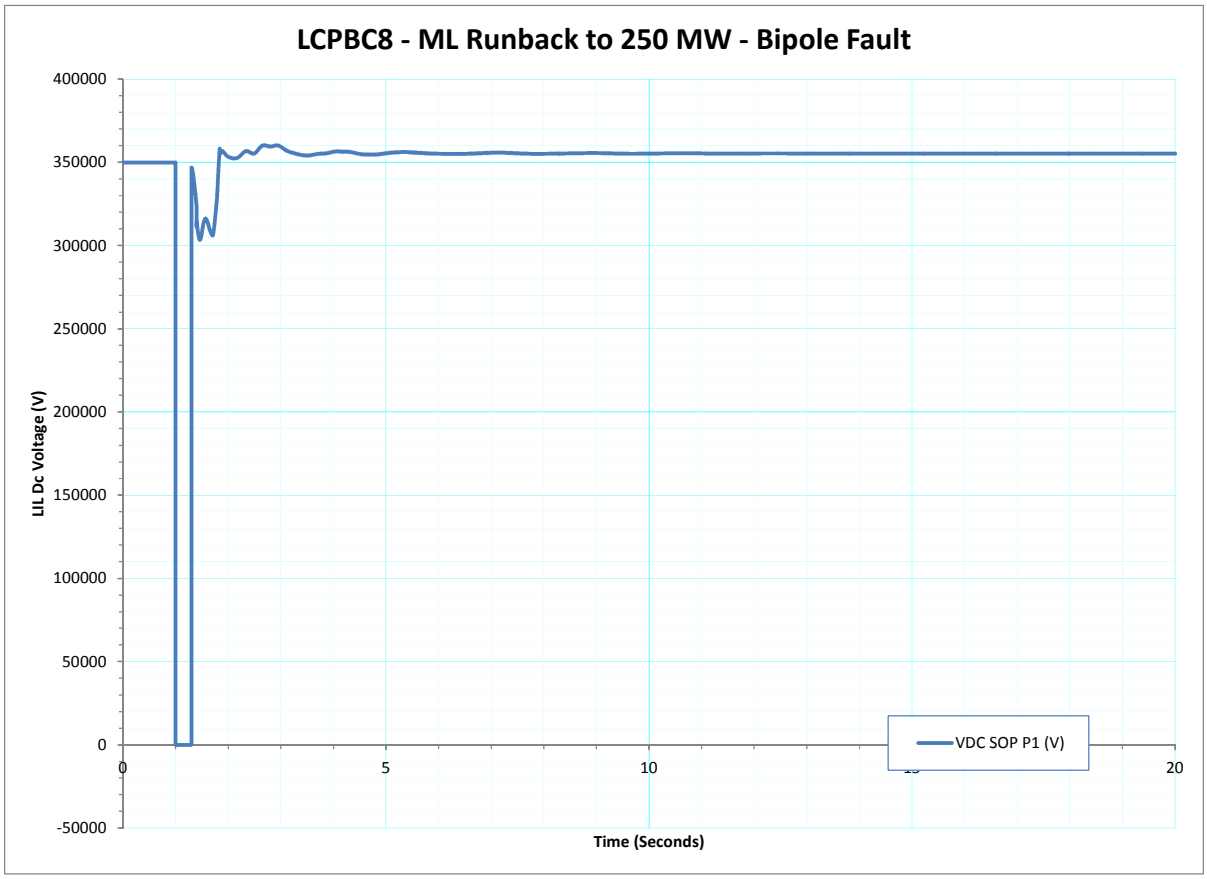

Figure 265 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - LIL Dc Voltage (V)

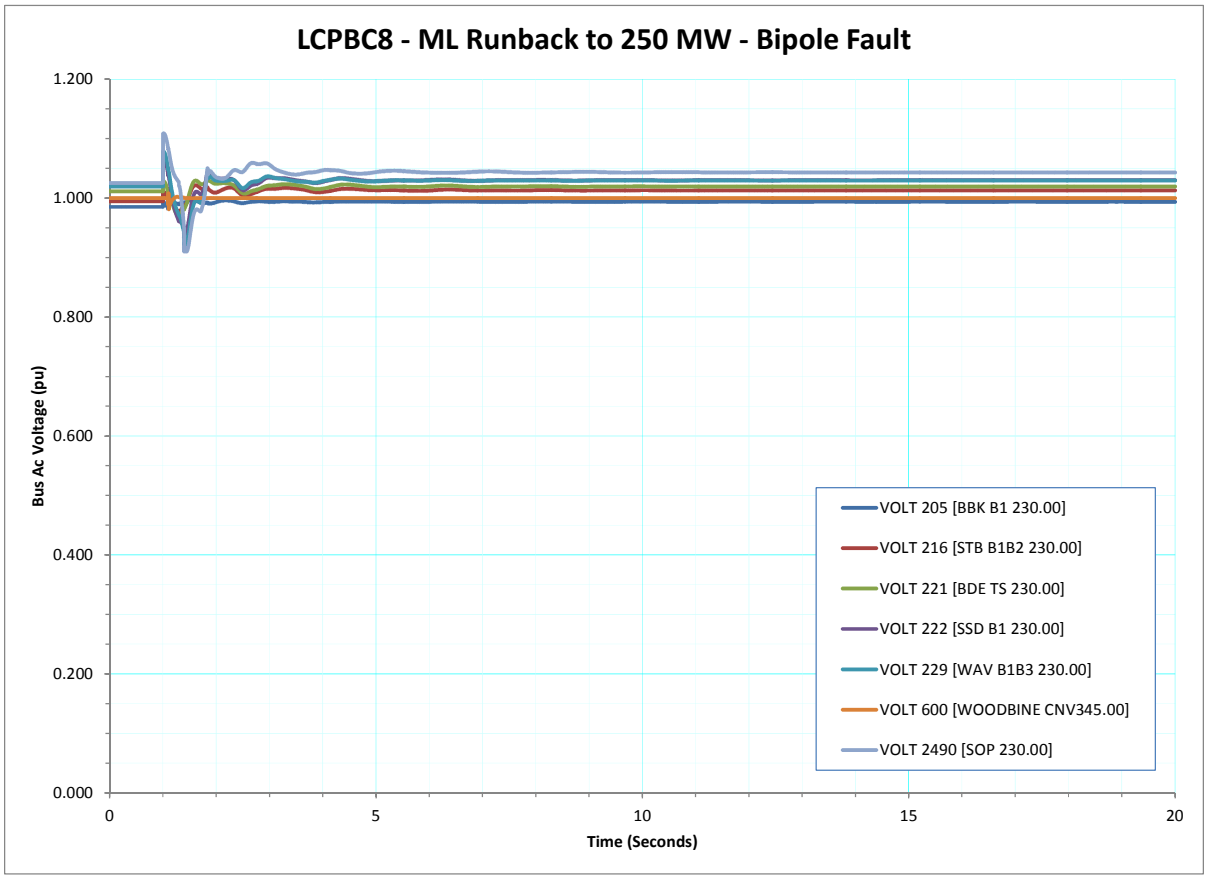

Figure 266 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - Bus Ac Voltage (pu)

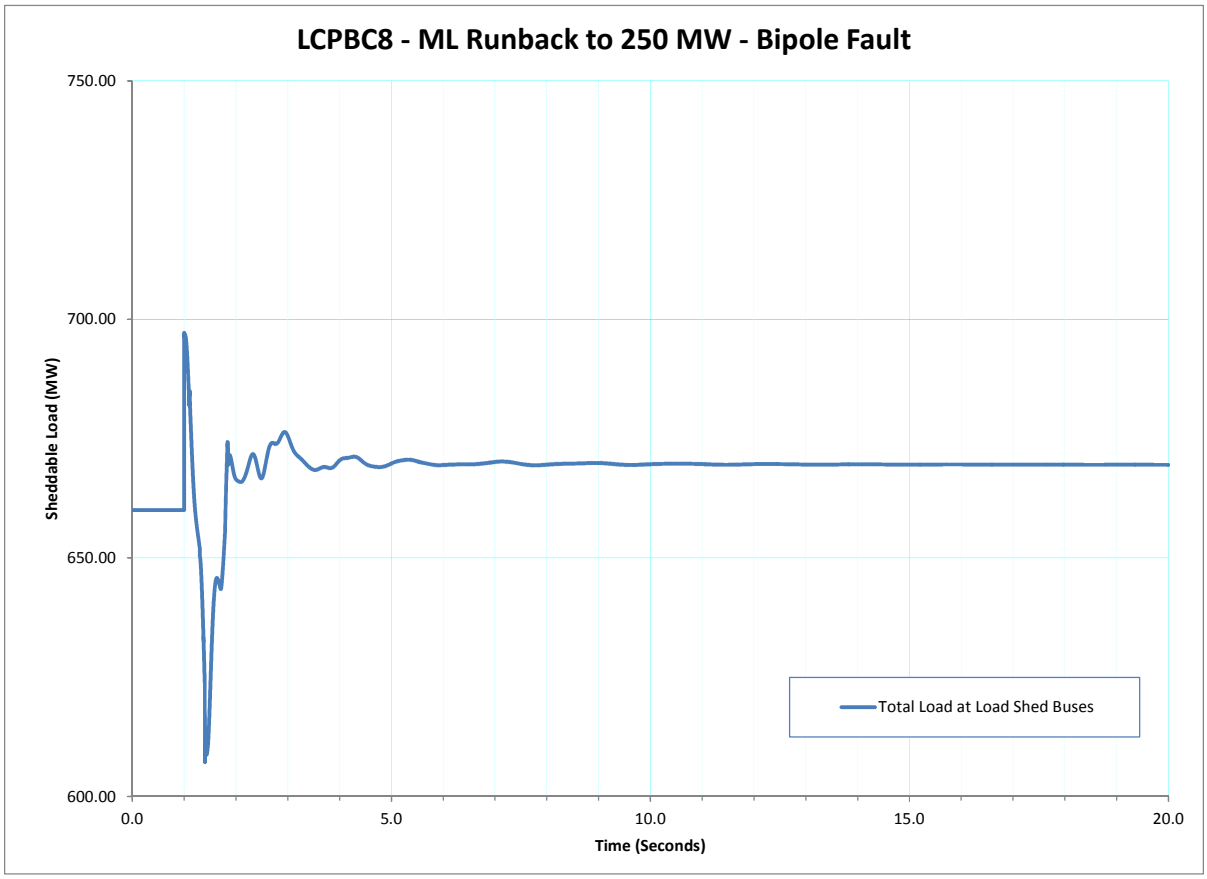

Figure 267 - LCPBC8 - ML Runback to 250 MW - Bipole Fault - Sheddable Load (MW)

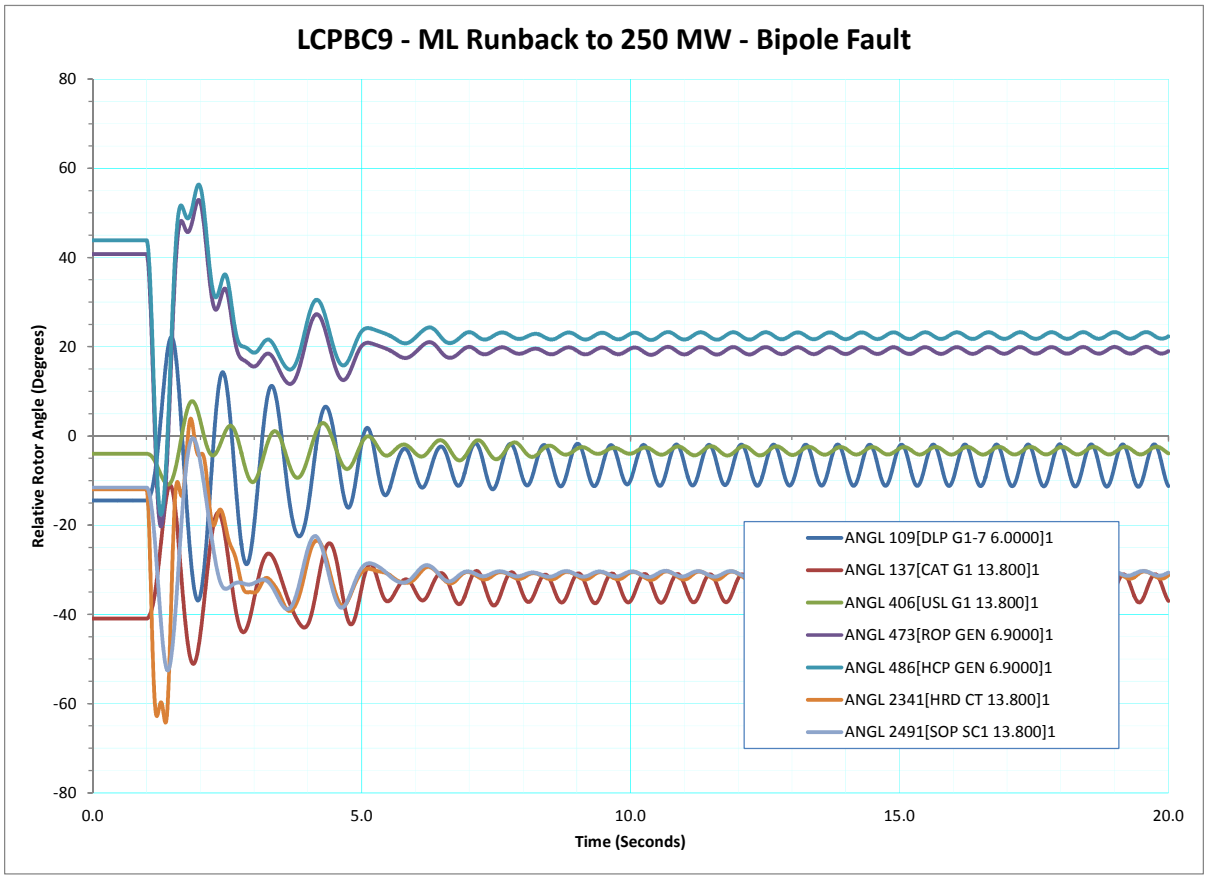

Figure 268 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - Relative Rotor Angle (Degrees)

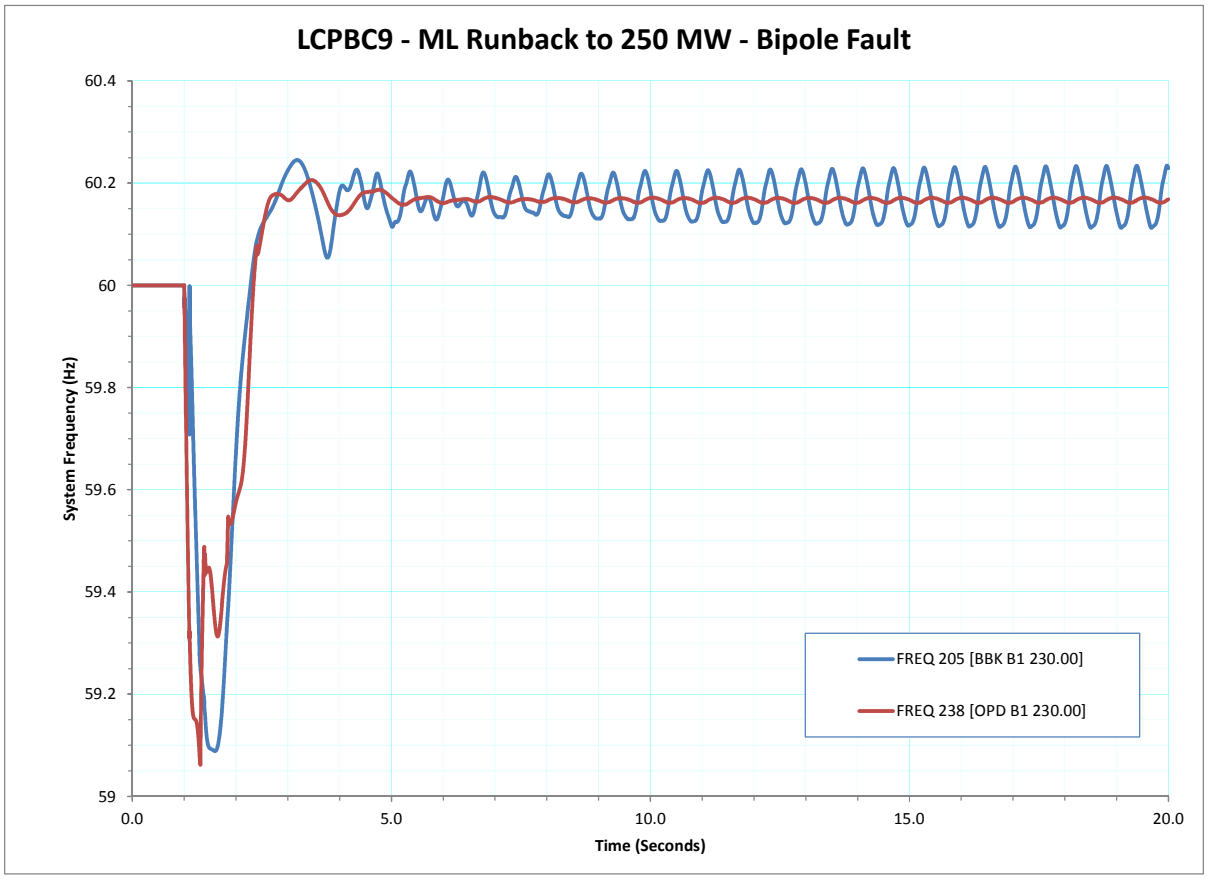

Figure 269 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - System Frequency (Hz)

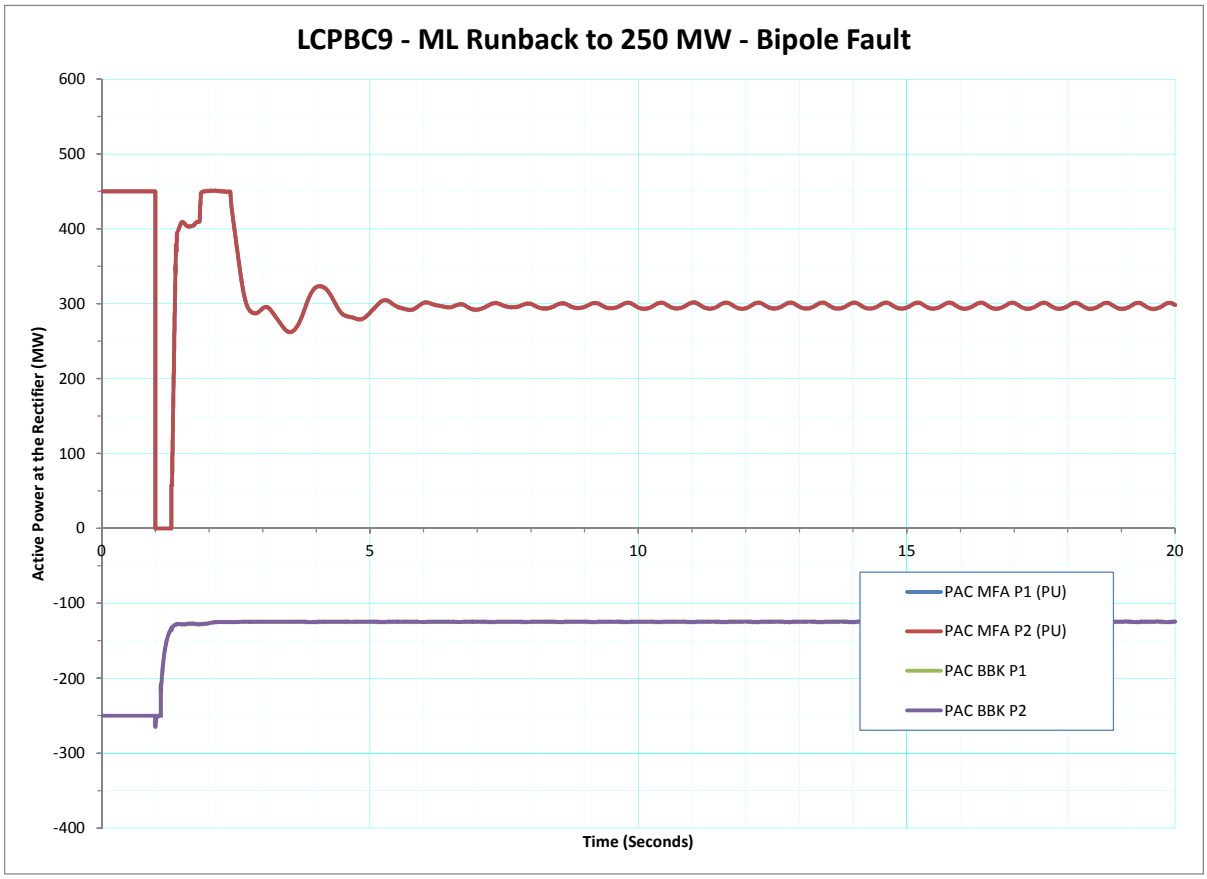

Figure 270 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - Active Power at the Rectifier (MW)

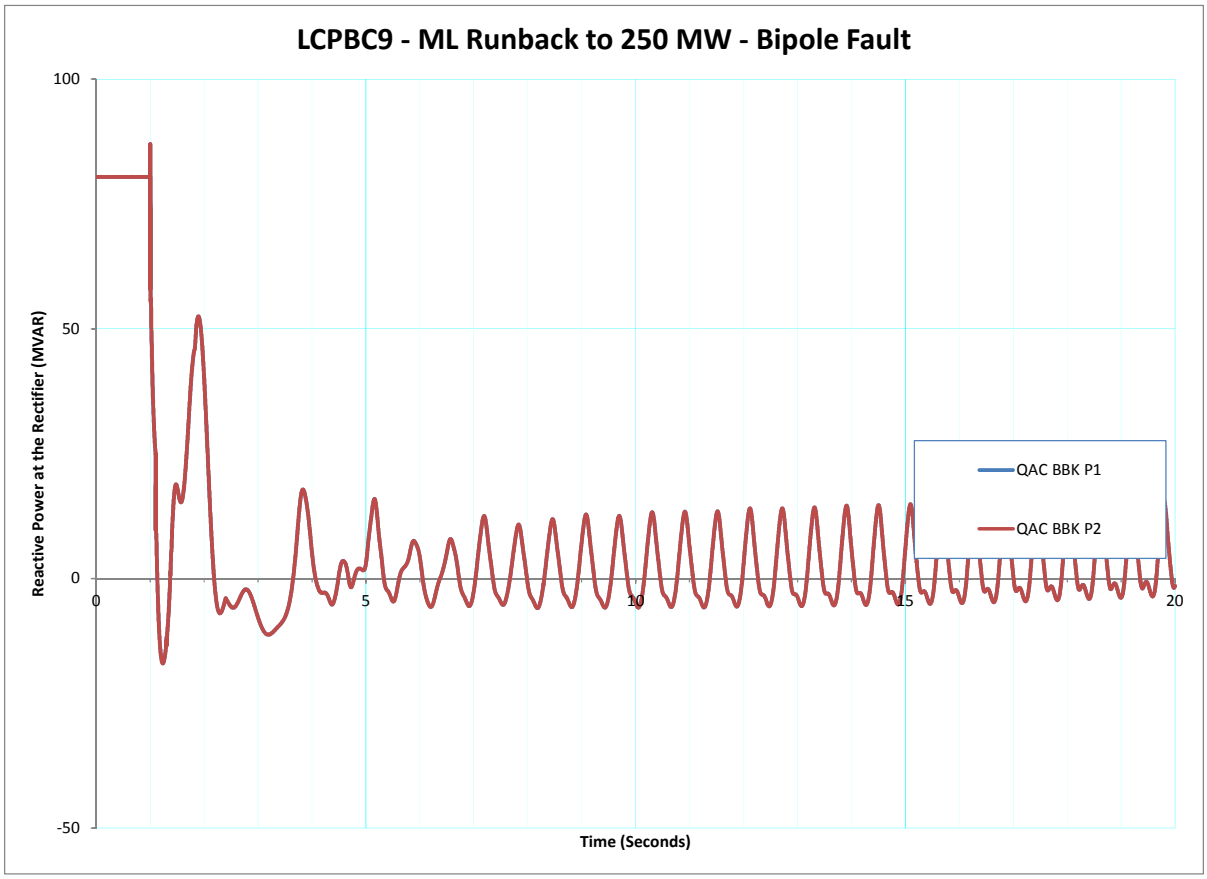

Figure 271 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

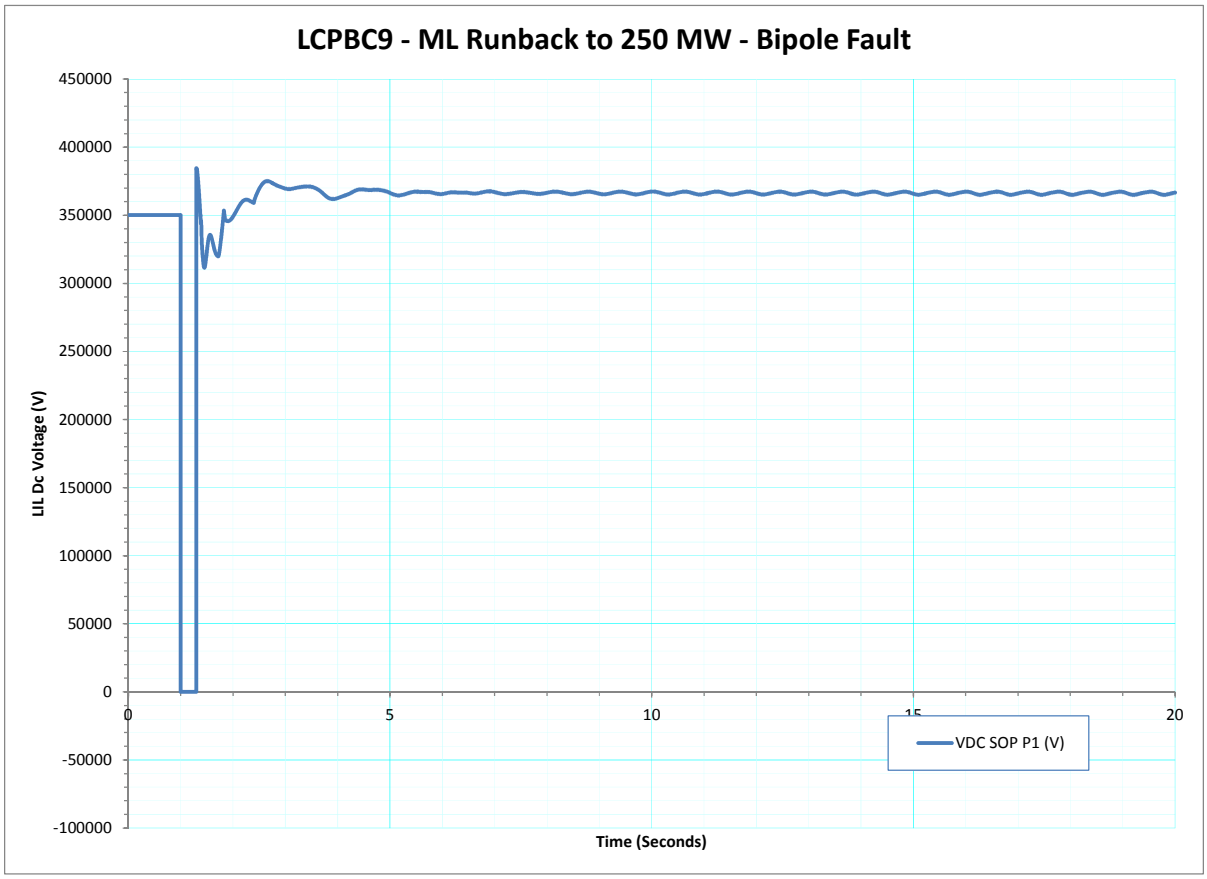

Figure 272 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - LIL Dc Voltage (V)

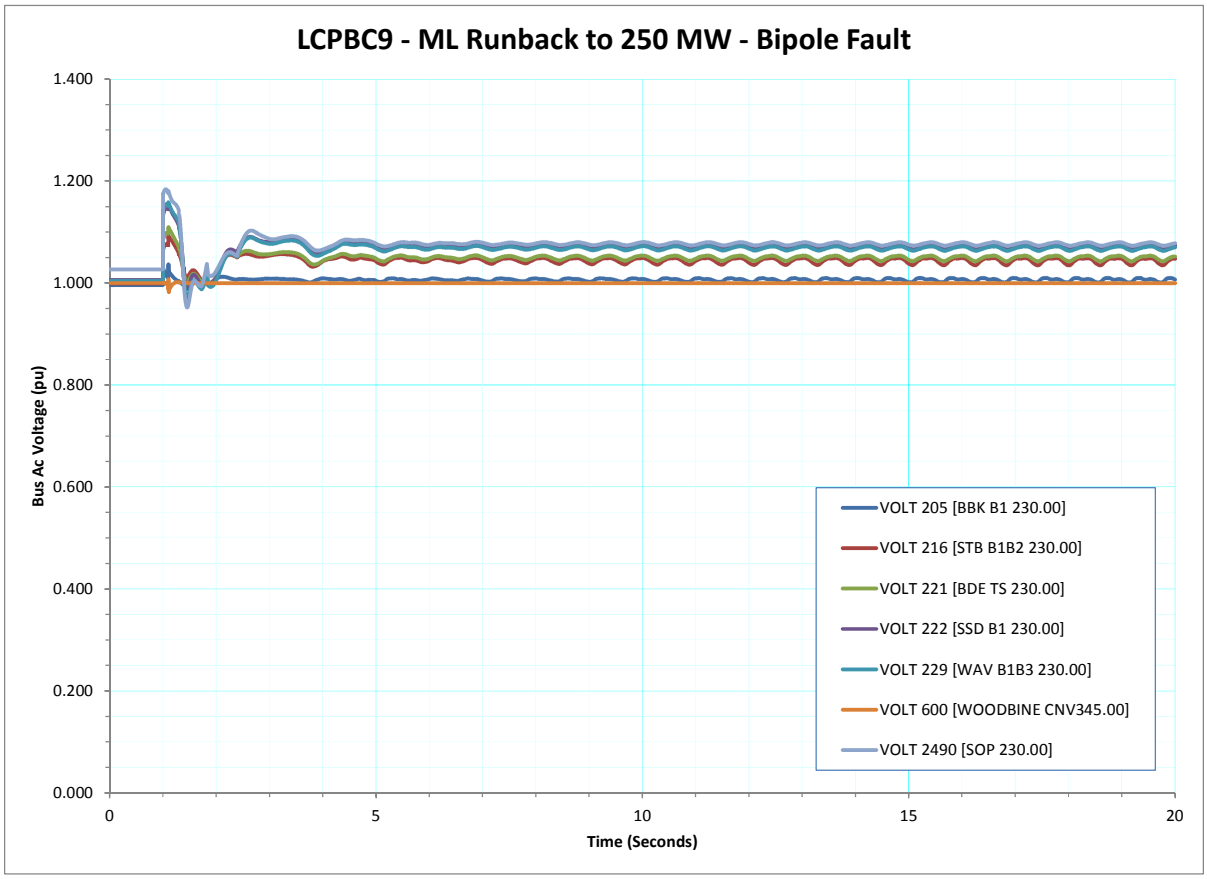

Figure 273 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - Bus Ac Voltage (pu)

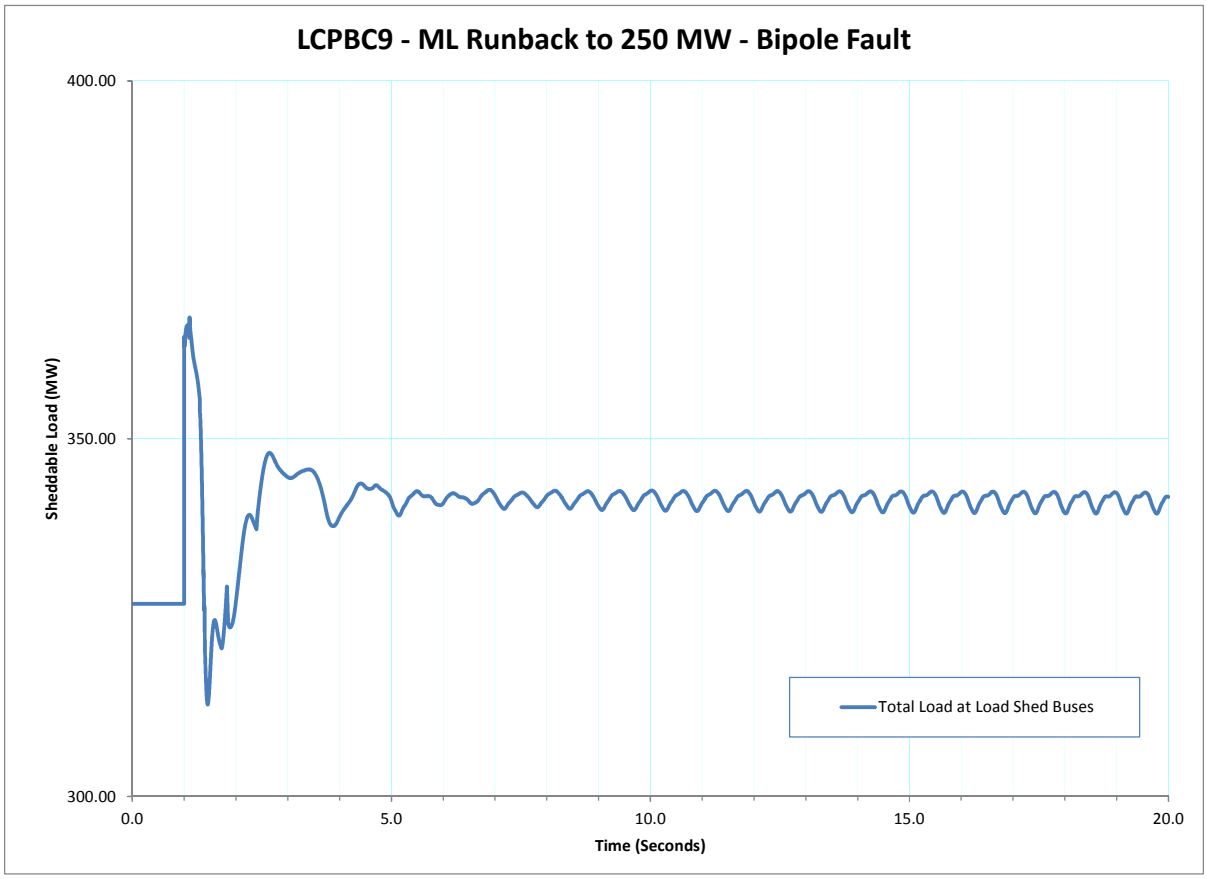

Figure 274 - LCPBC9 - ML Runback to 250 MW - Bipole Fault - Sheddable Load (MW)

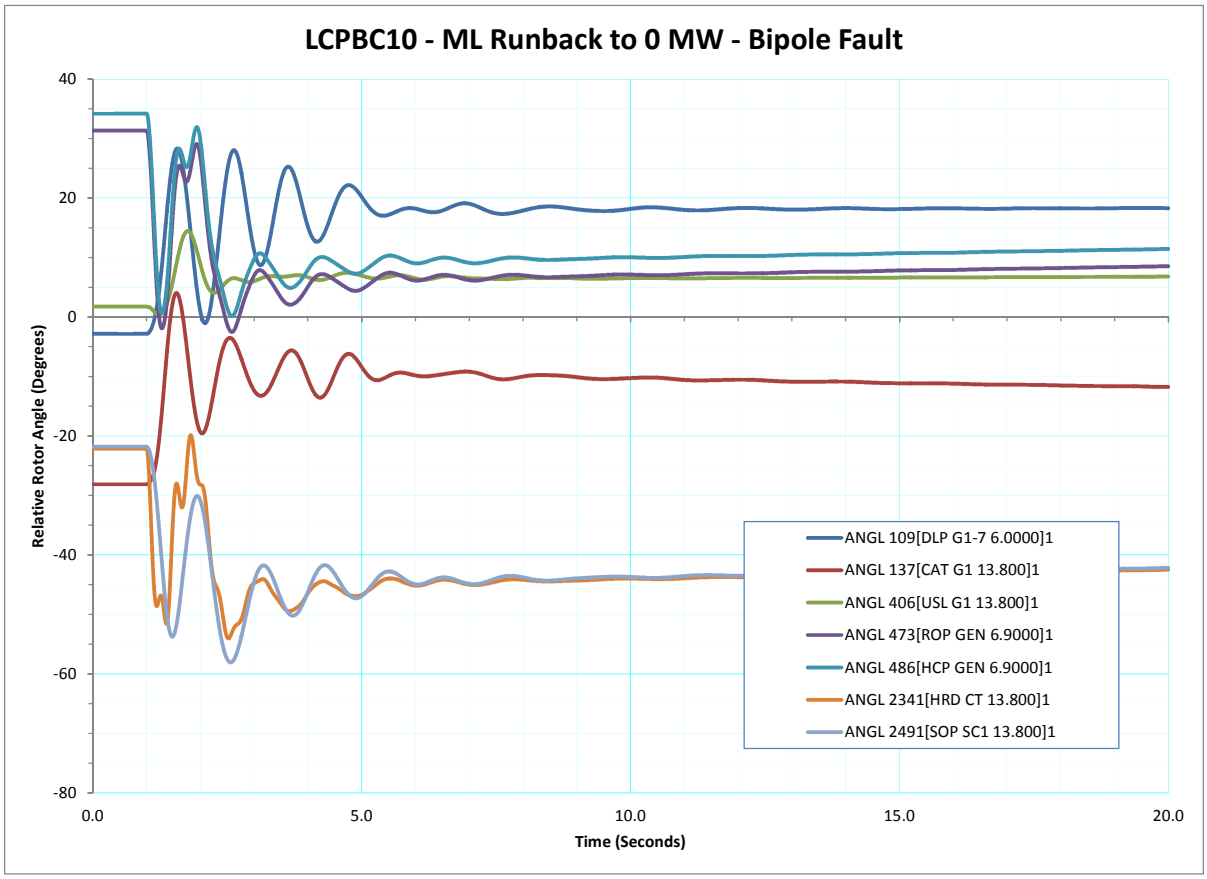

Figure 275 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - Relative Rotor Angle (Degrees)

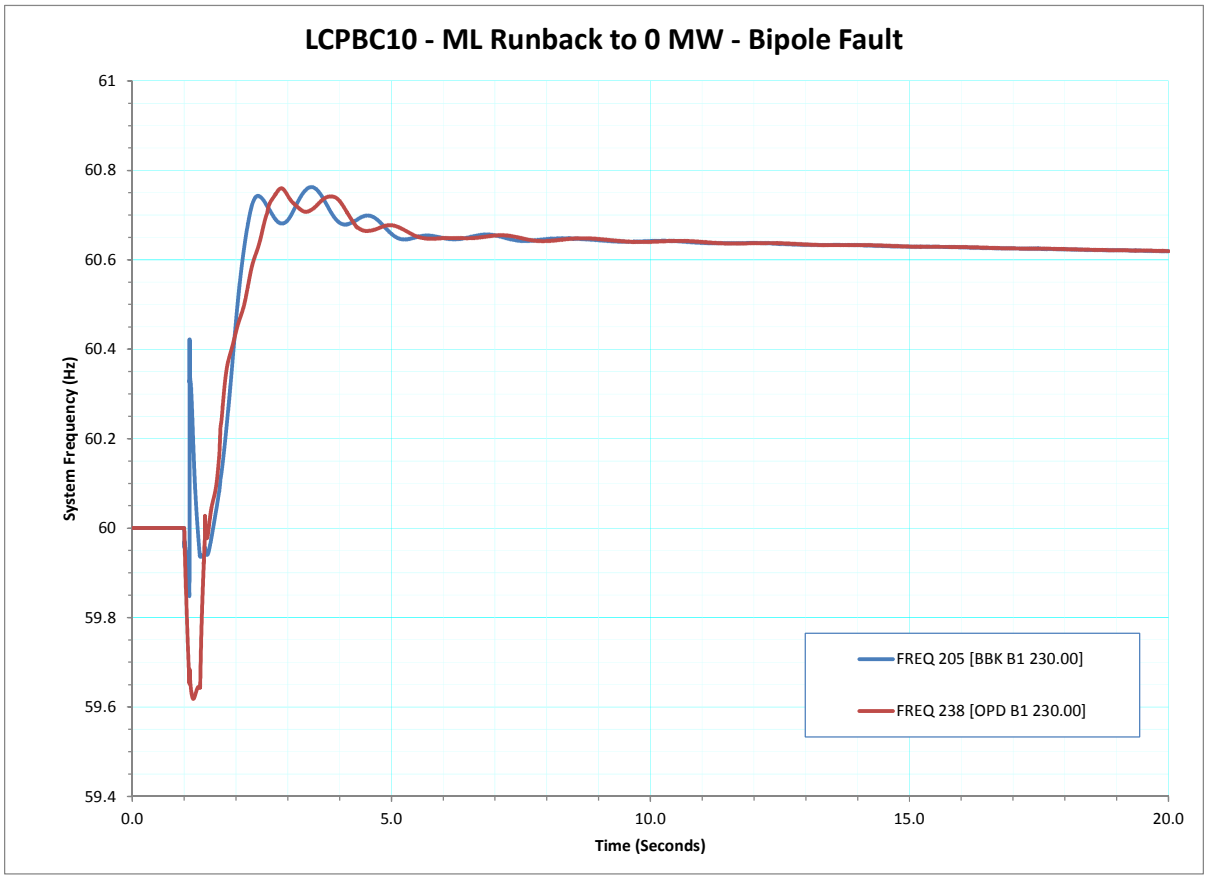

Figure 276 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - System Frequency (Hz)

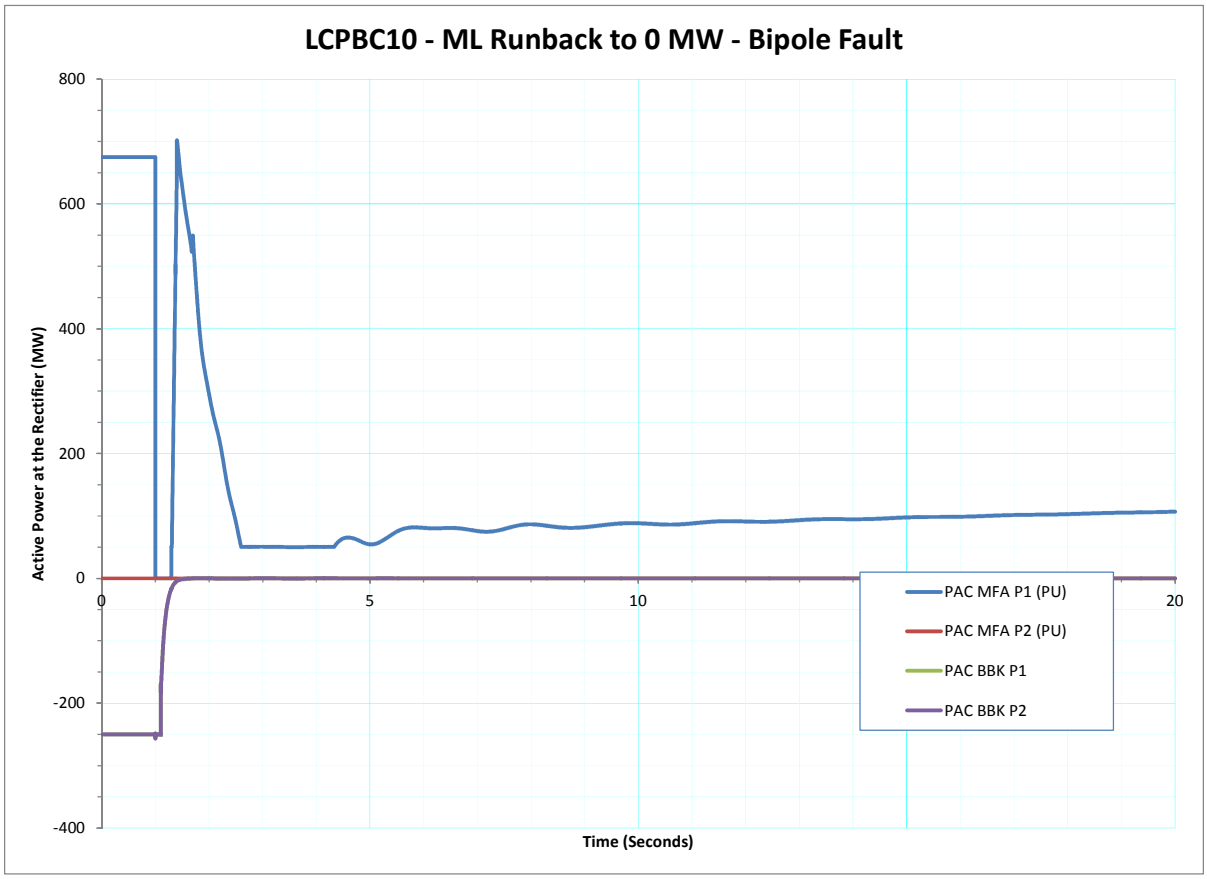

Figure 277 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - Active Power at the Rectifier (MW)

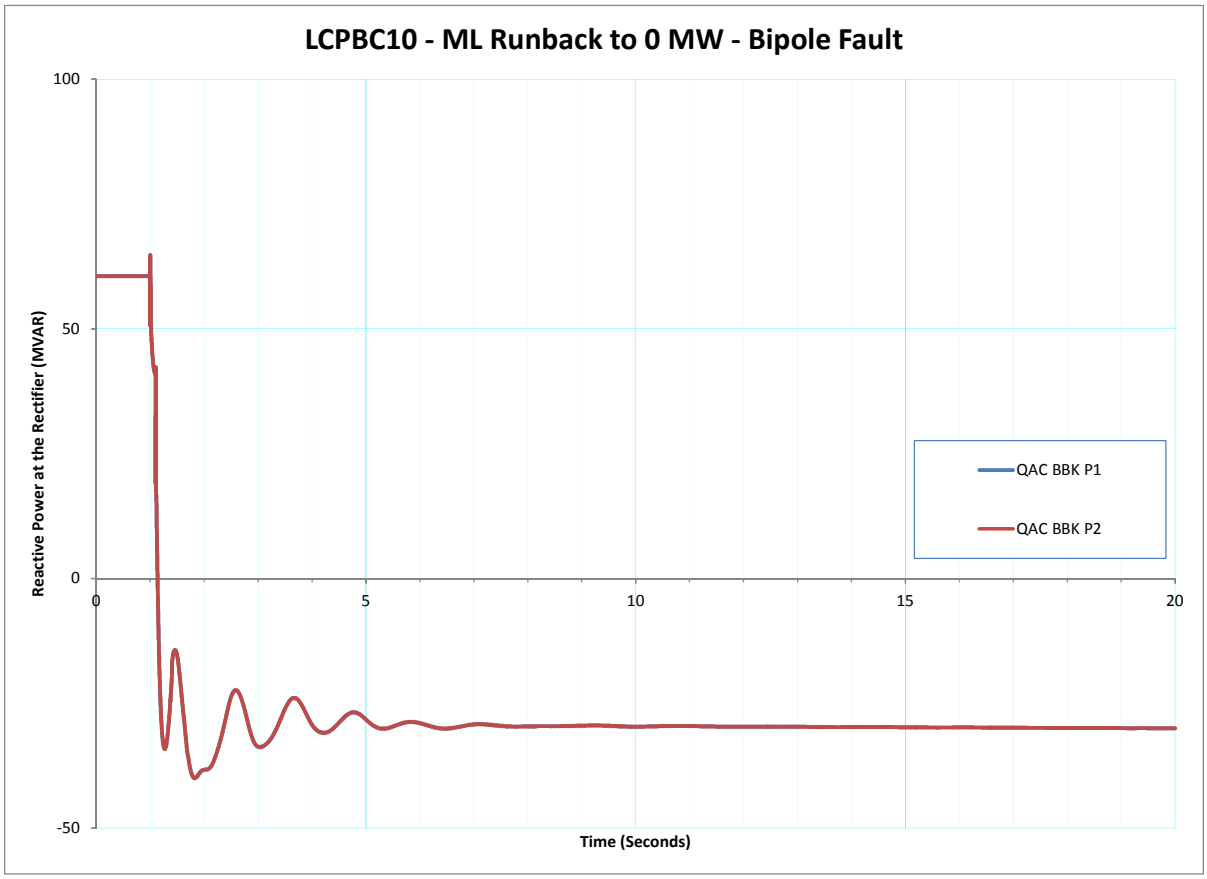

Figure 278 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

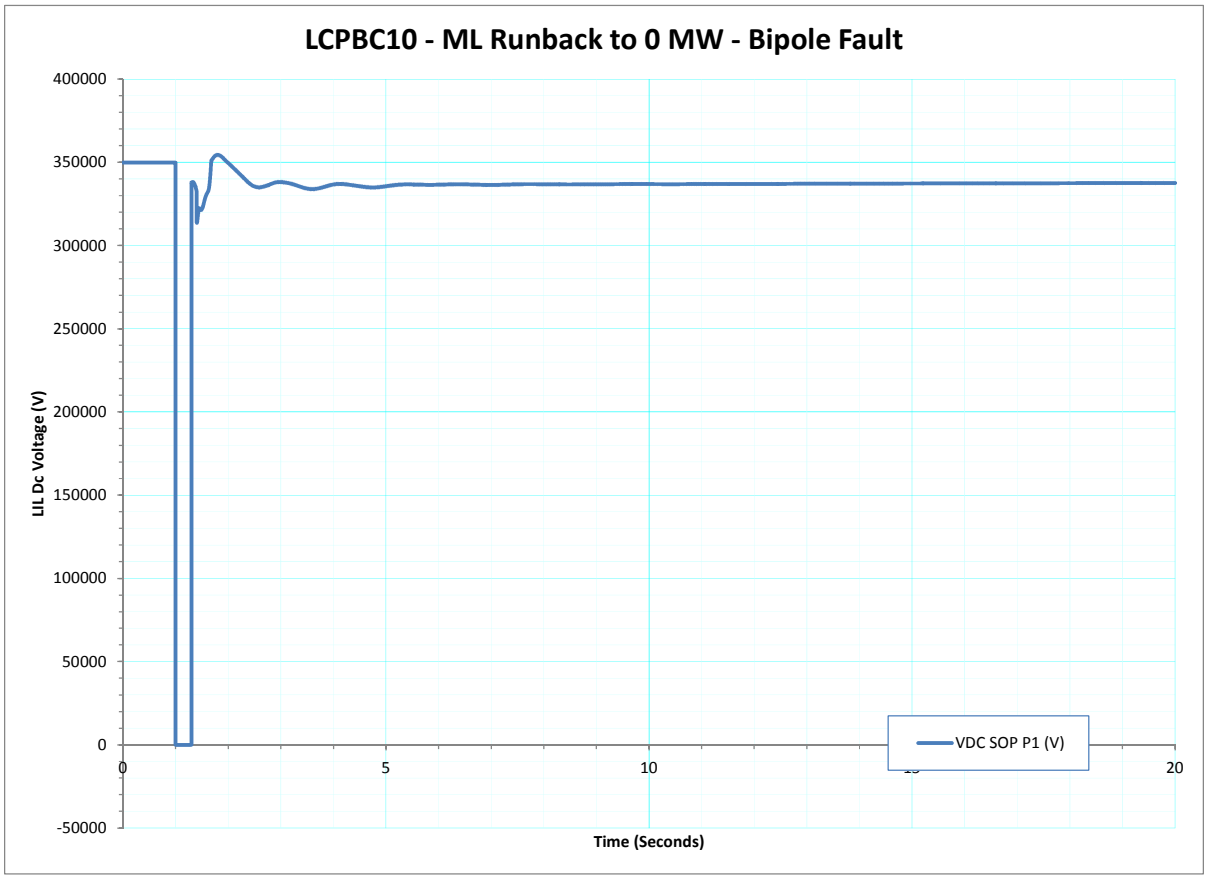

Figure 279 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - LIL Dc Voltage (V)

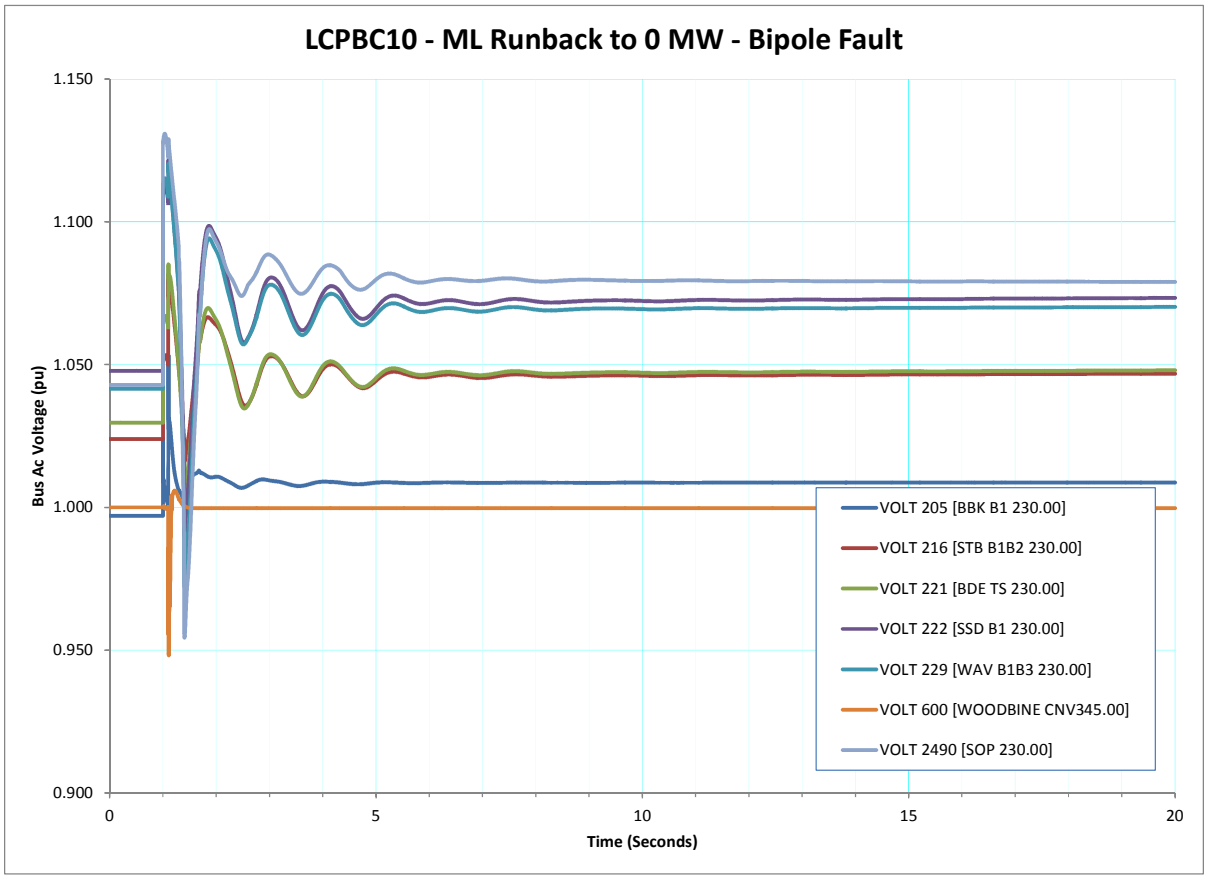

Figure 280 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - Bus Ac Voltage (pu)

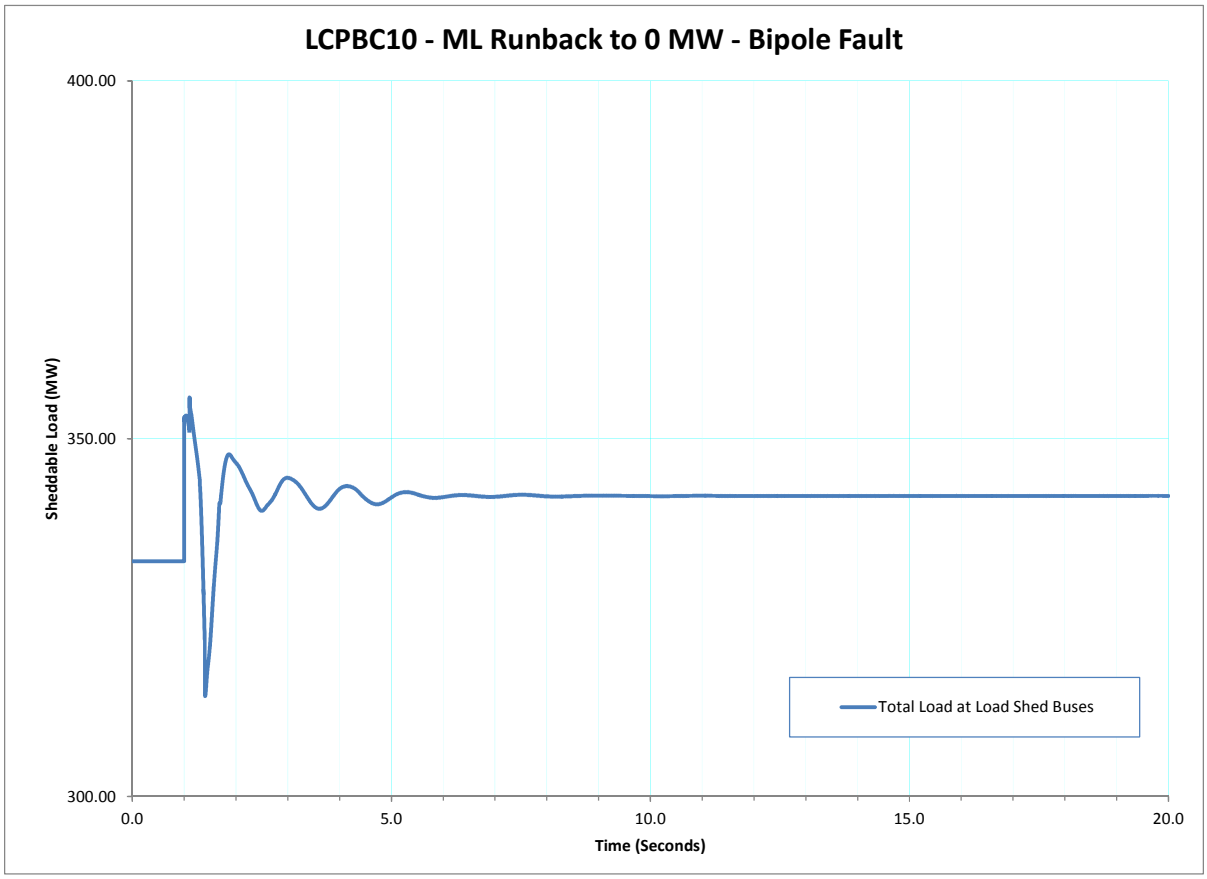

Figure 281 - LCPBC10 - ML Runback to 0 MW - Bipole Fault - Sheddable Load (MW)

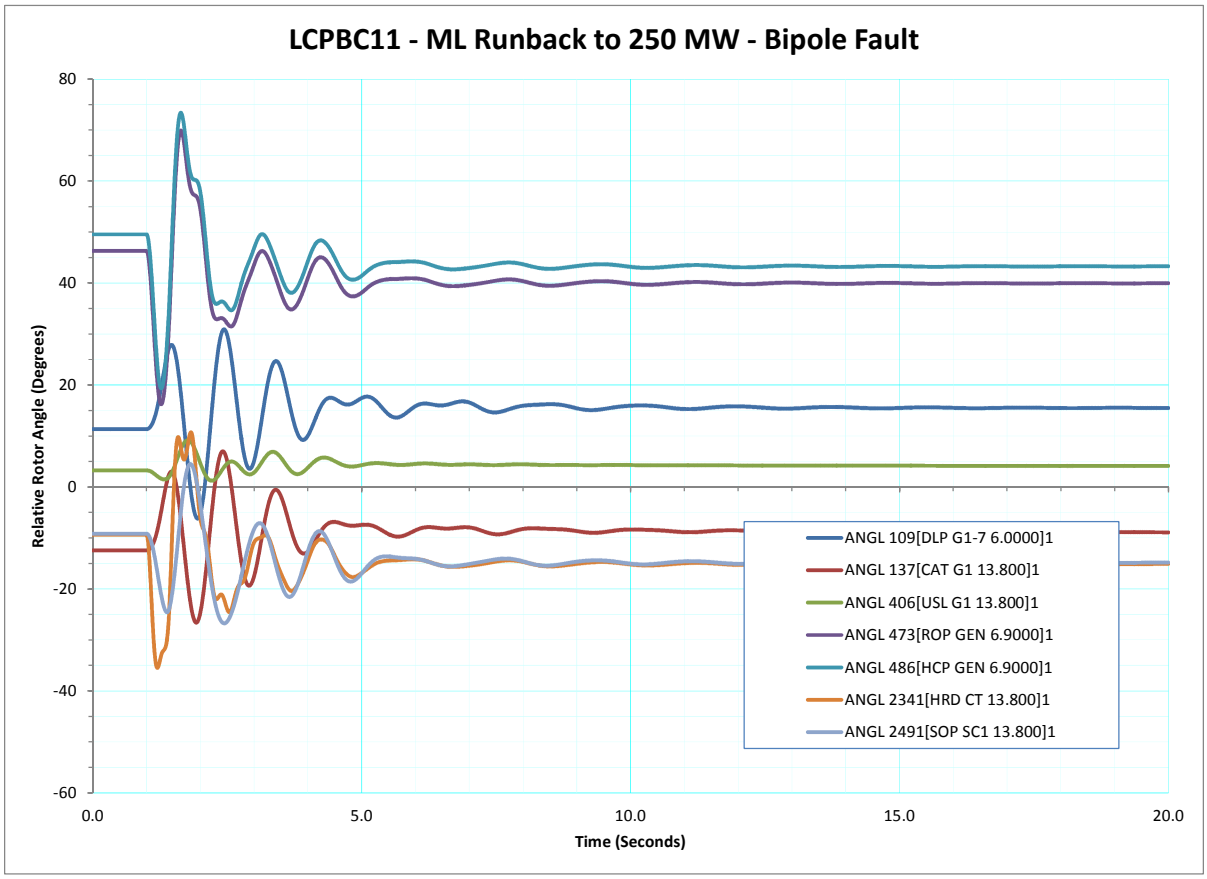

Figure 282 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - Relative Rotor Angle (Degrees)

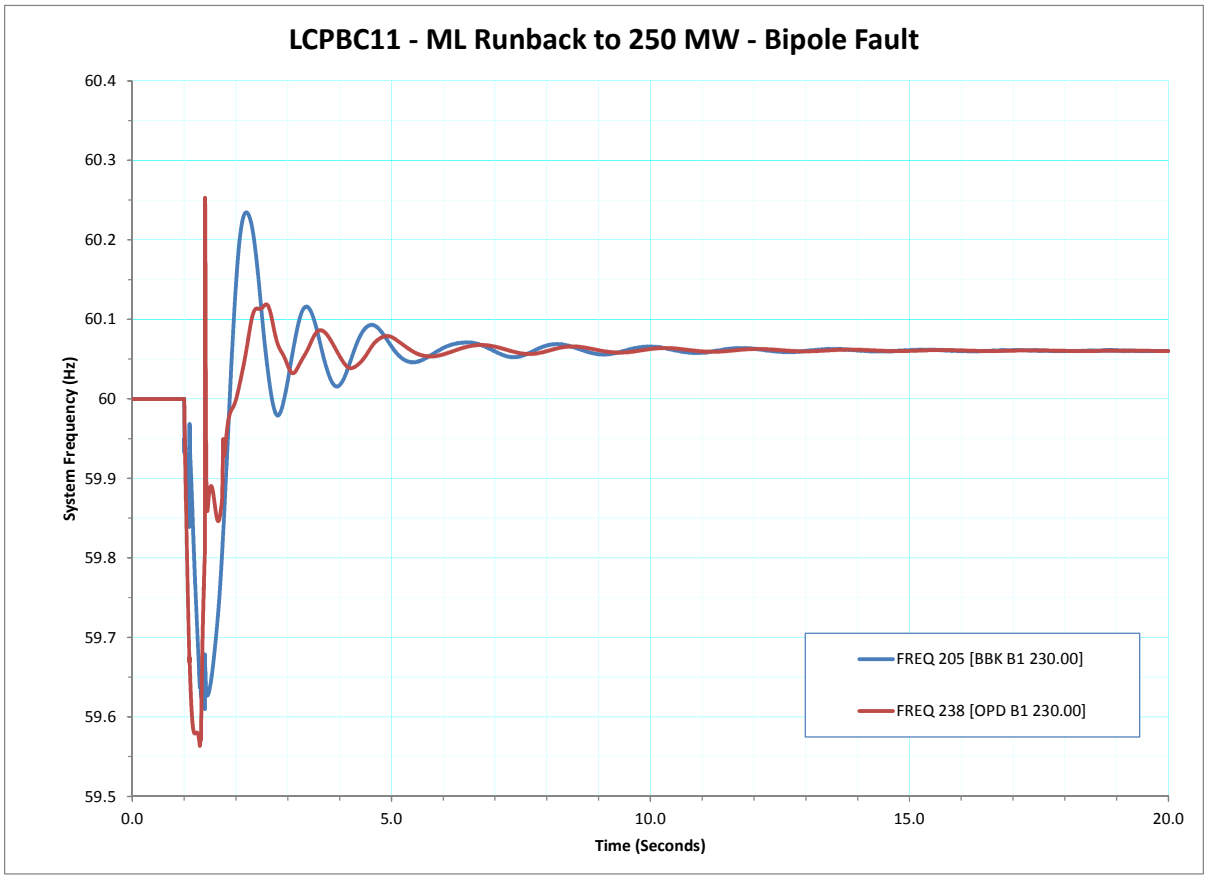

Figure 283 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - System Frequency (Hz)

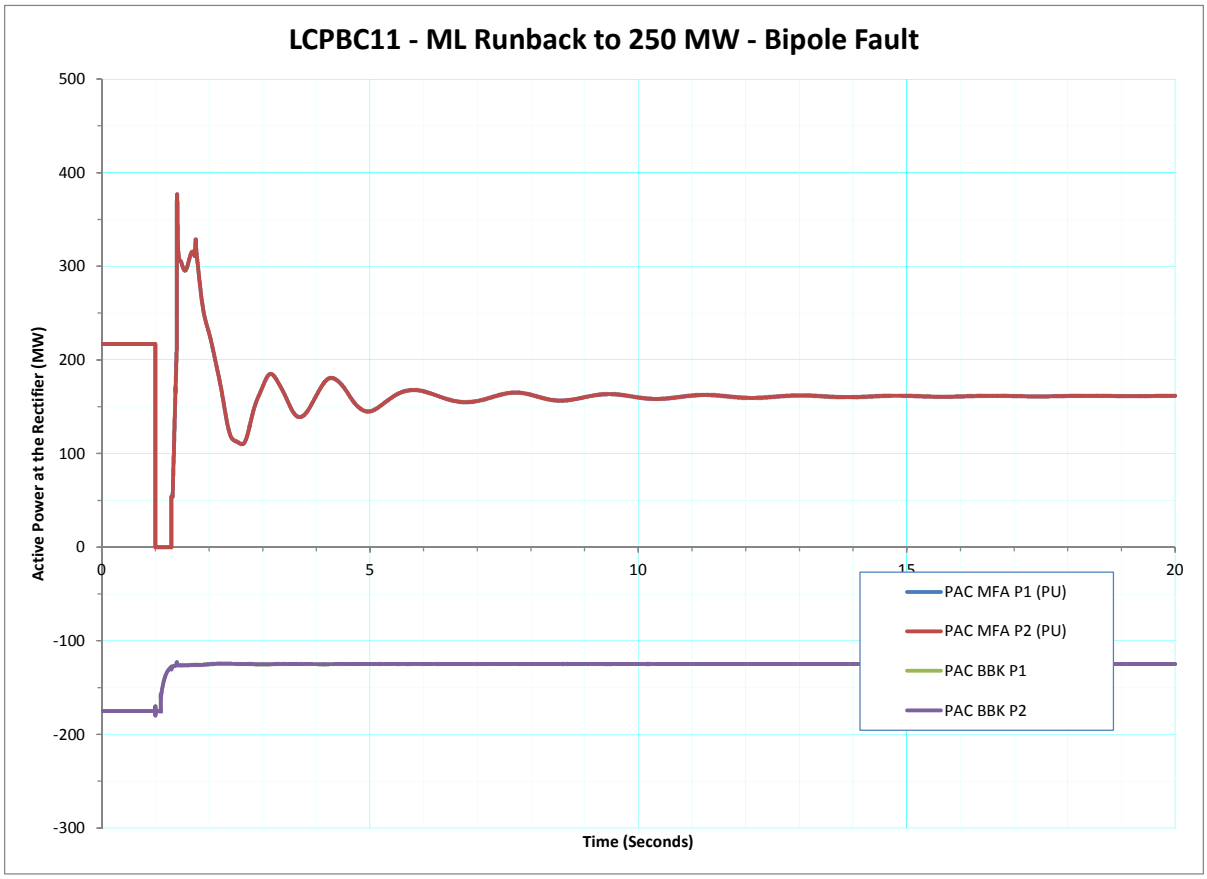

Figure 284 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - Active Power at the Rectifier (MW)

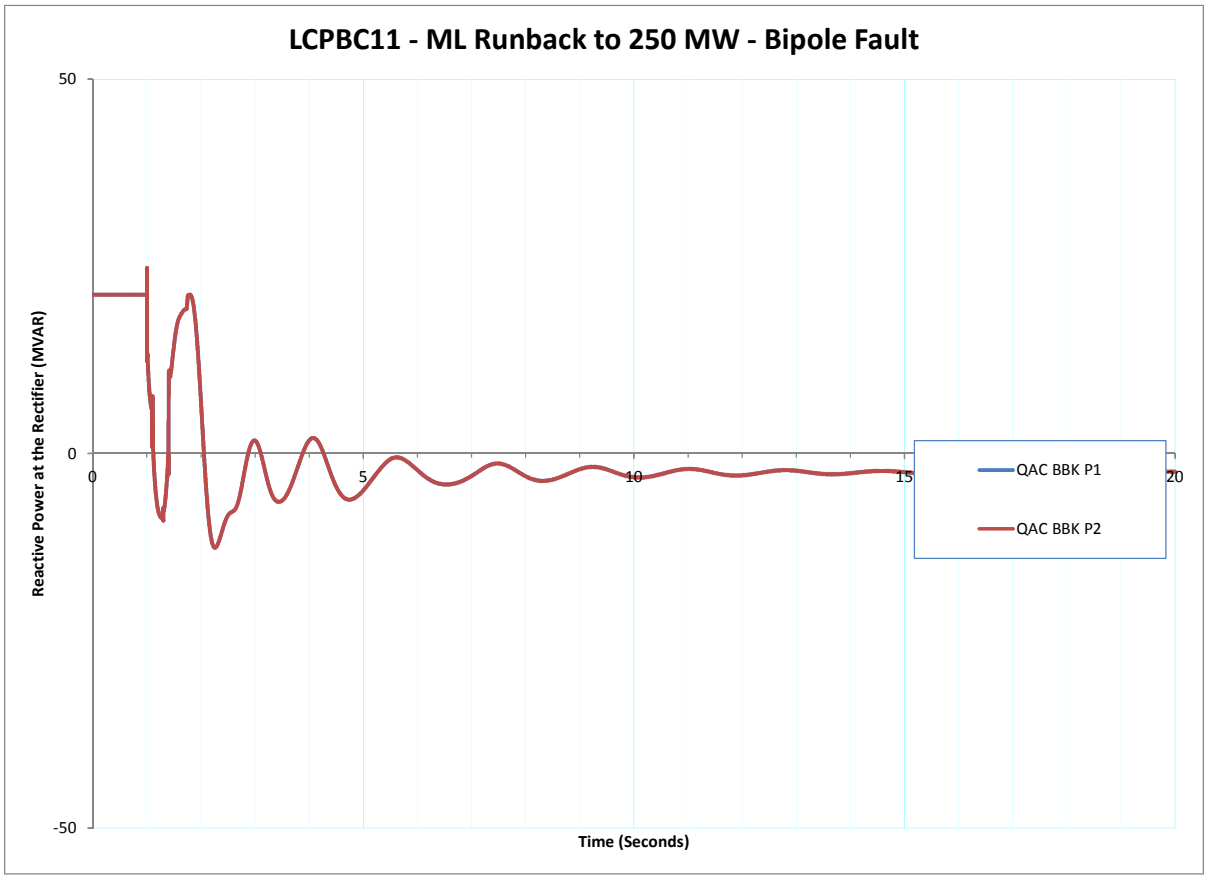

Figure 285 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - Reactive Power at the Rectifier (MVAR)

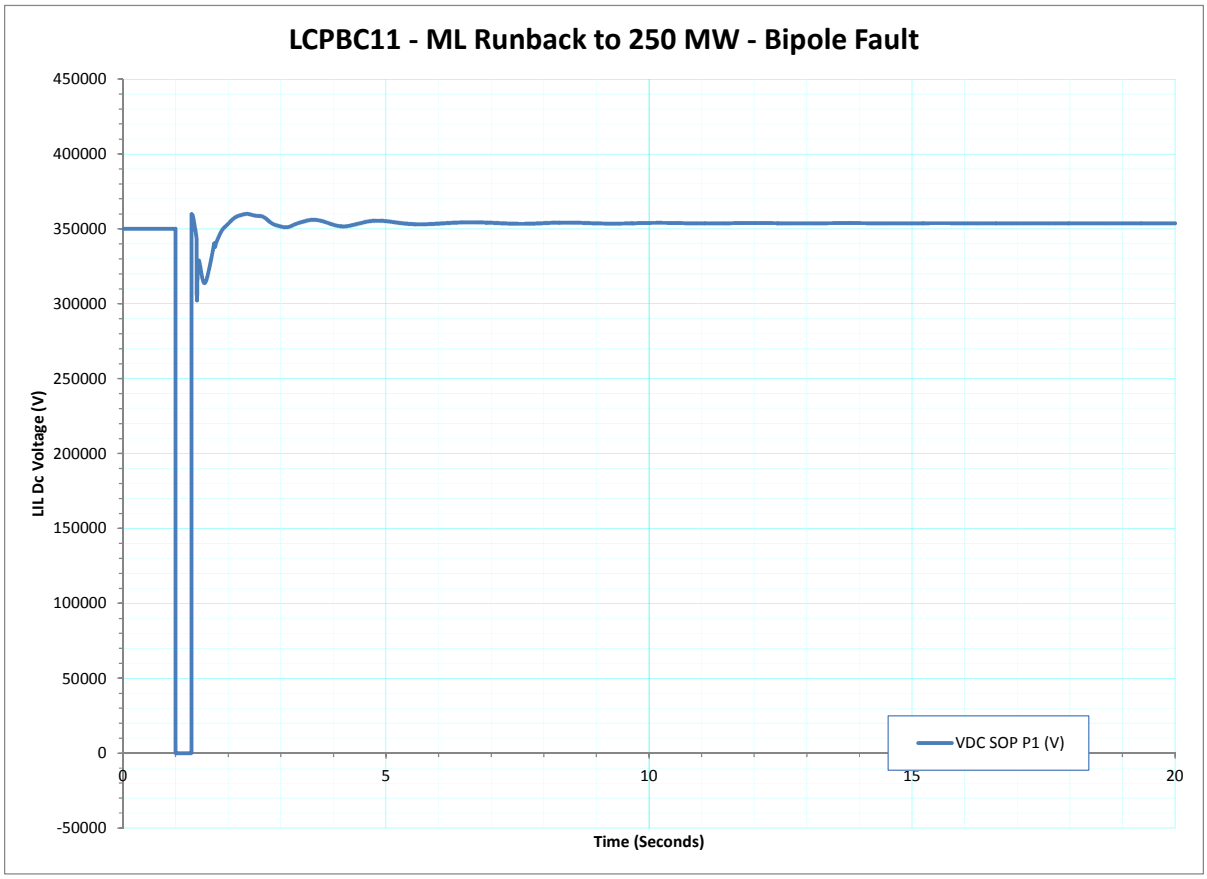

Figure 286 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - LIL Dc Voltage (V)

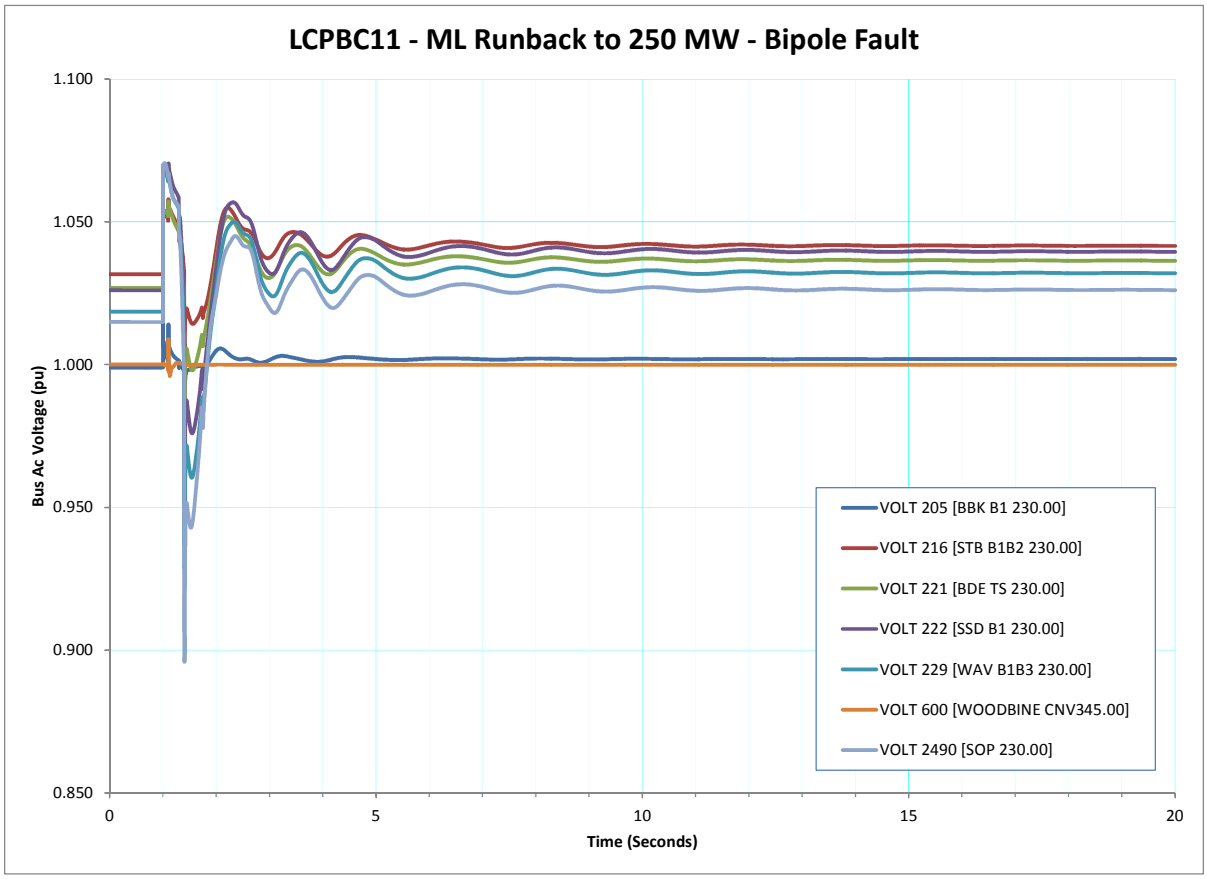

Figure 287 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - Bus Ac Voltage (pu)

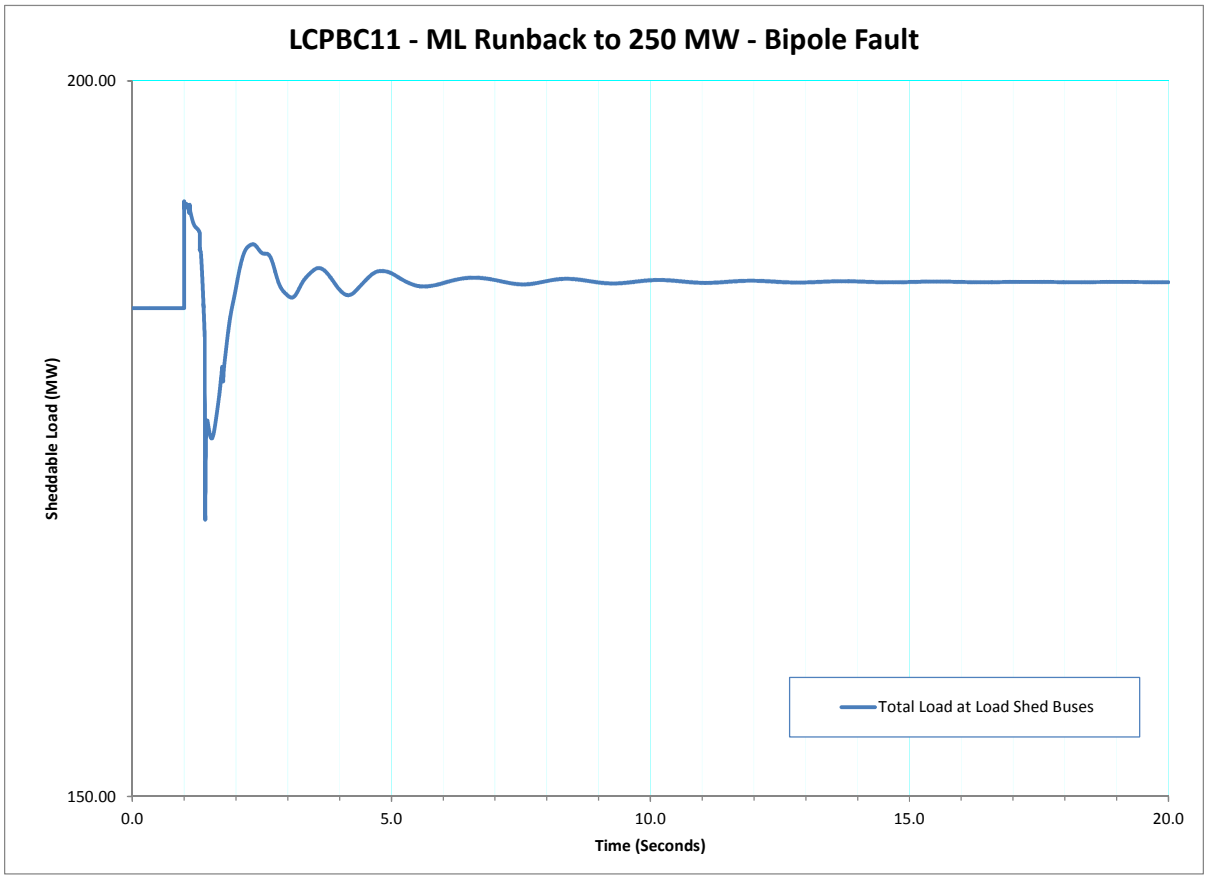

Figure 288 - LCPBC11 - ML Runback to 250 MW - Bipole Fault - Sheddable Load (MW)

APPENDIX E Remedial ML Curtailment for Permanent Pole Faults

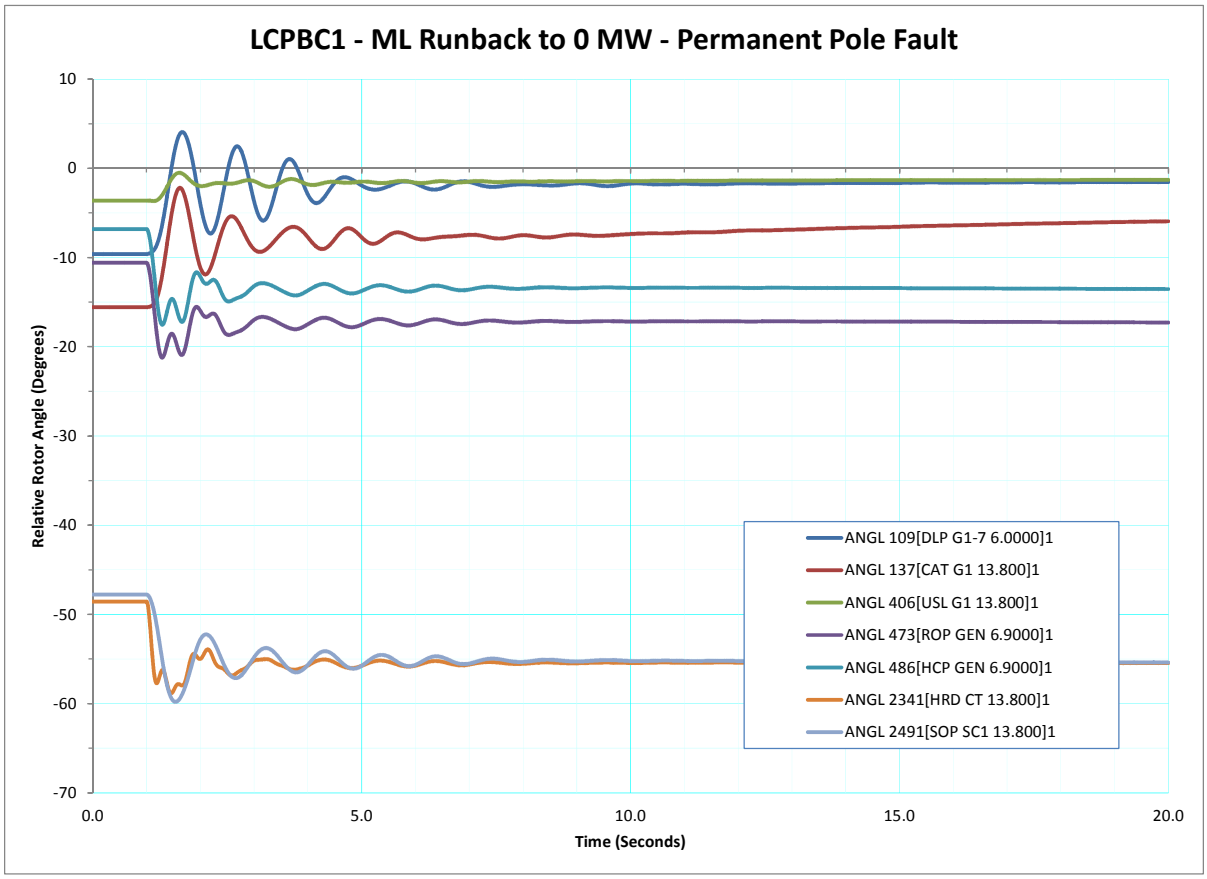

Figure 289 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

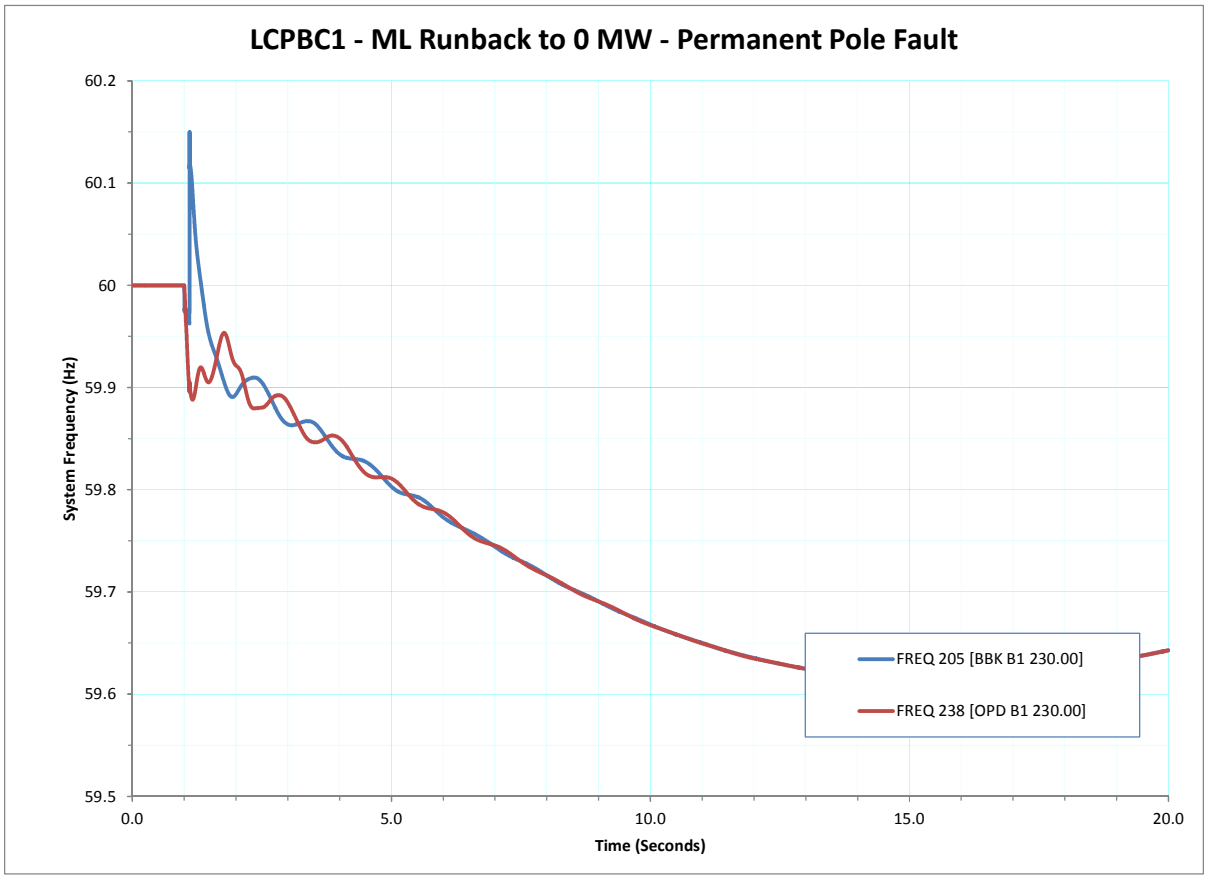

Figure 290 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

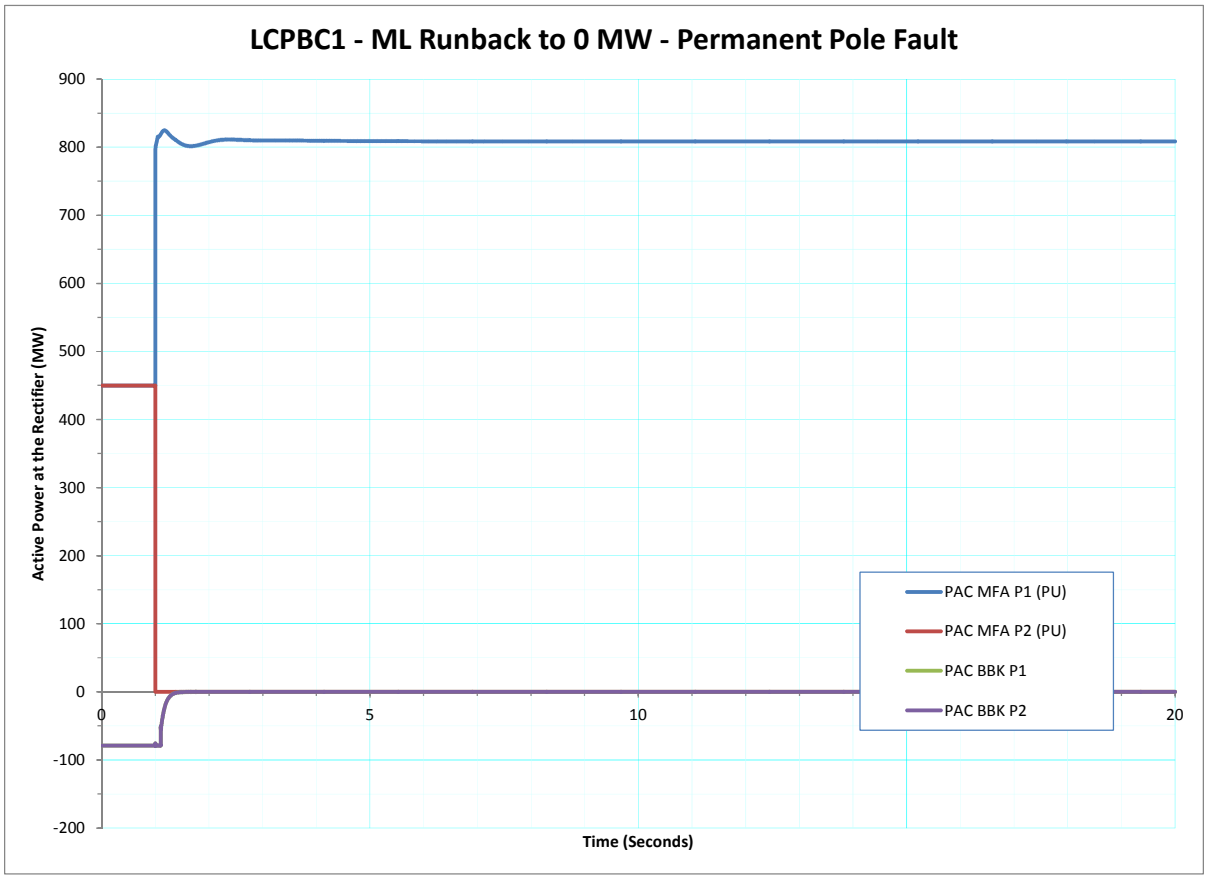

Figure 291 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

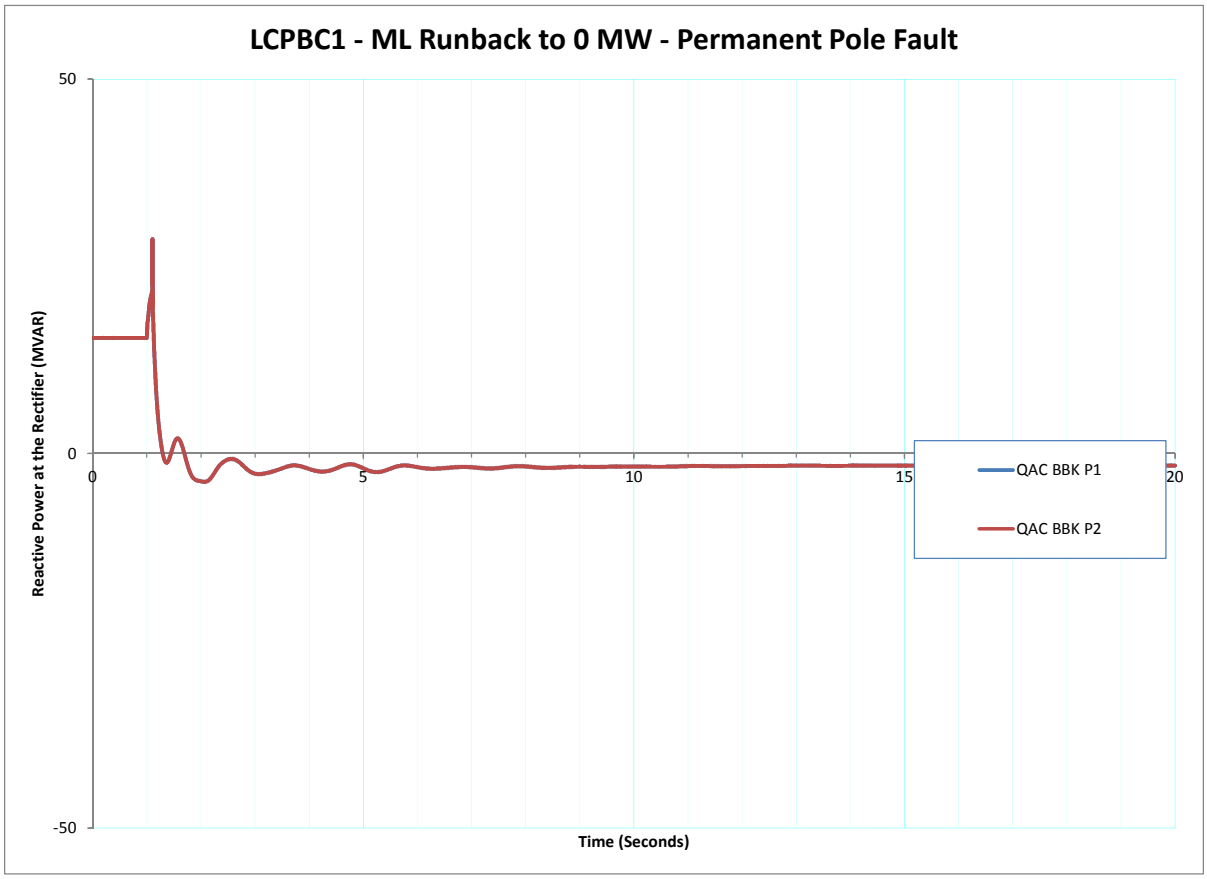

Figure 292 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

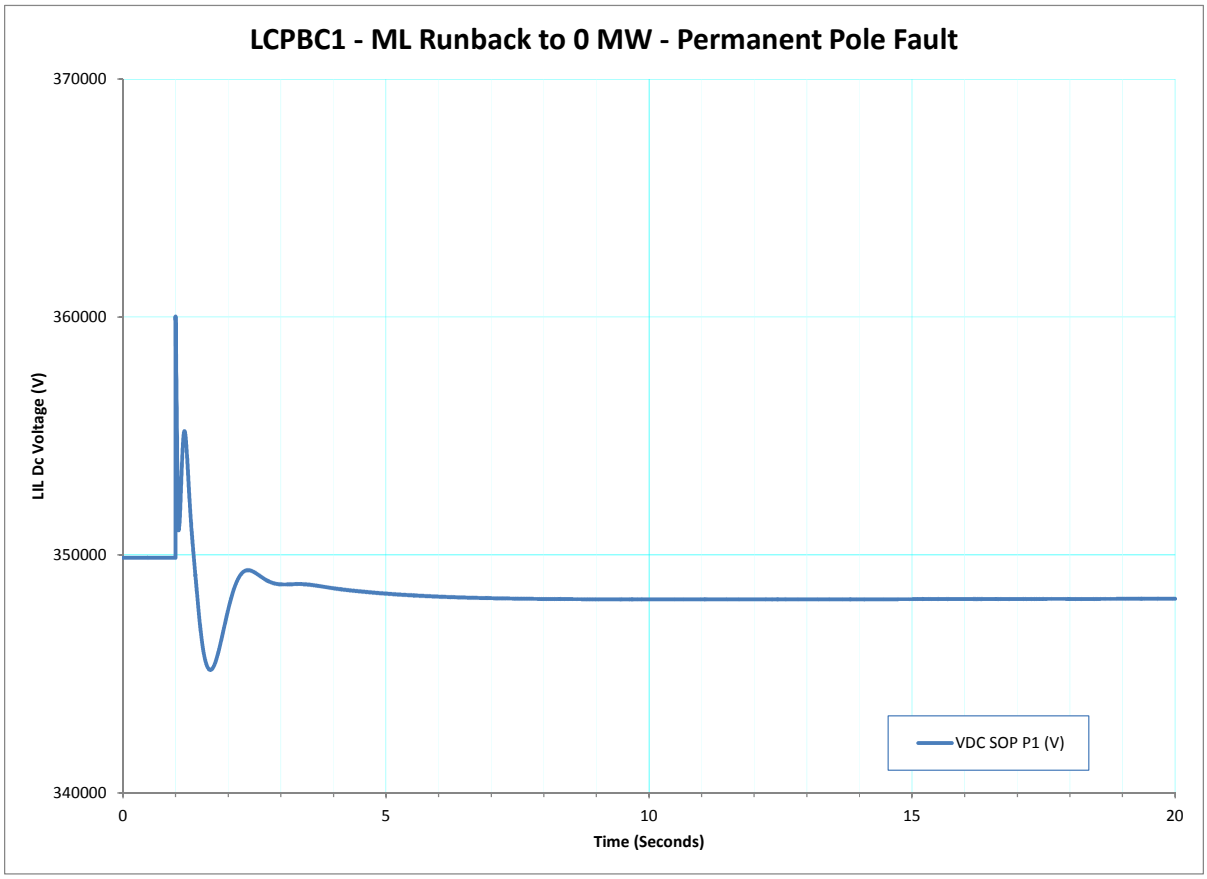

Figure 293 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

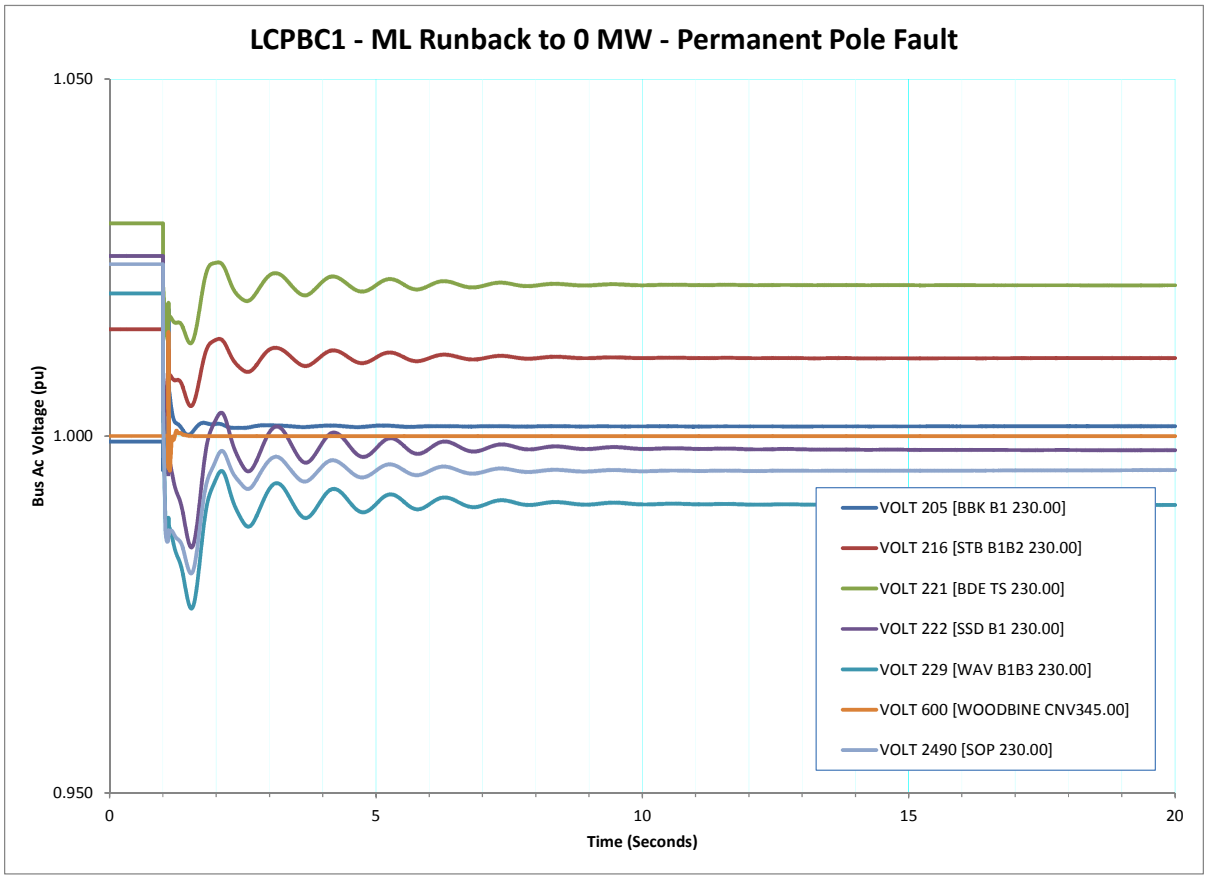

Figure 294 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

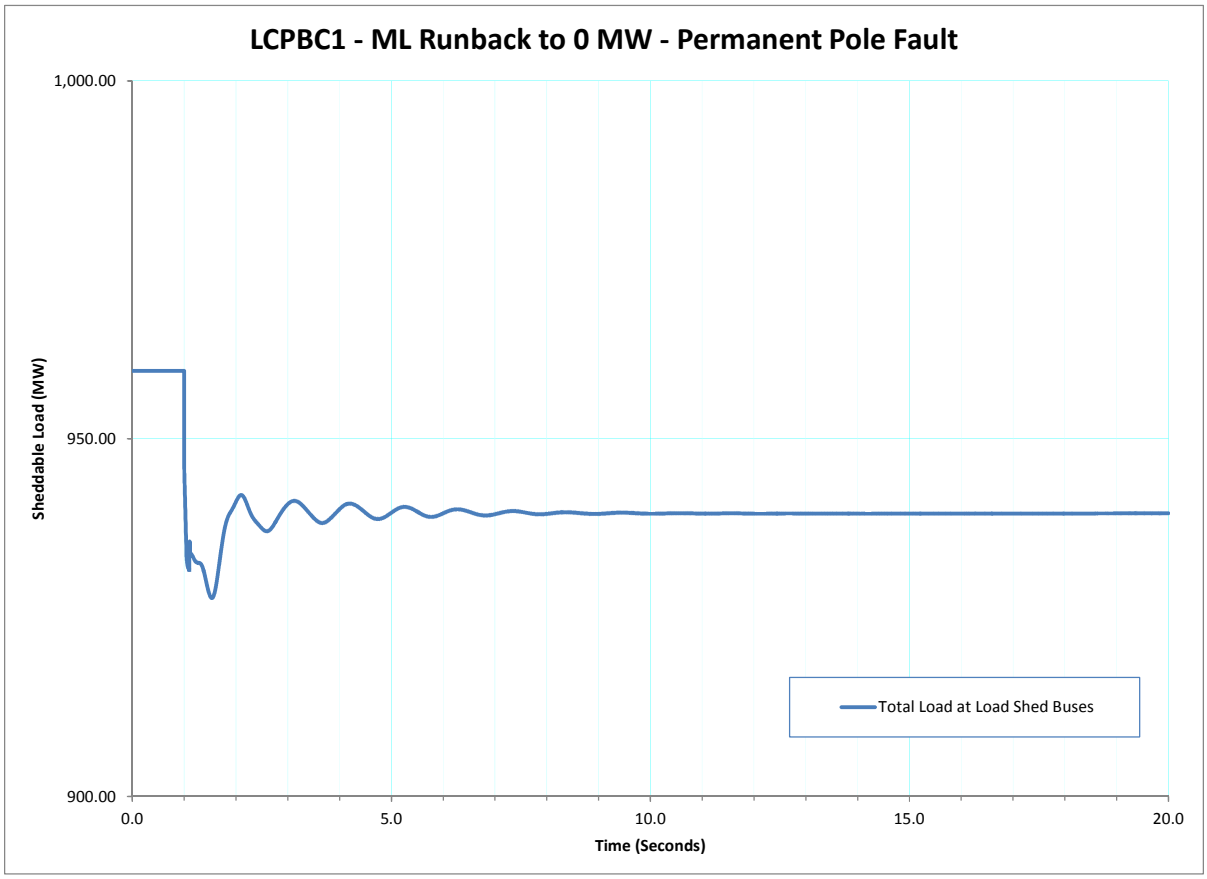

Figure 295 - LCPBC1 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

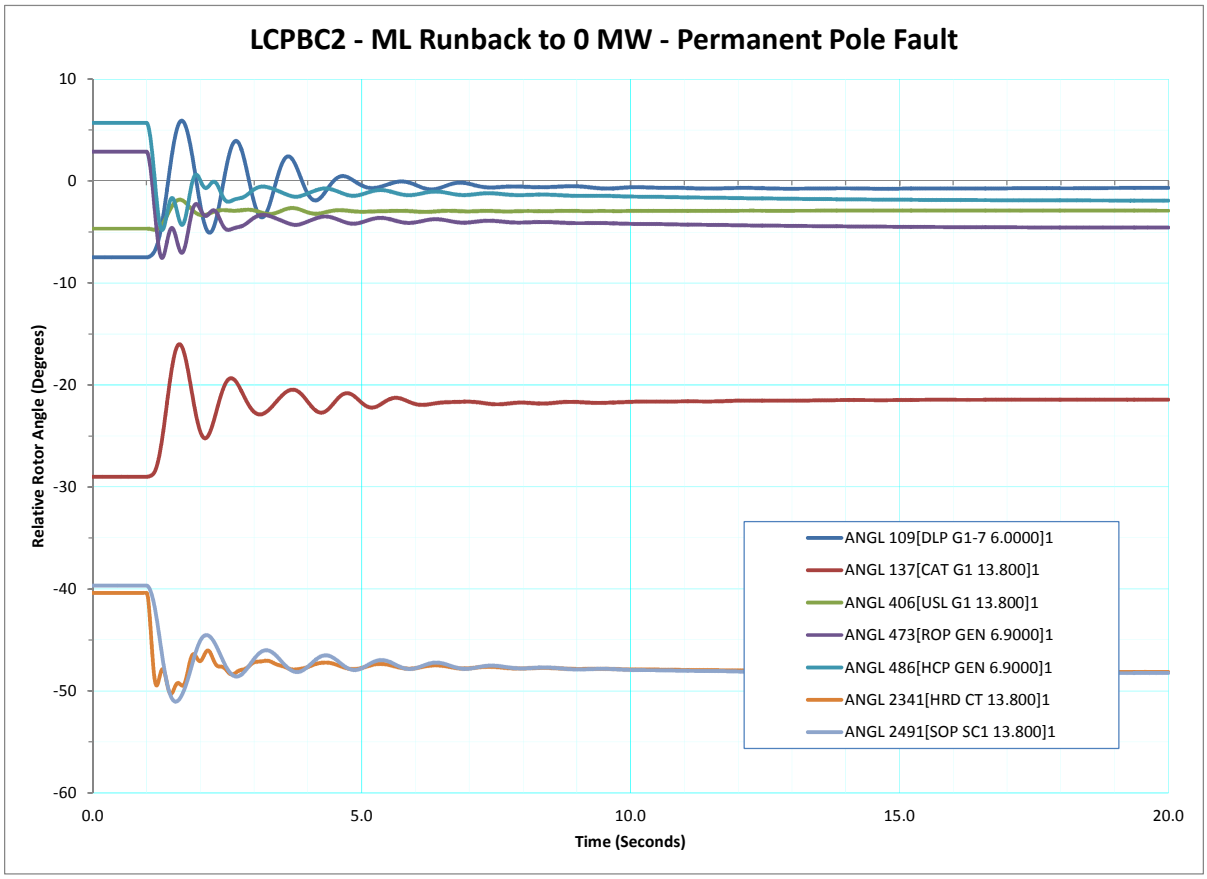

Figure 296 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

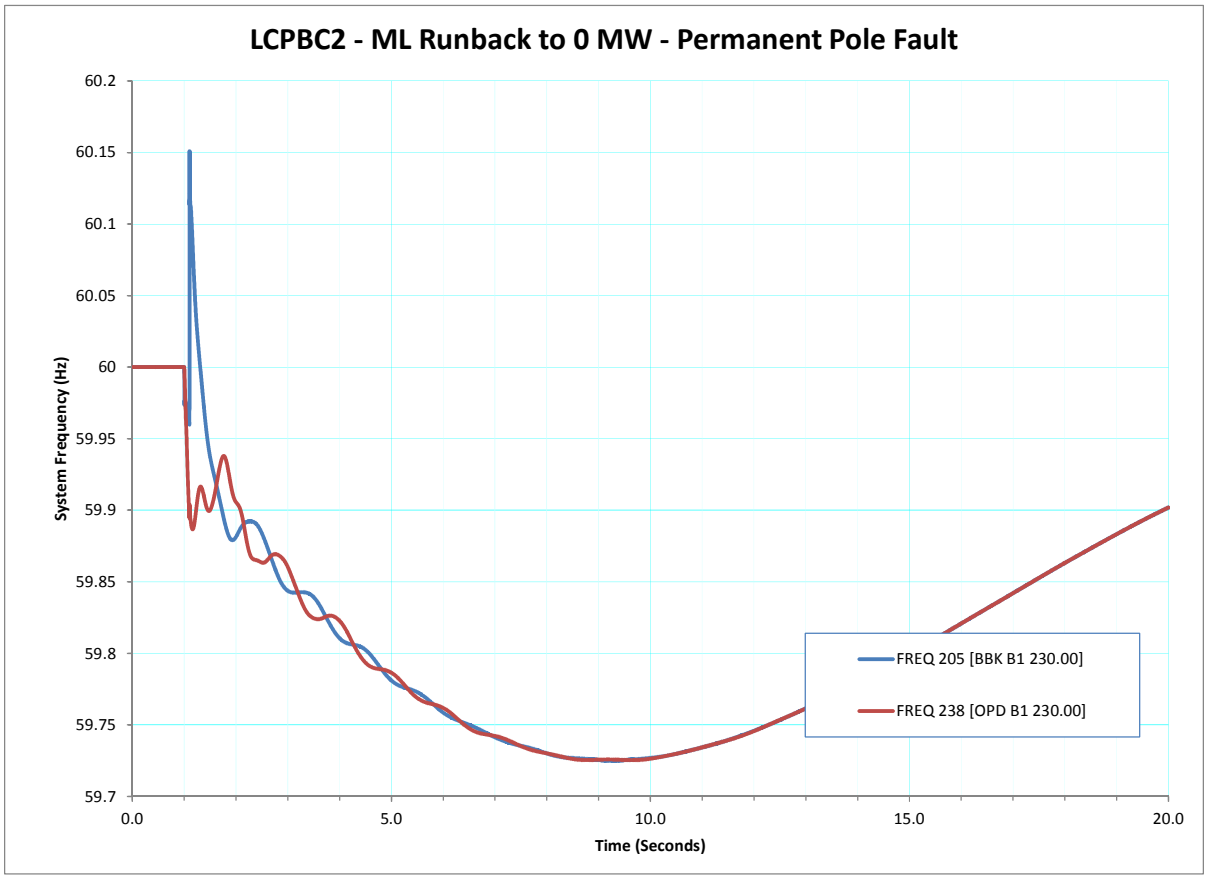

Figure 297 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

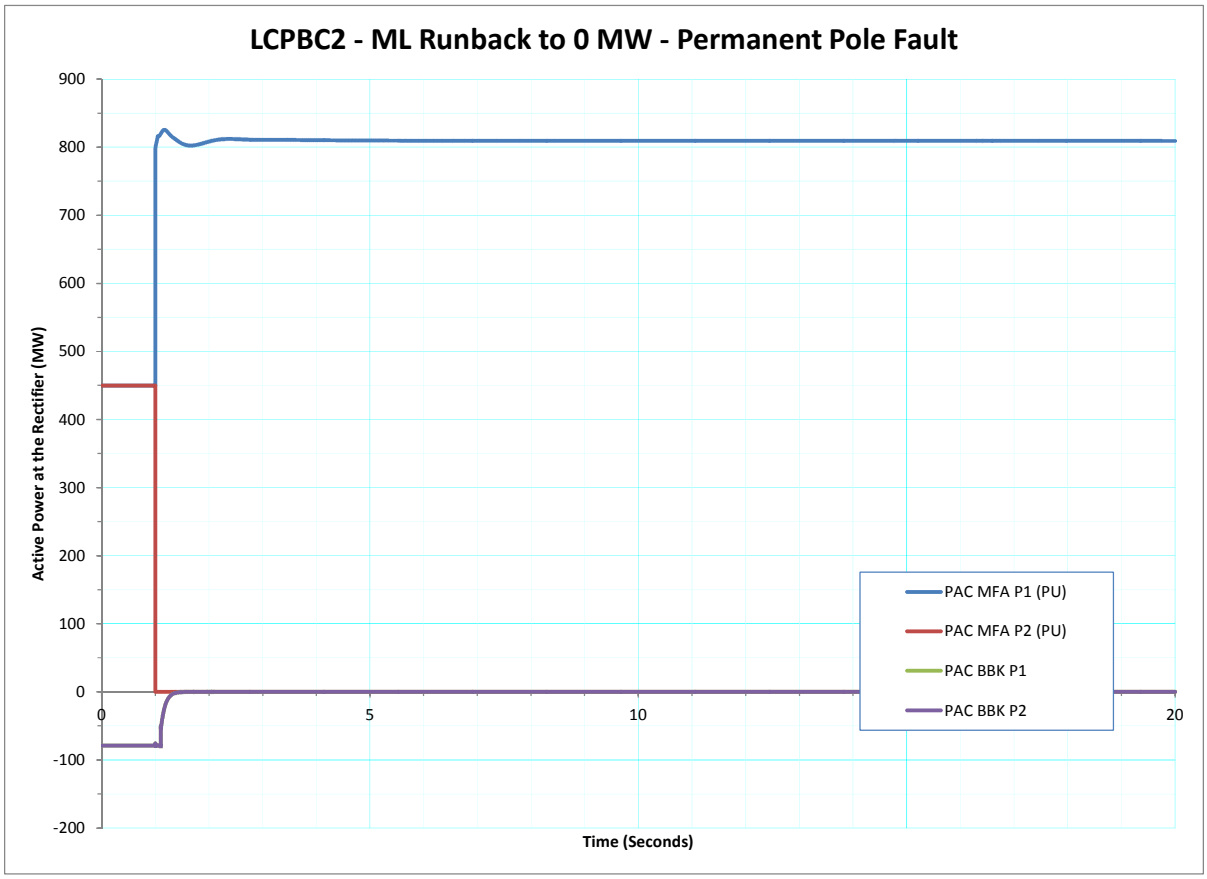

Figure 298 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

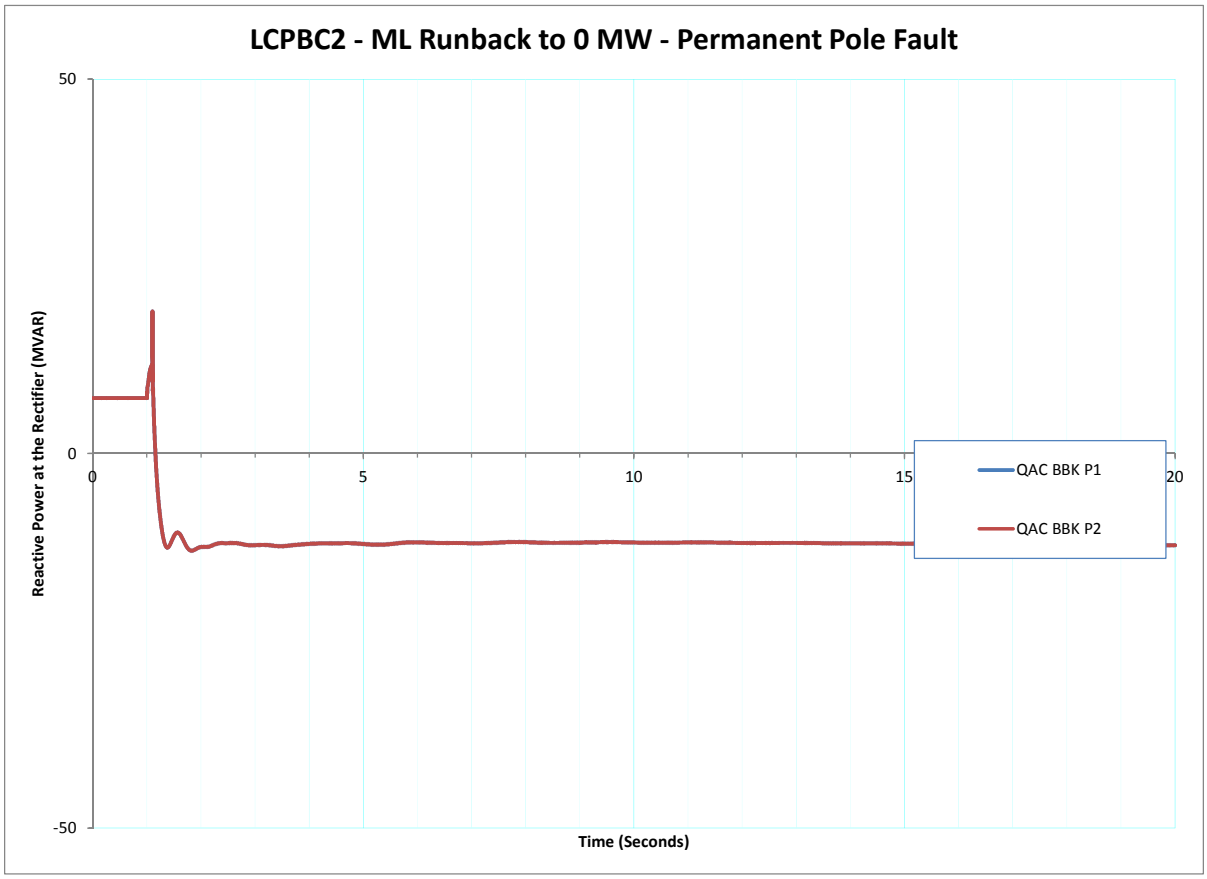

Figure 299 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

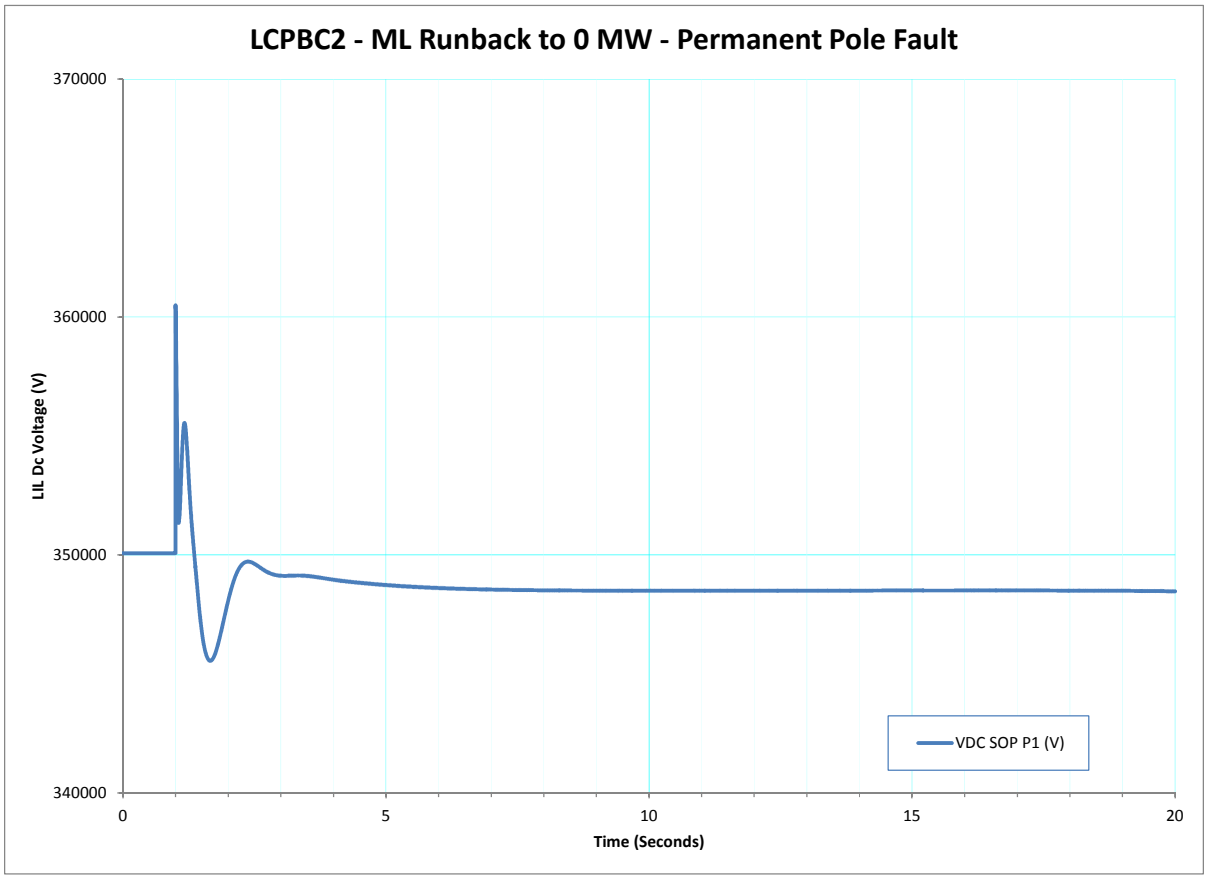

Figure 300 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

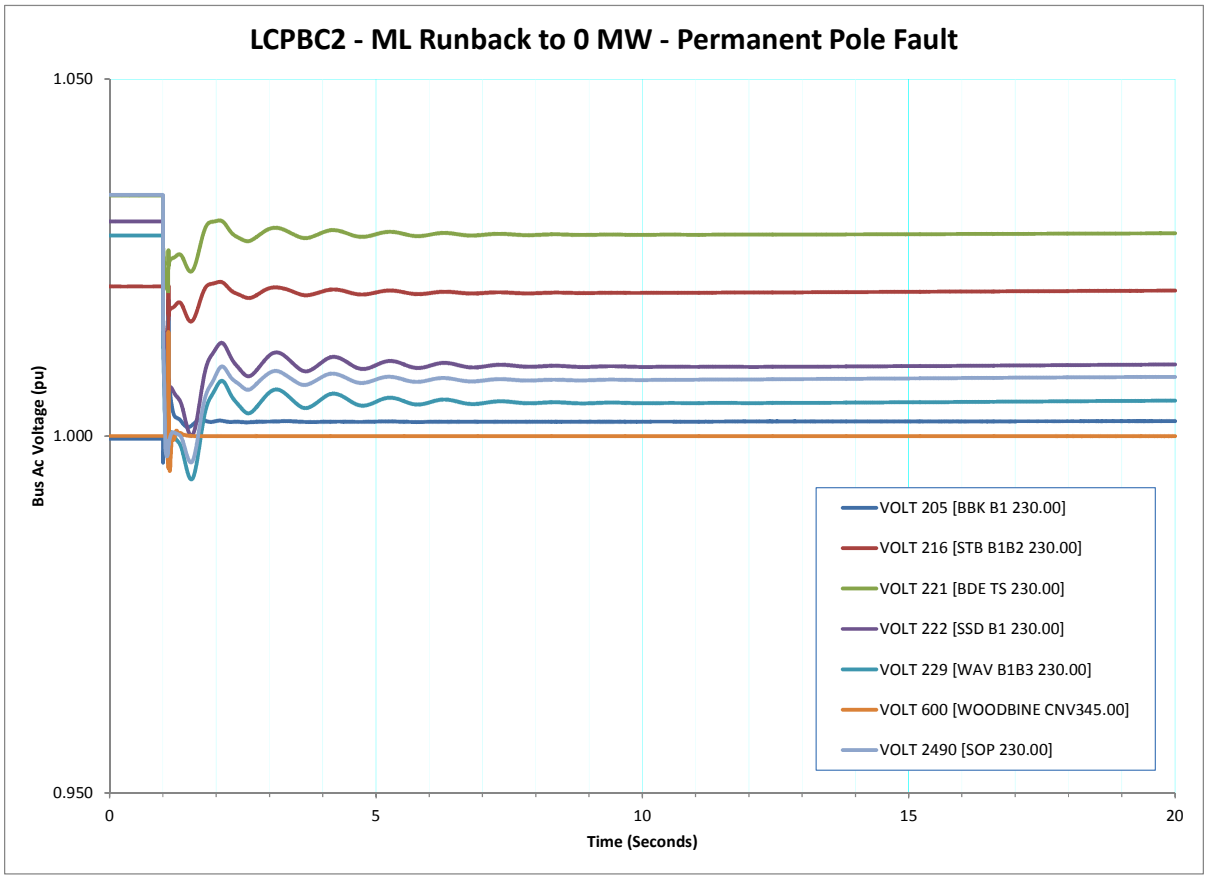

Figure 301 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

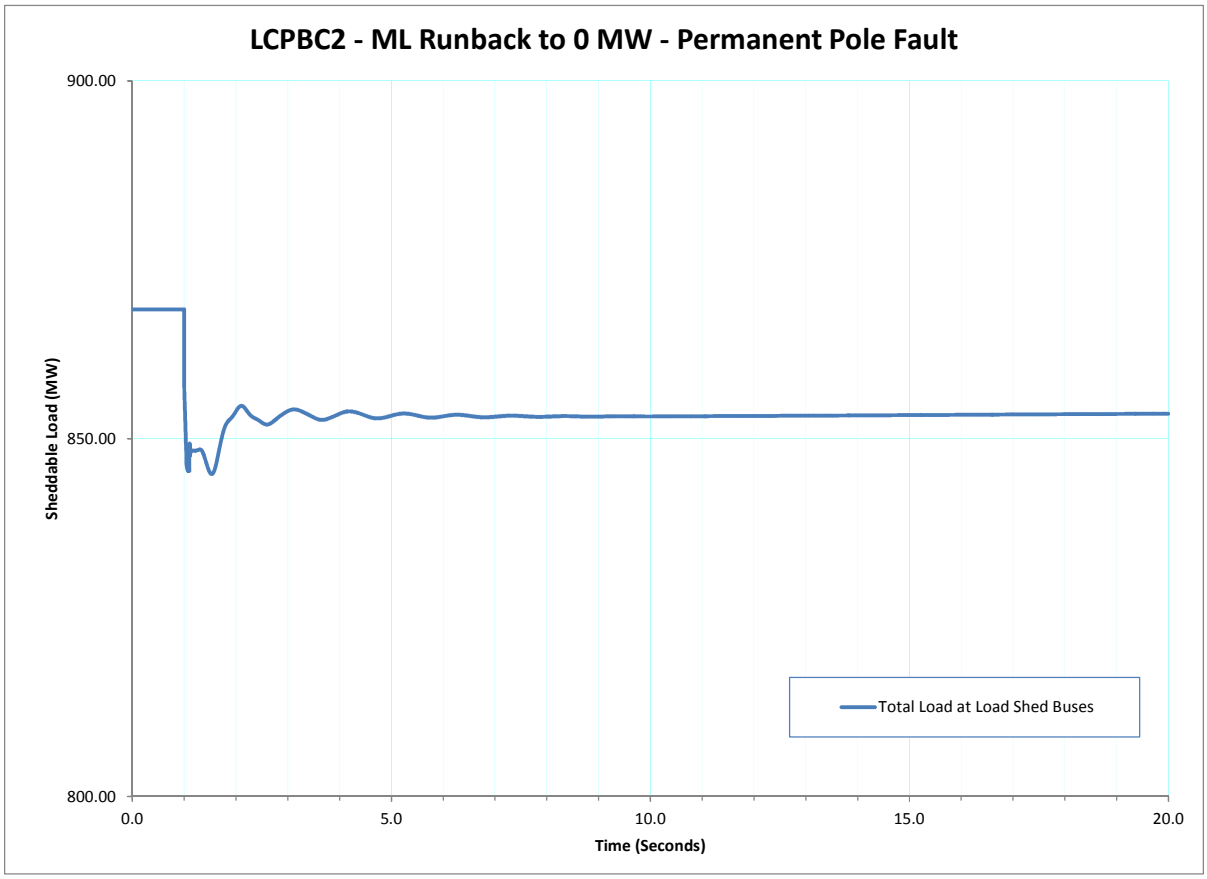

Figure 302 - LCPBC2 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

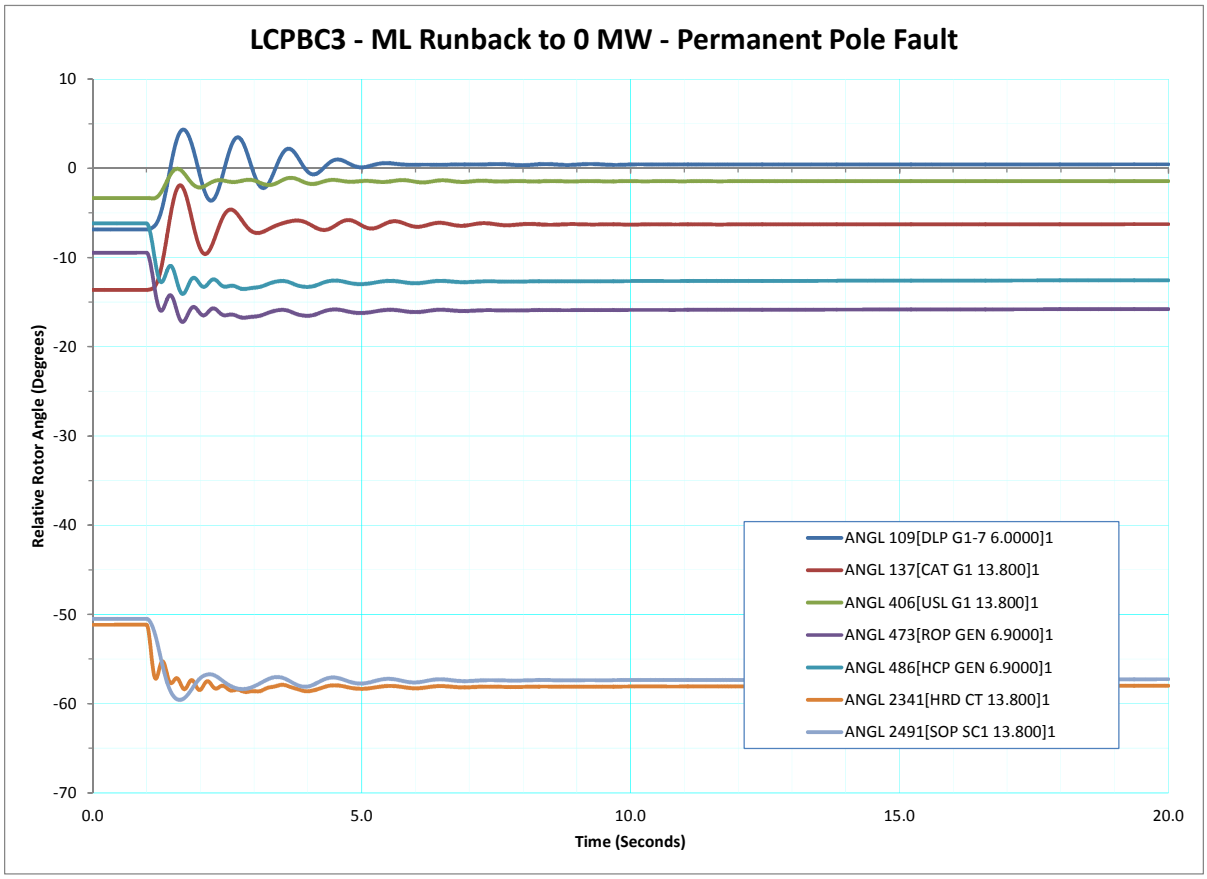

Figure 303 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

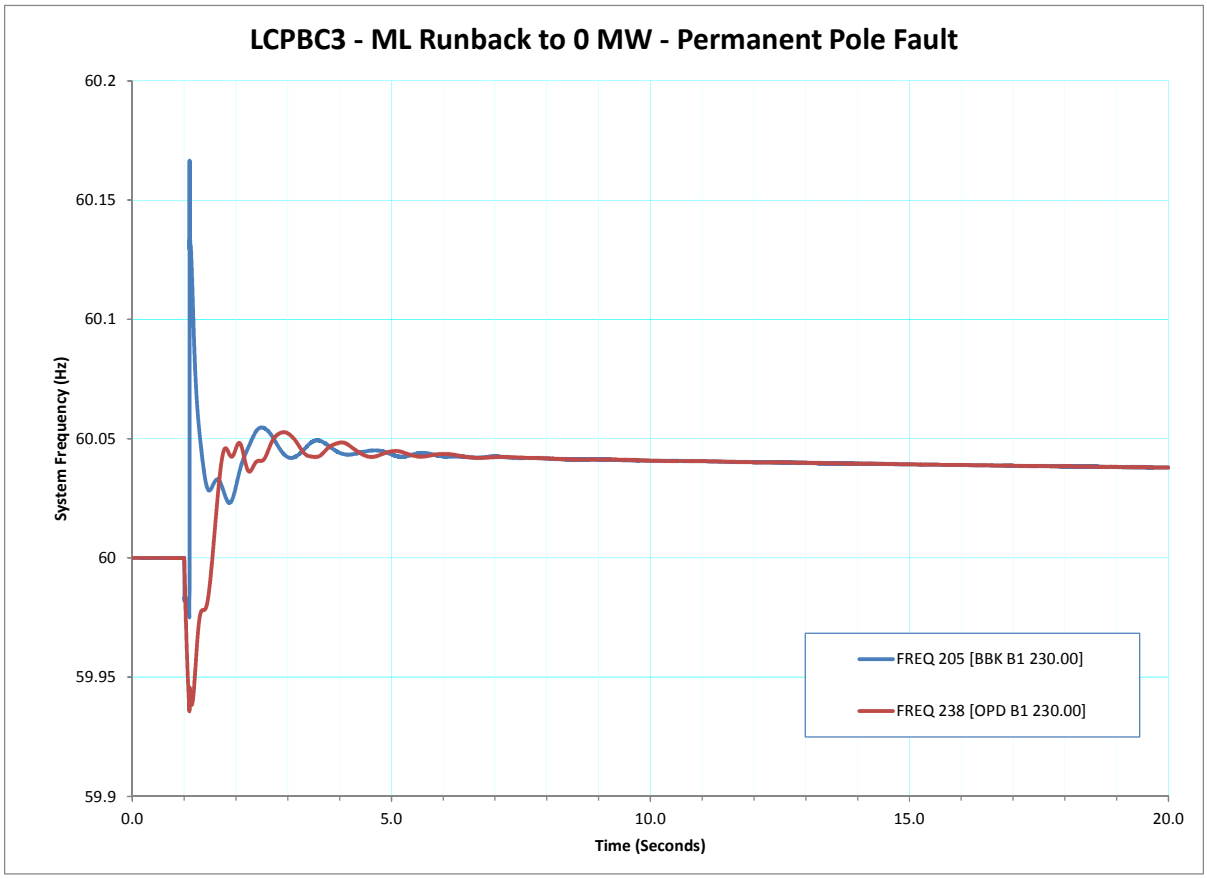

Figure 304 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

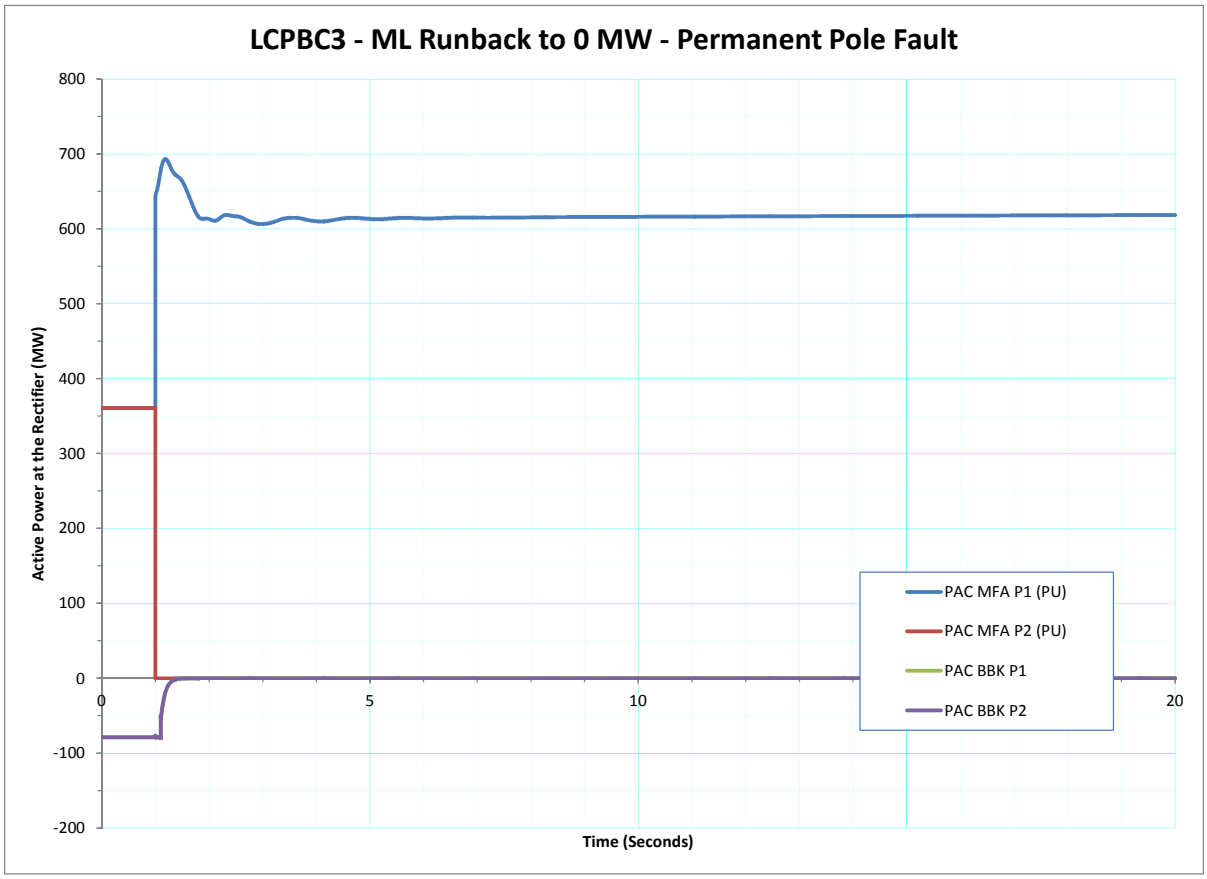

Figure 305 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

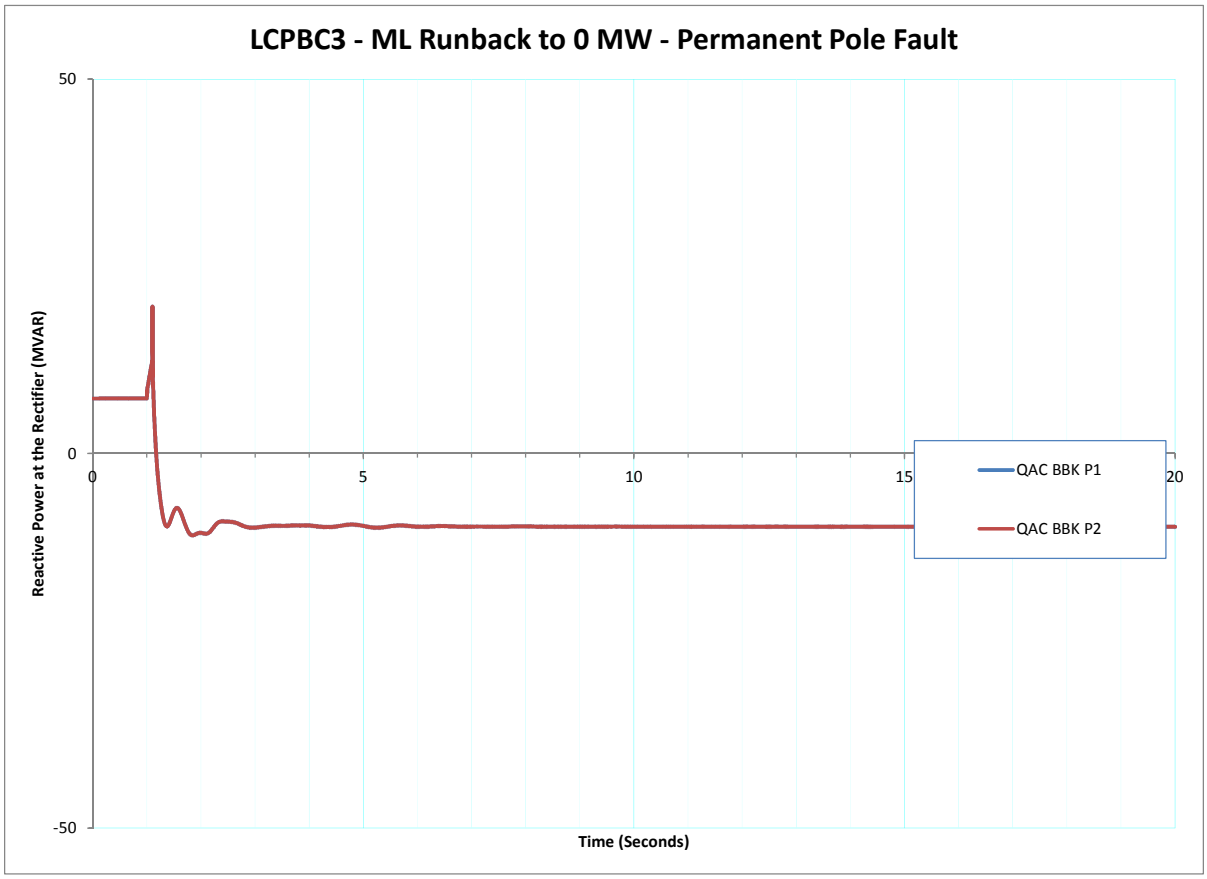

Figure 306 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

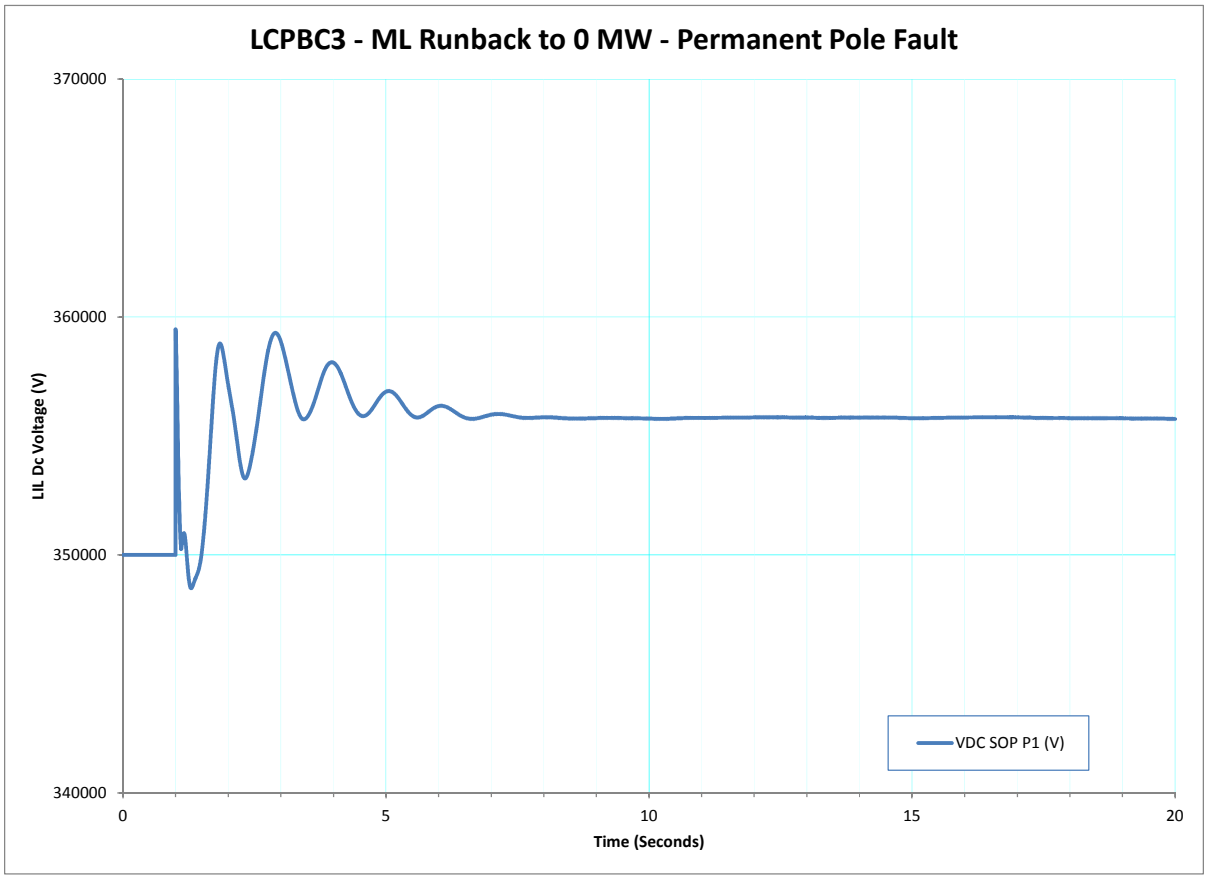

Figure 307 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

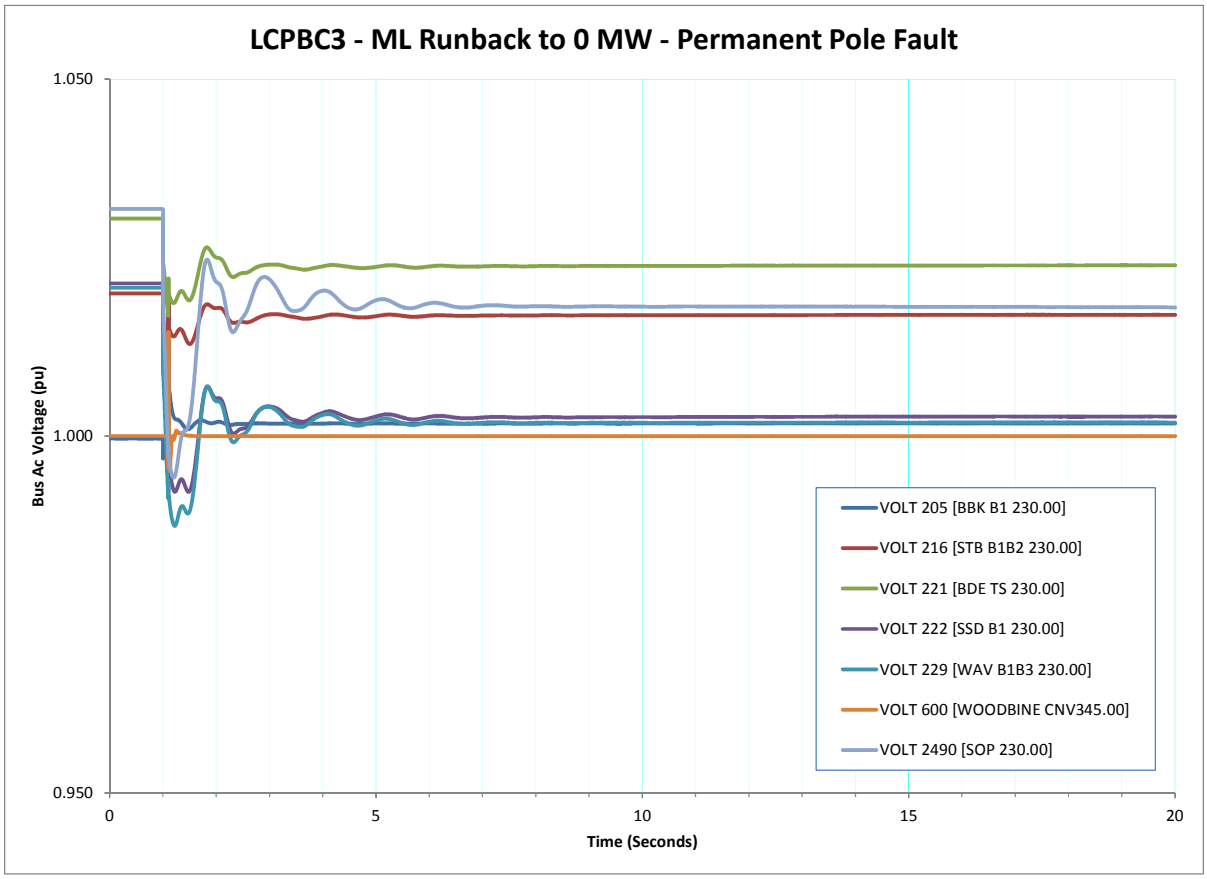

Figure 308 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

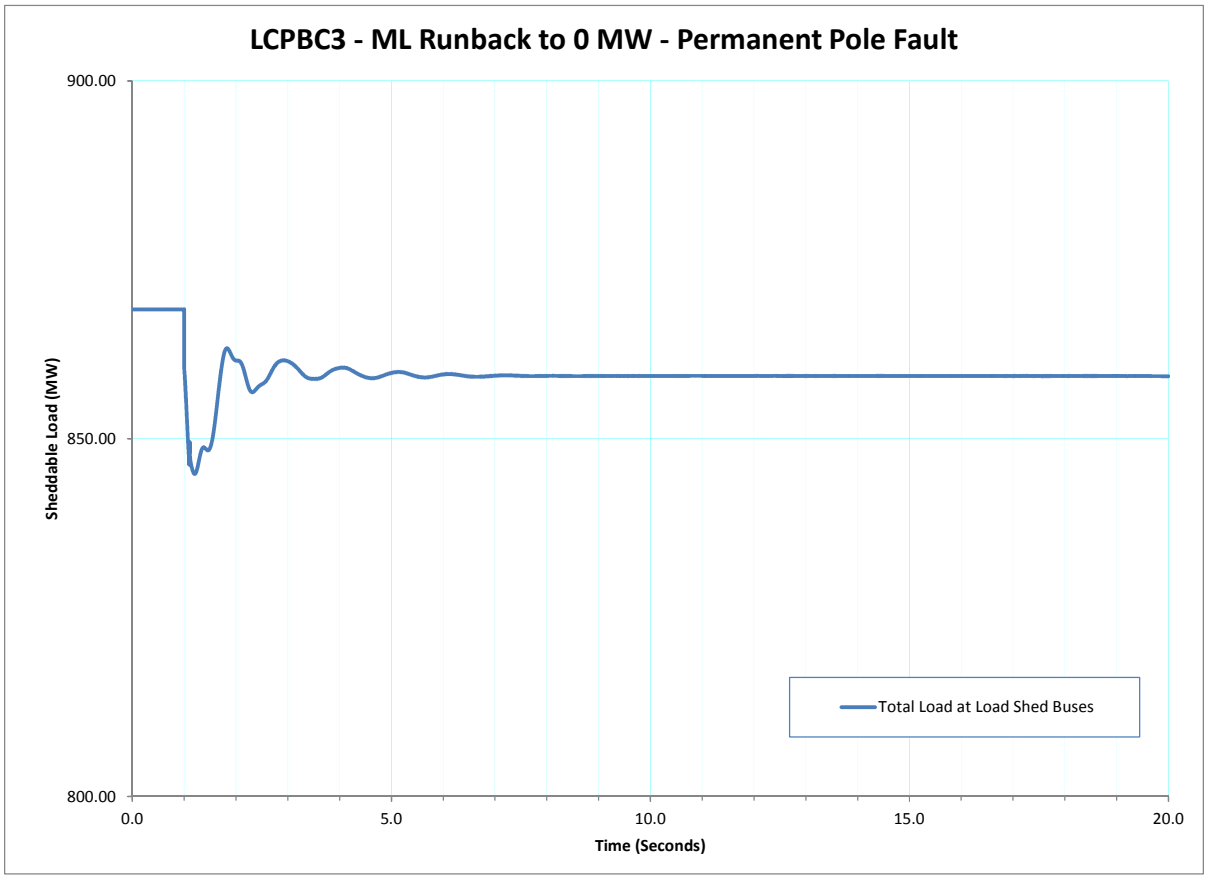

Figure 309 - LCPBC3 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

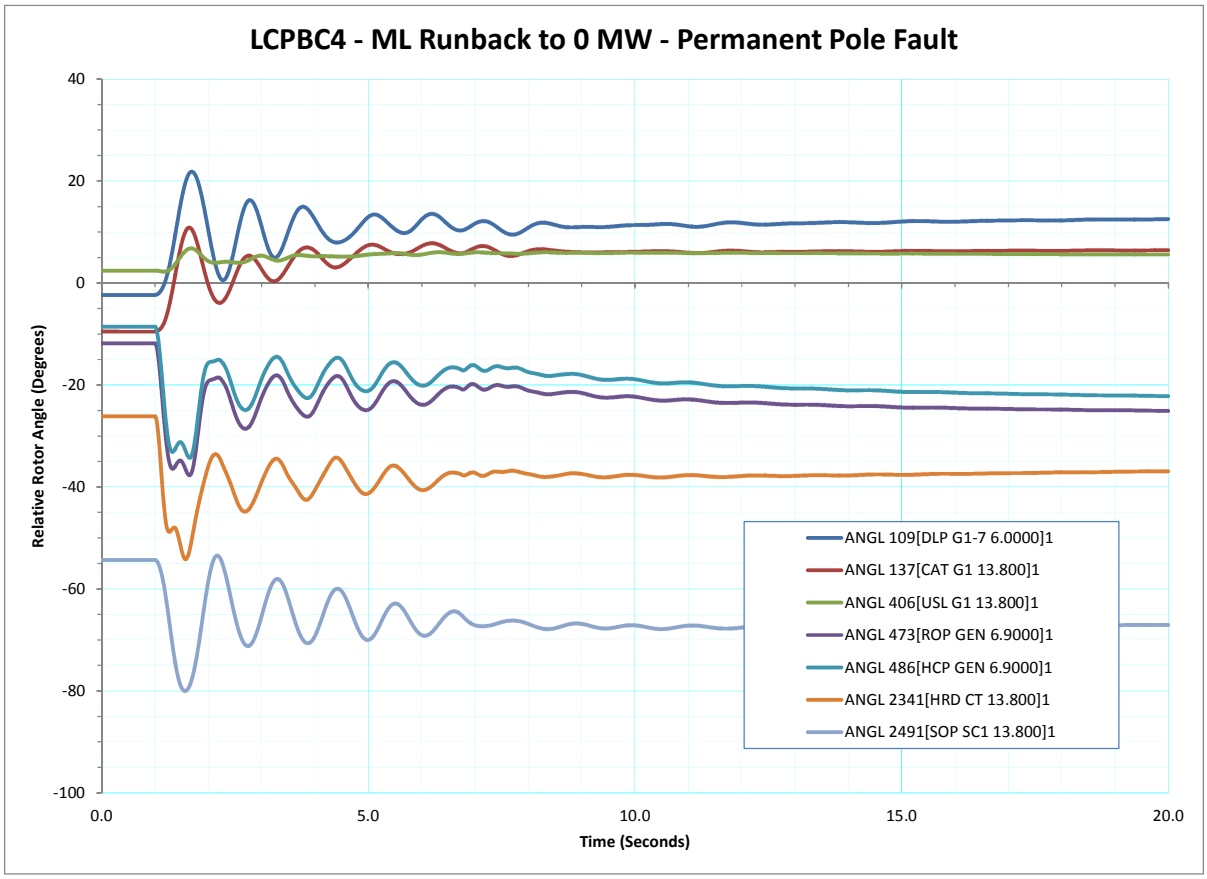

Figure 310 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

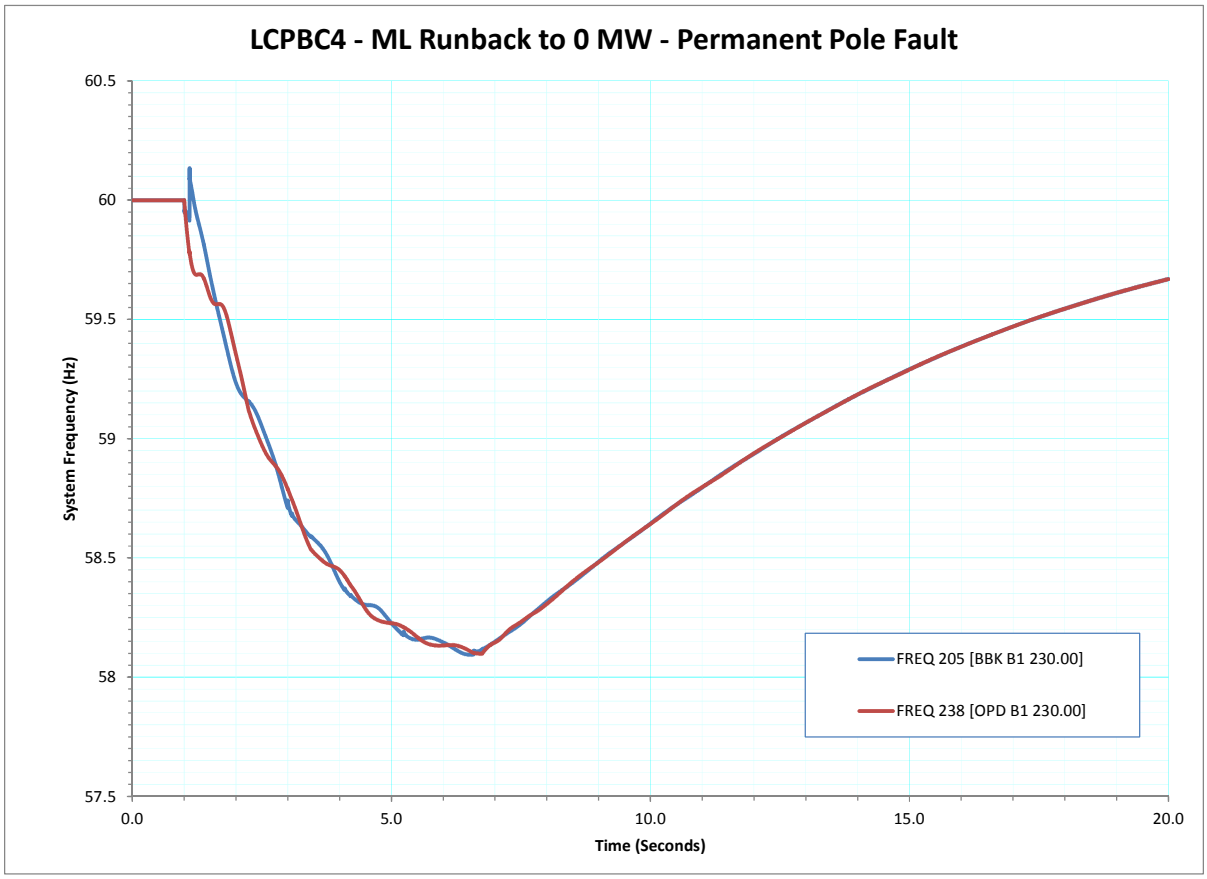

Figure 311 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

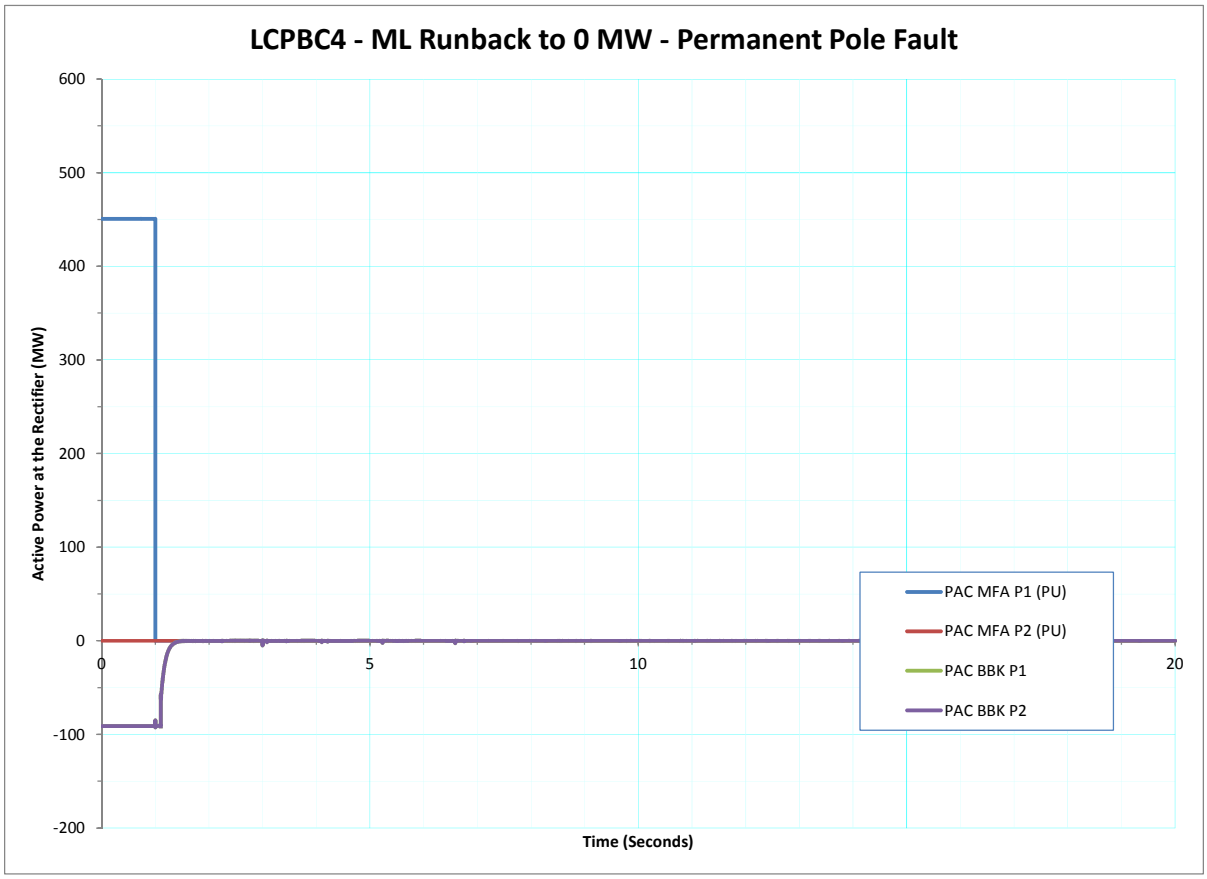

Figure 312 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

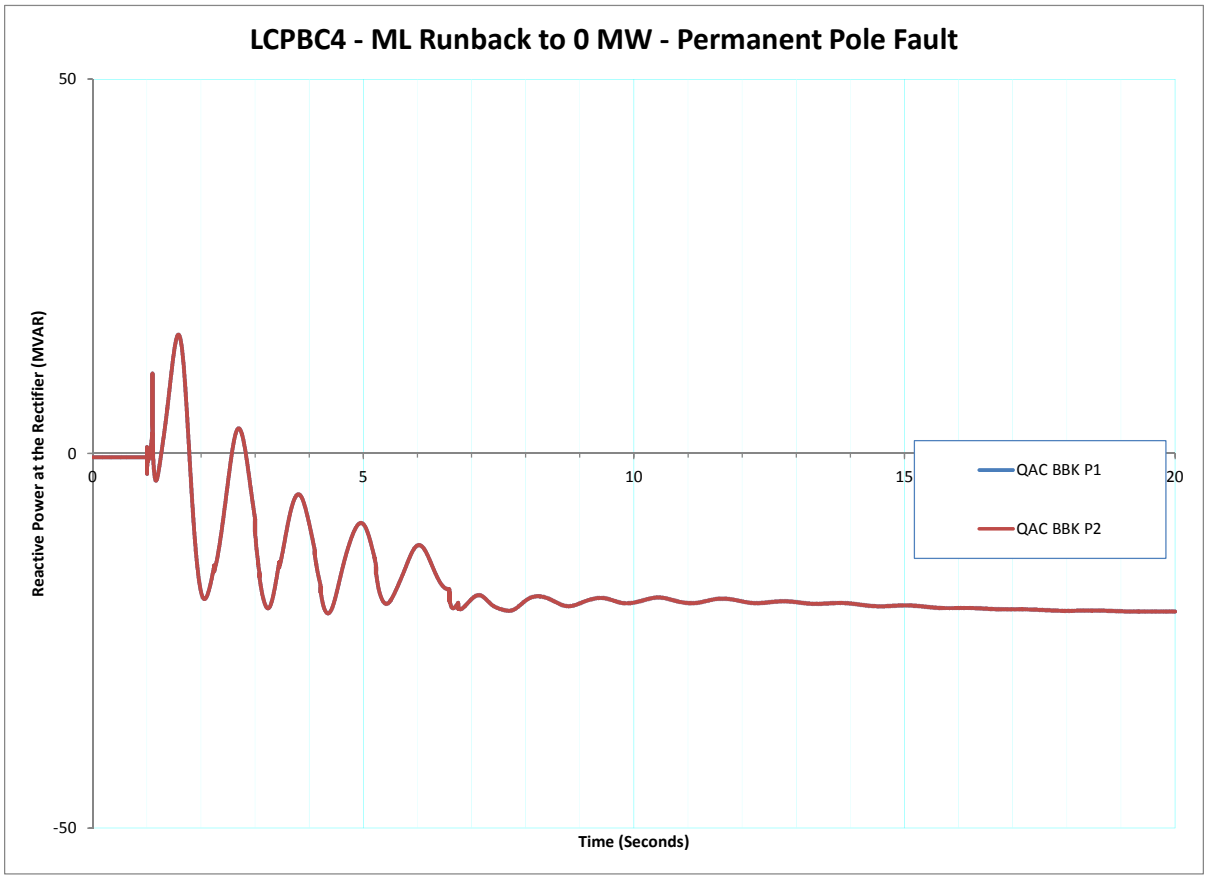

Figure 313 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

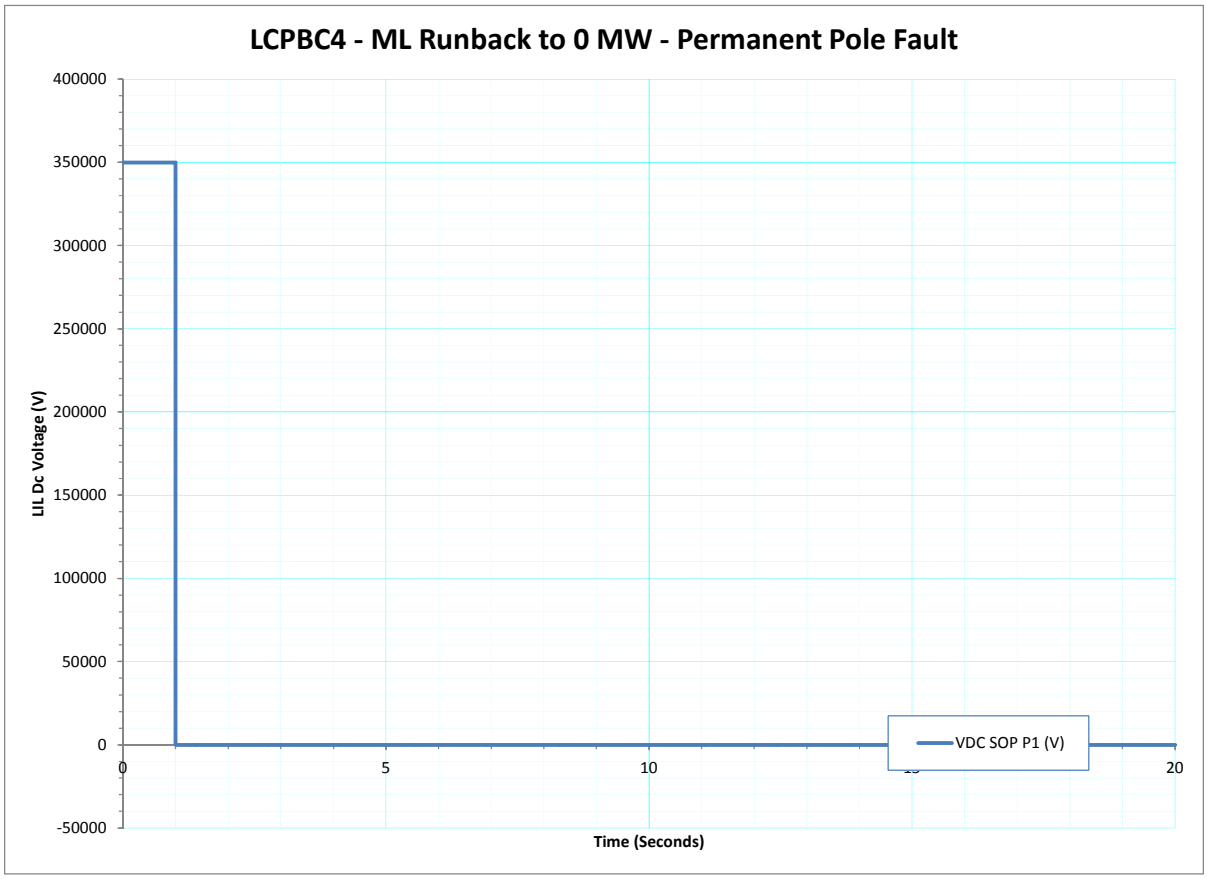

Figure 314 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

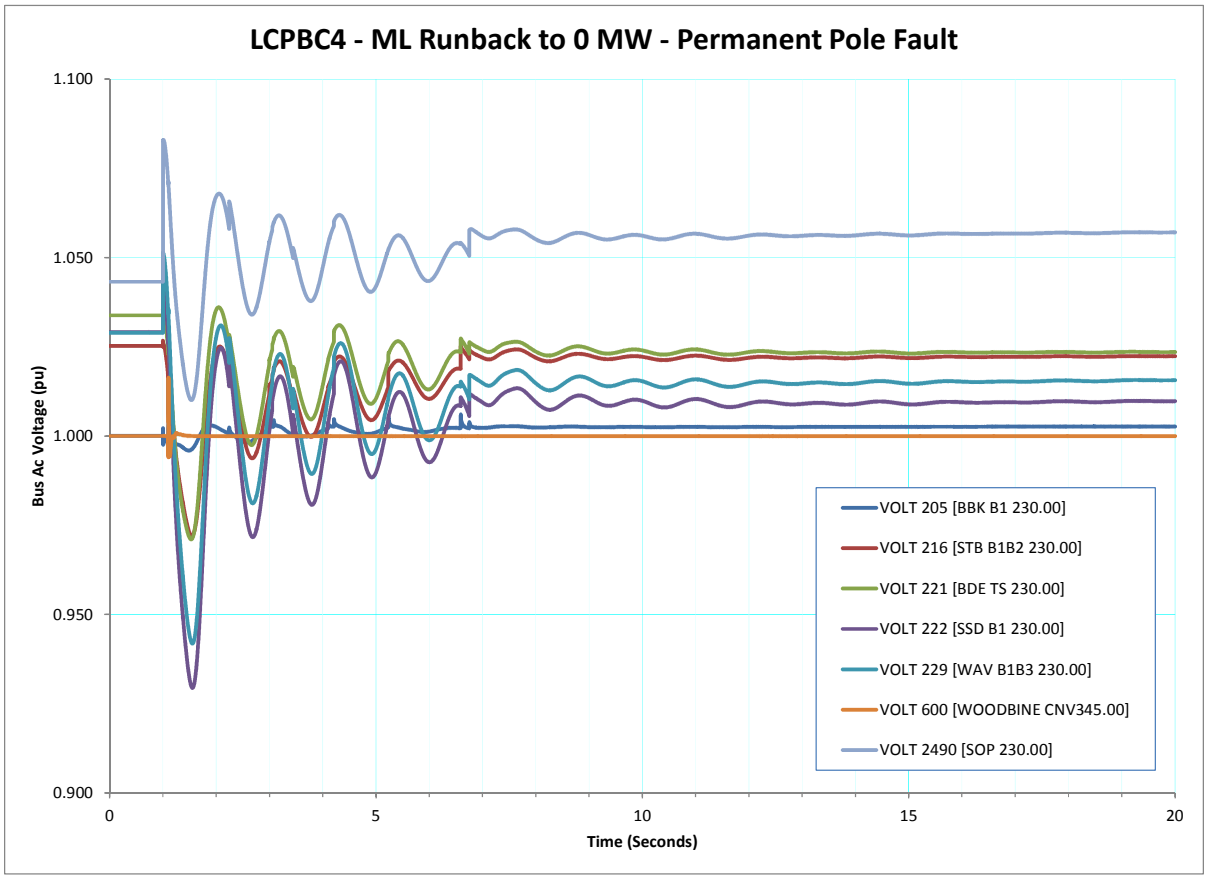

Figure 315 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

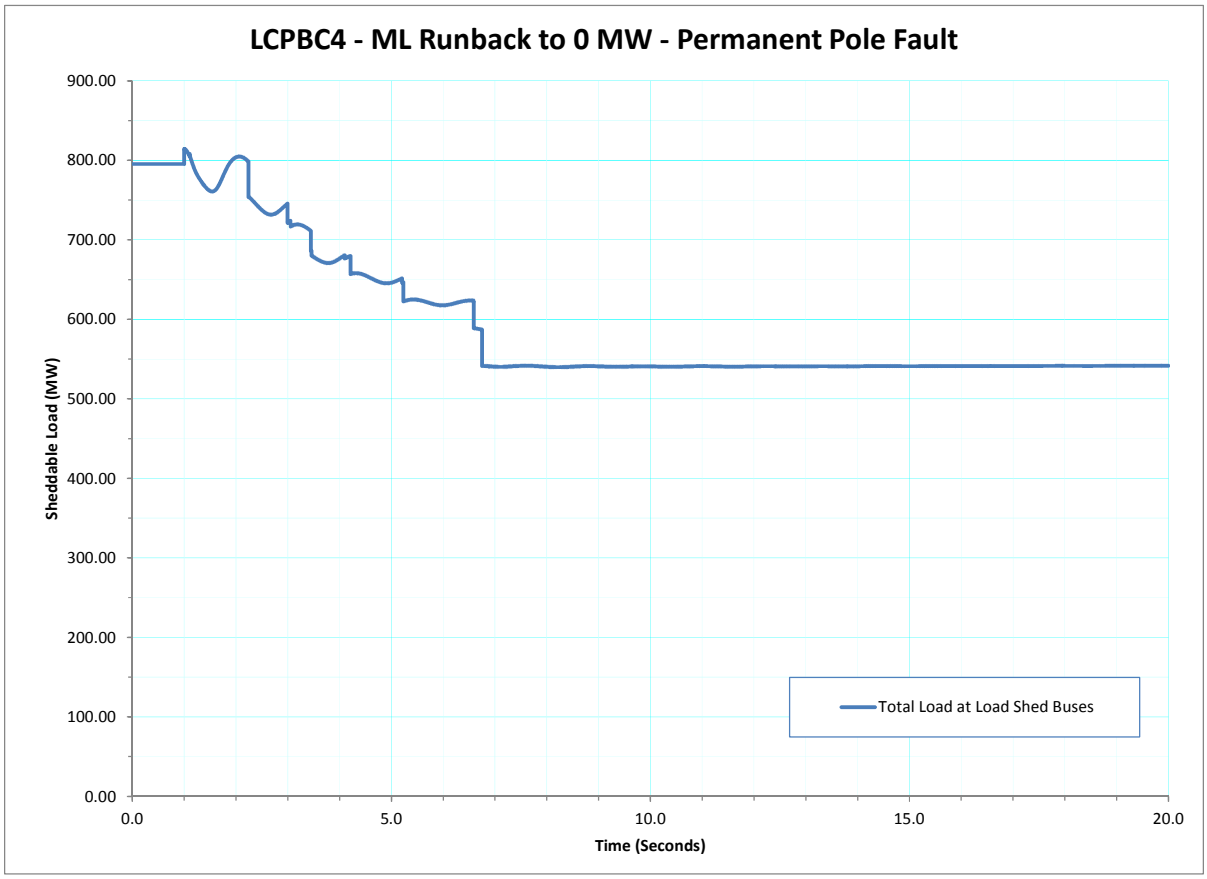

Figure 316 - LCPBC4 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

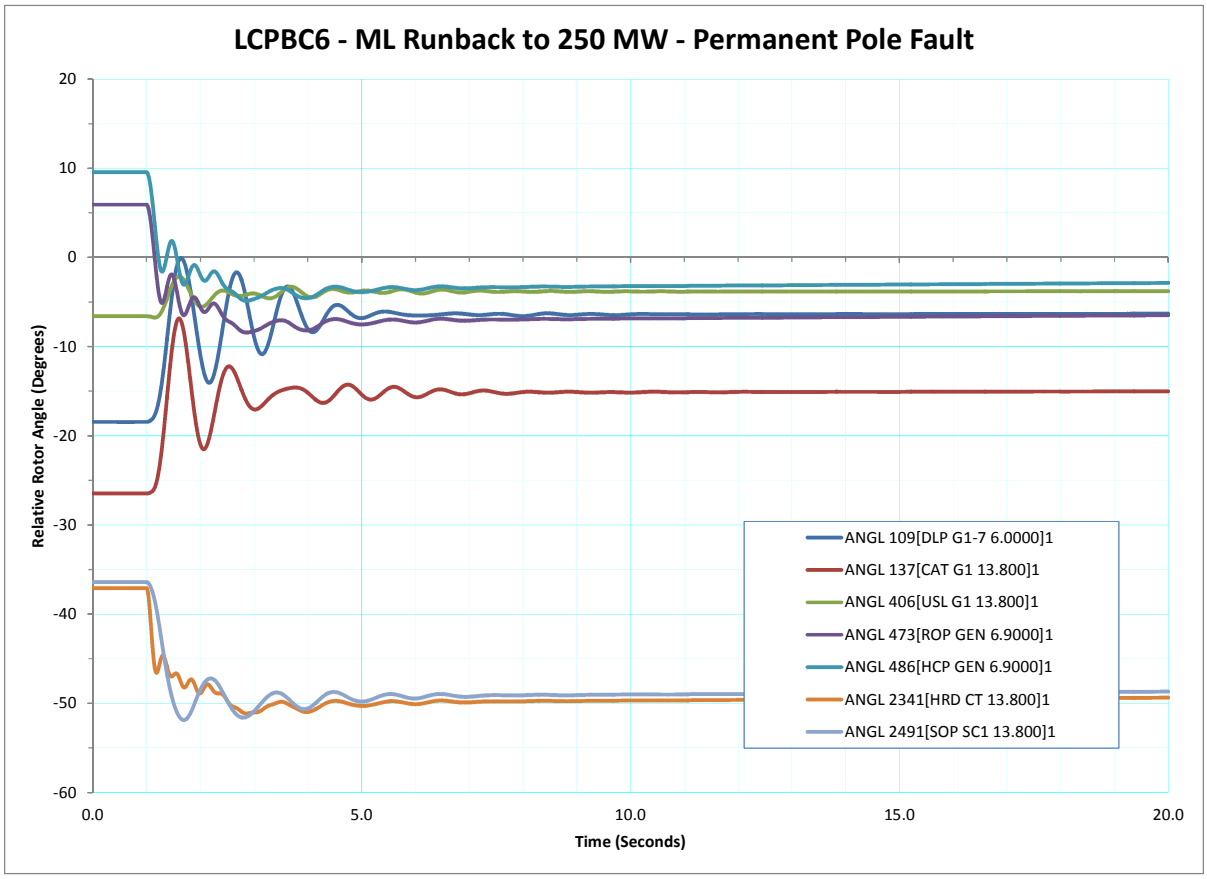

Figure 317 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

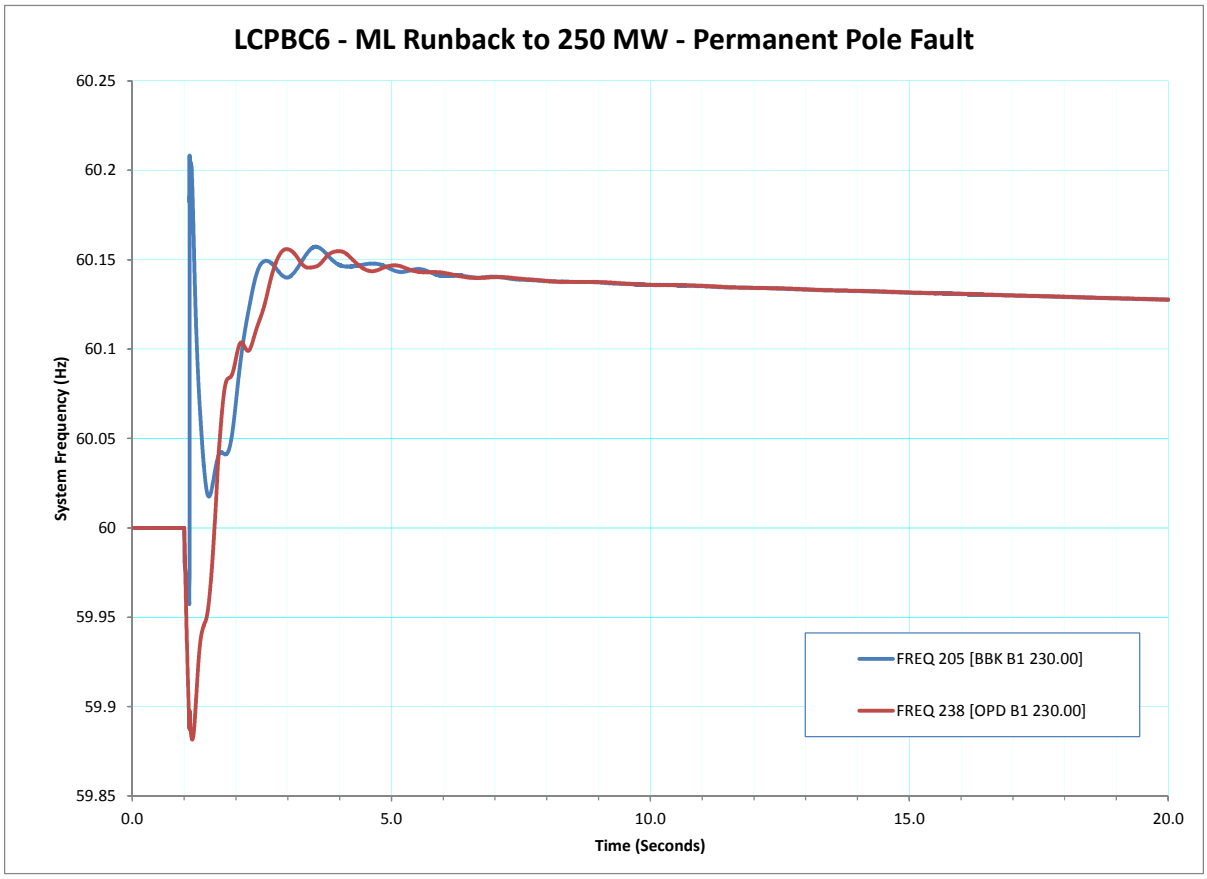

Figure 318 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - System Frequency (Hz)

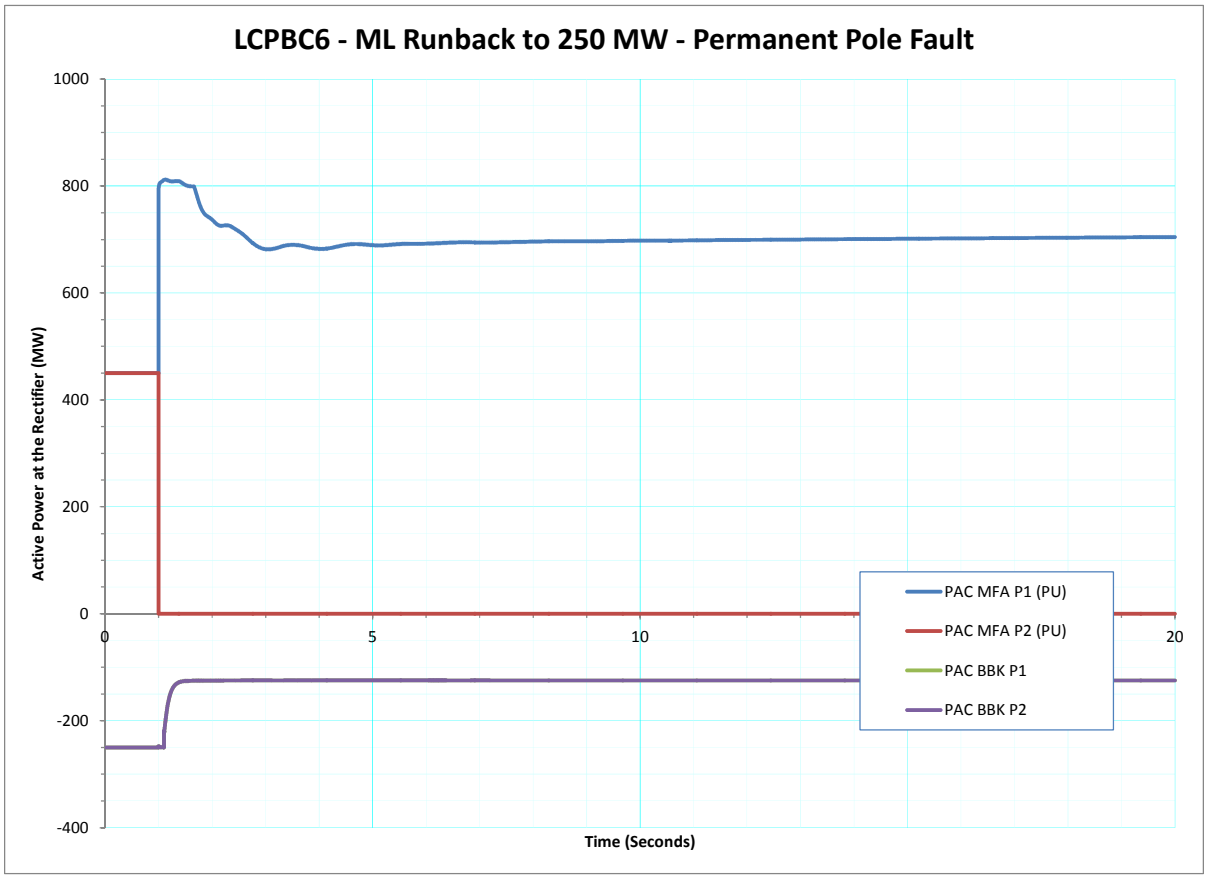

Figure 319 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

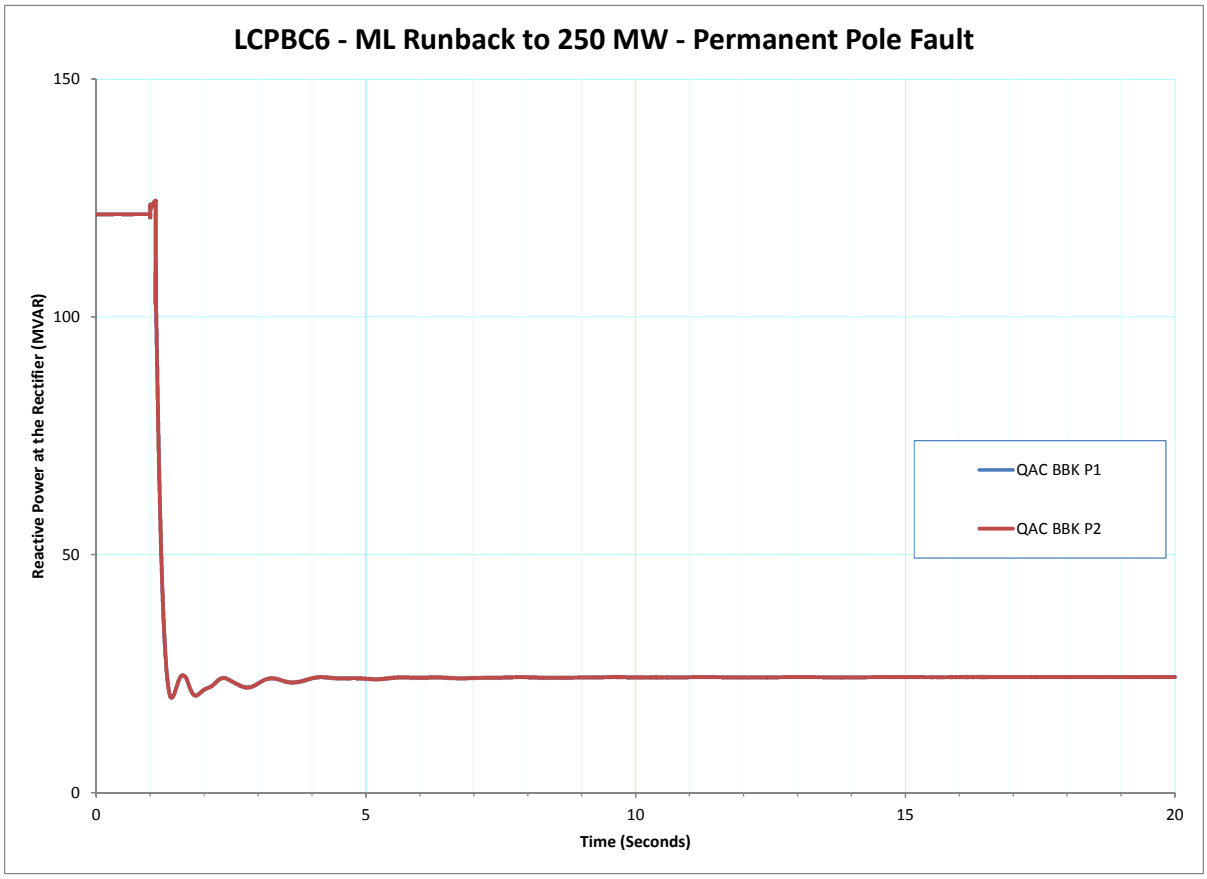

Figure 320 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

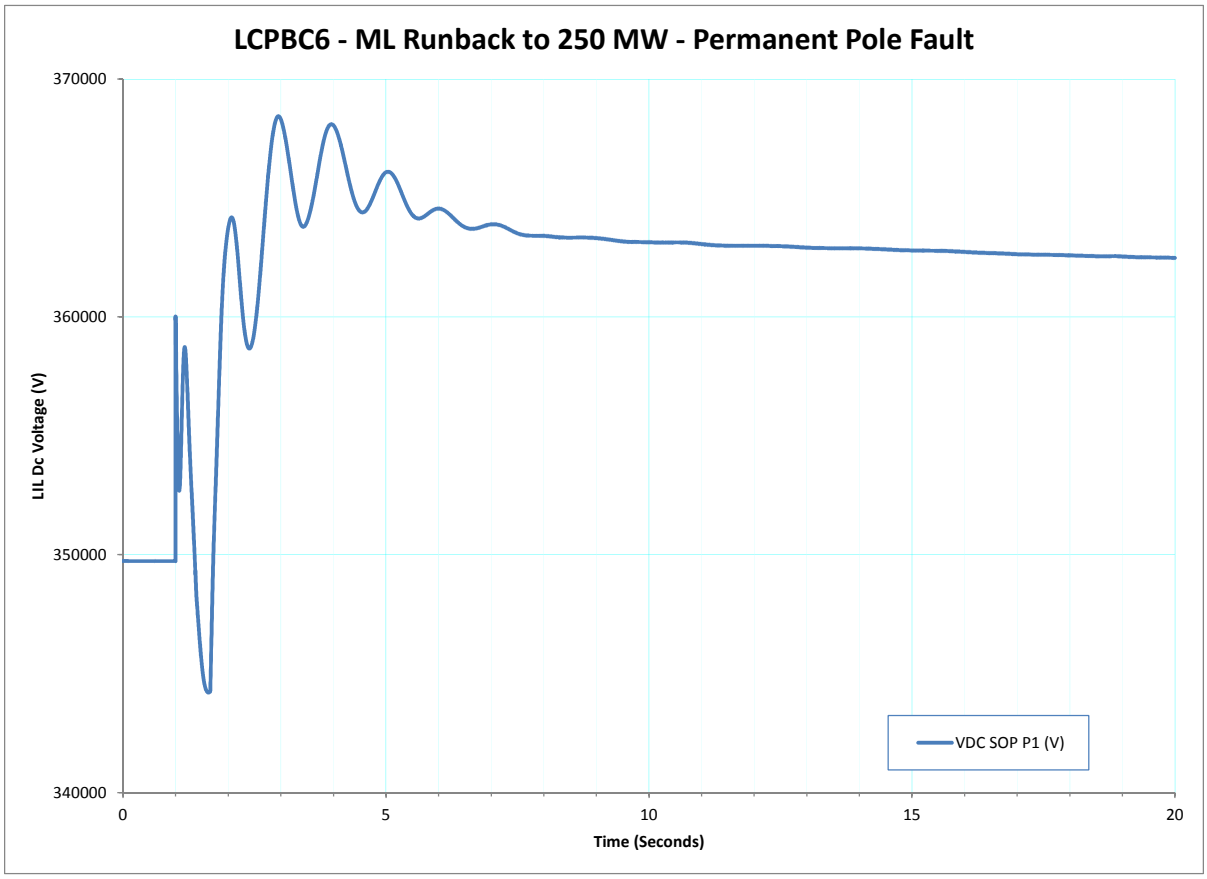

Figure 321 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - LIL Dc Voltage (V)

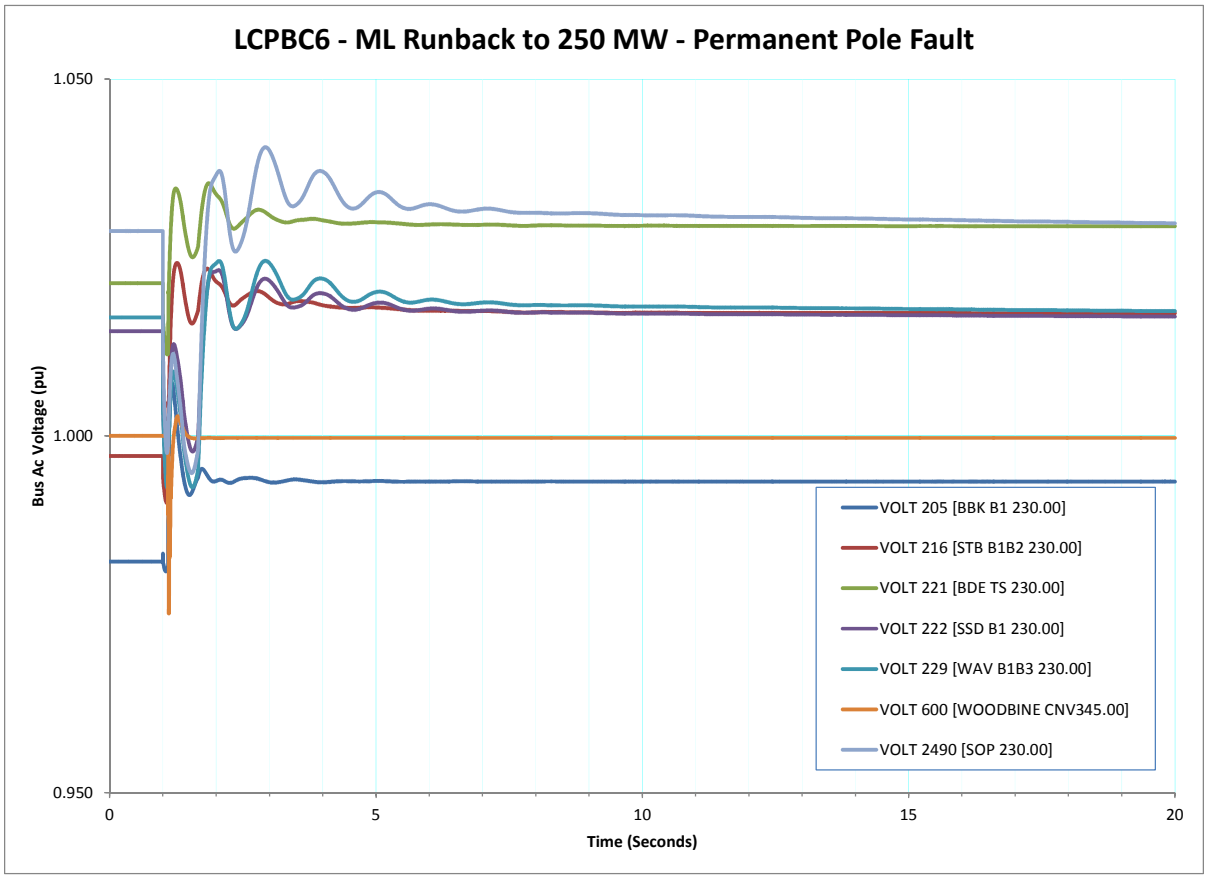

Figure 322 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

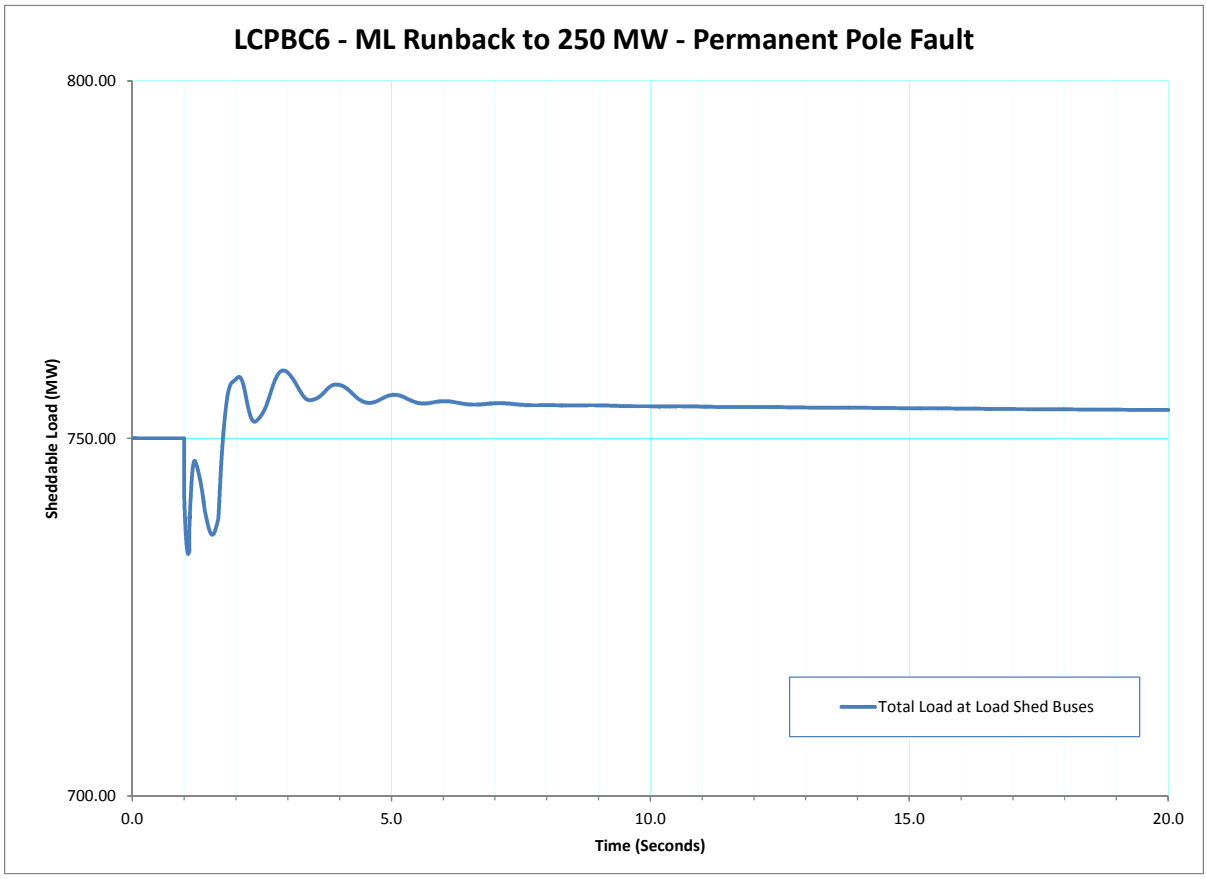

Figure 323 - LCPBC6 - ML Runback to 250 MW - Permanent Pole Fault - Sheddable Load (MW)

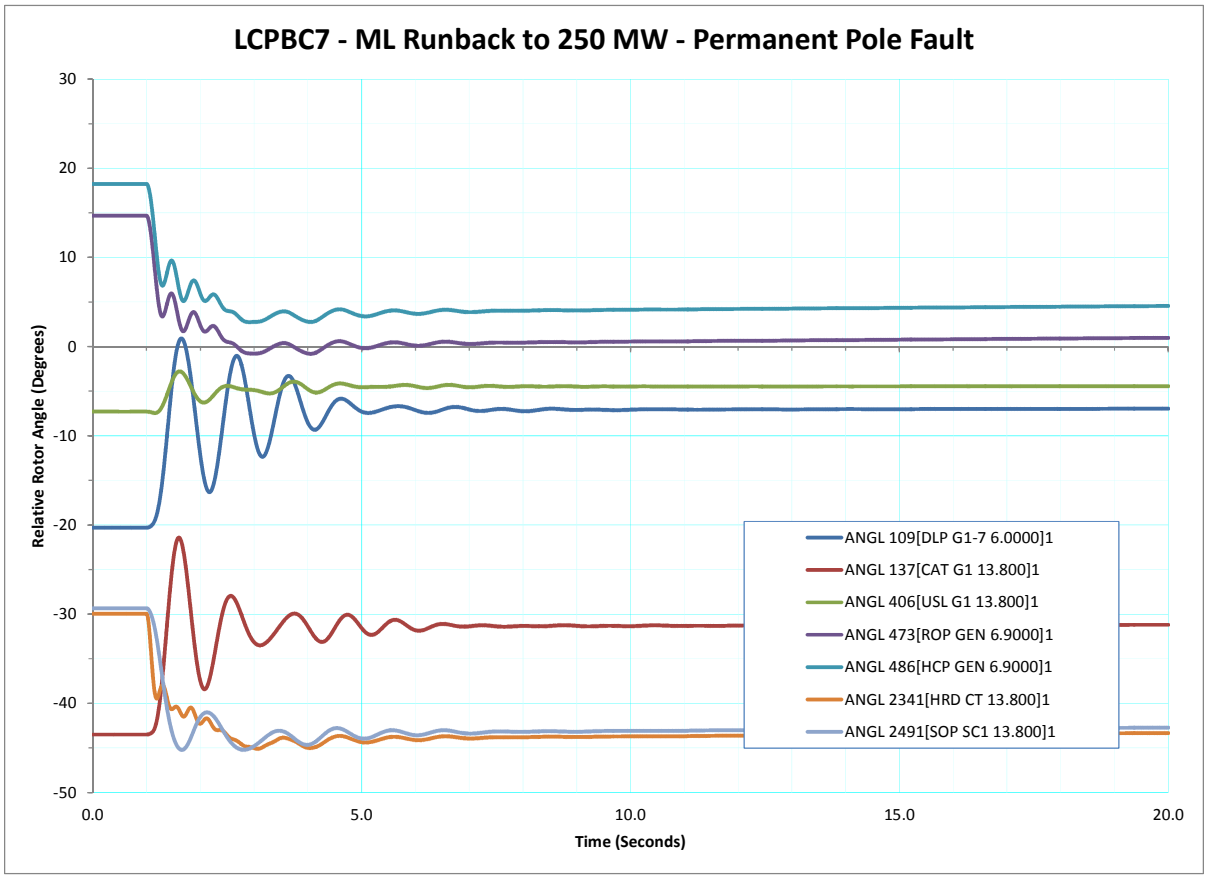

Figure 324 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

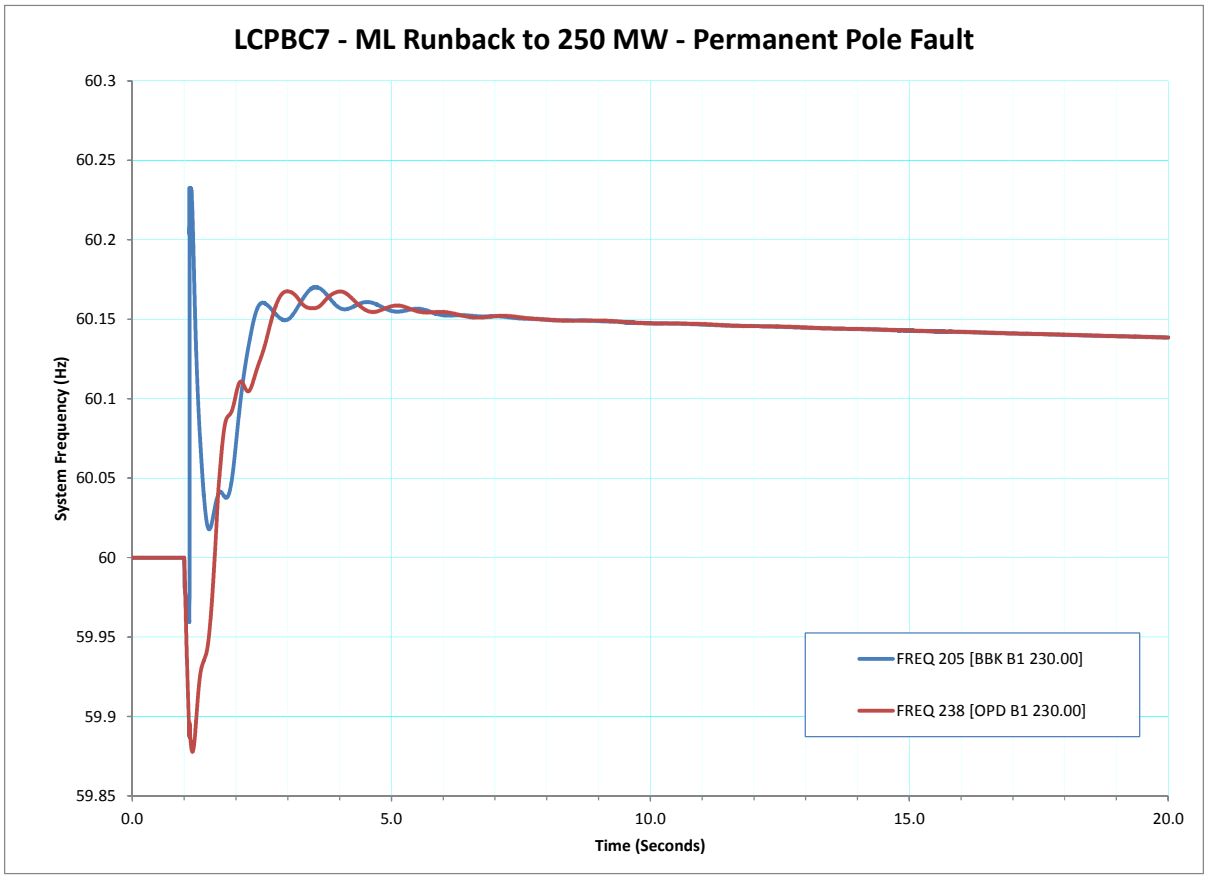

Figure 325 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - System Frequency (Hz)

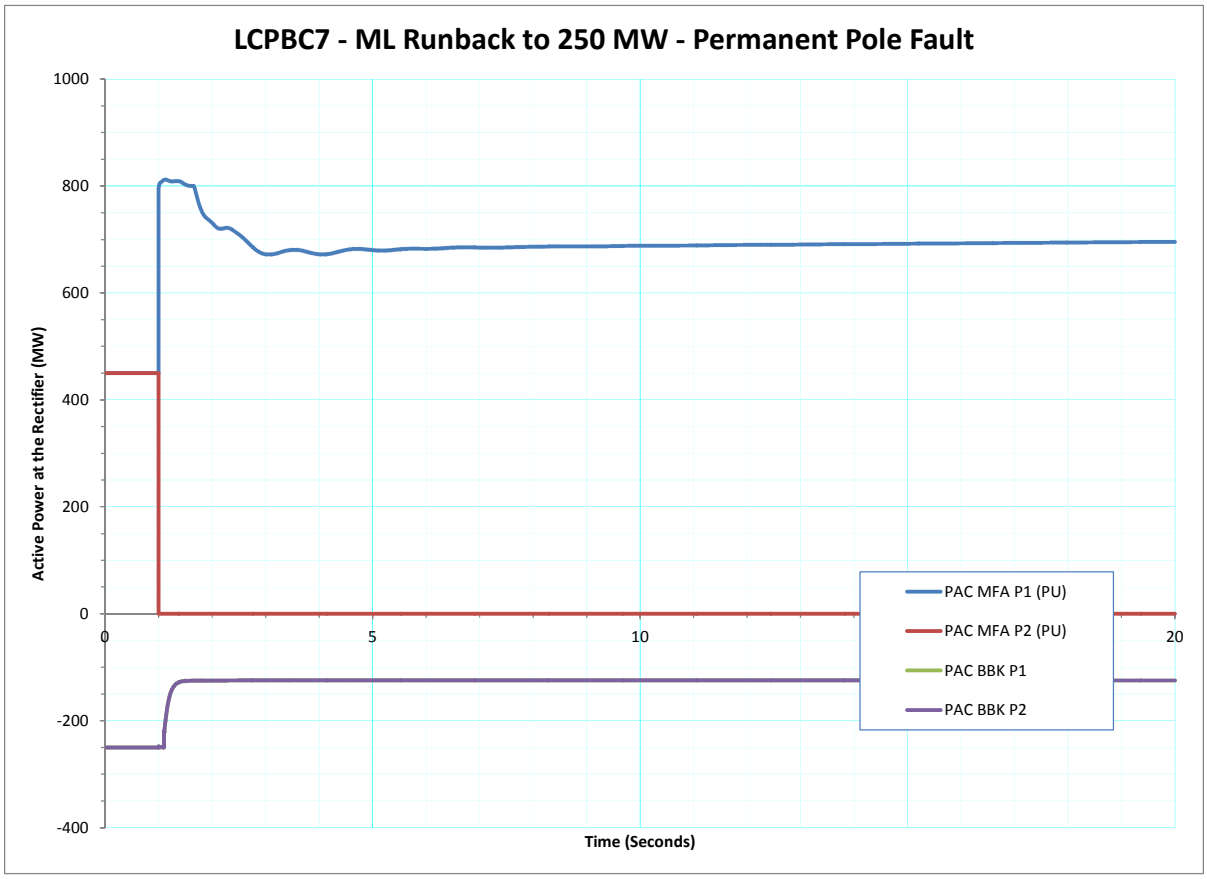

Figure 326 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

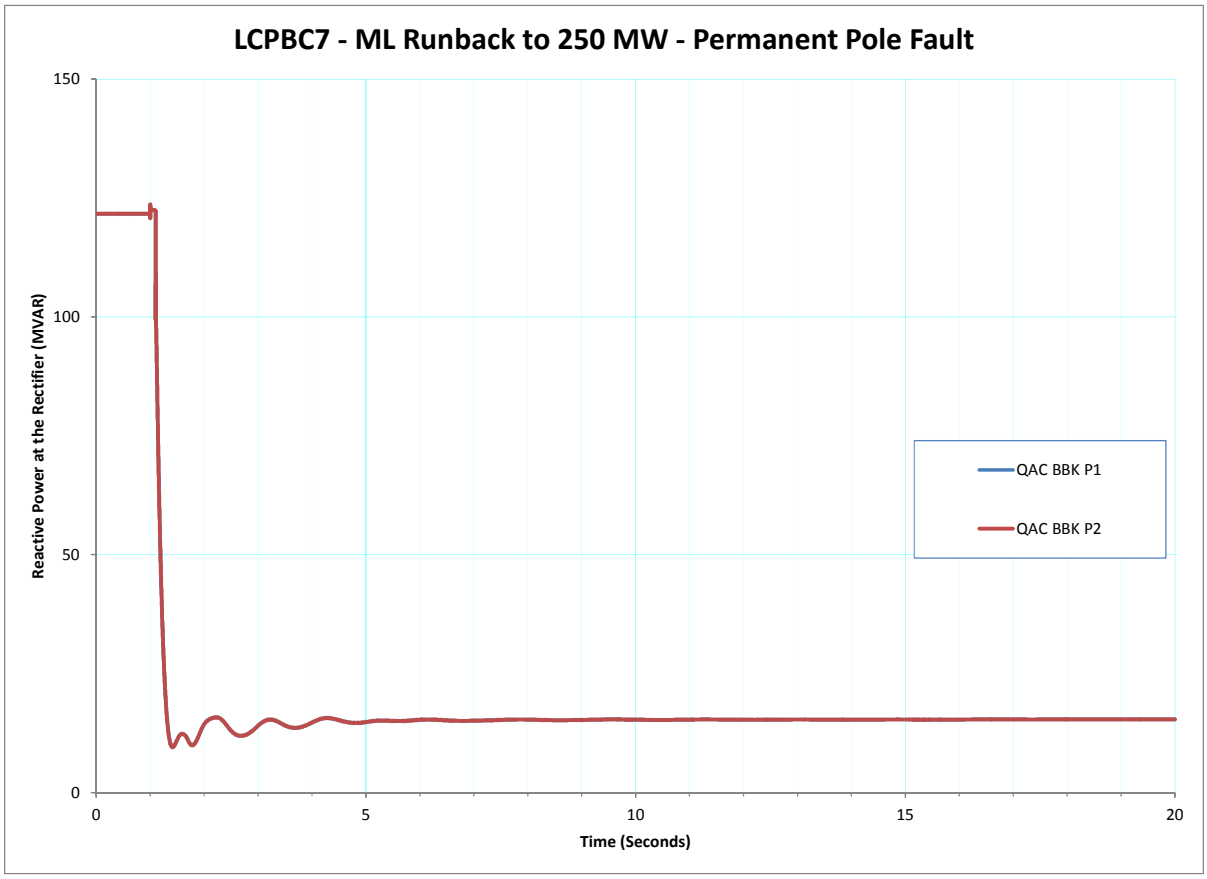

Figure 327 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

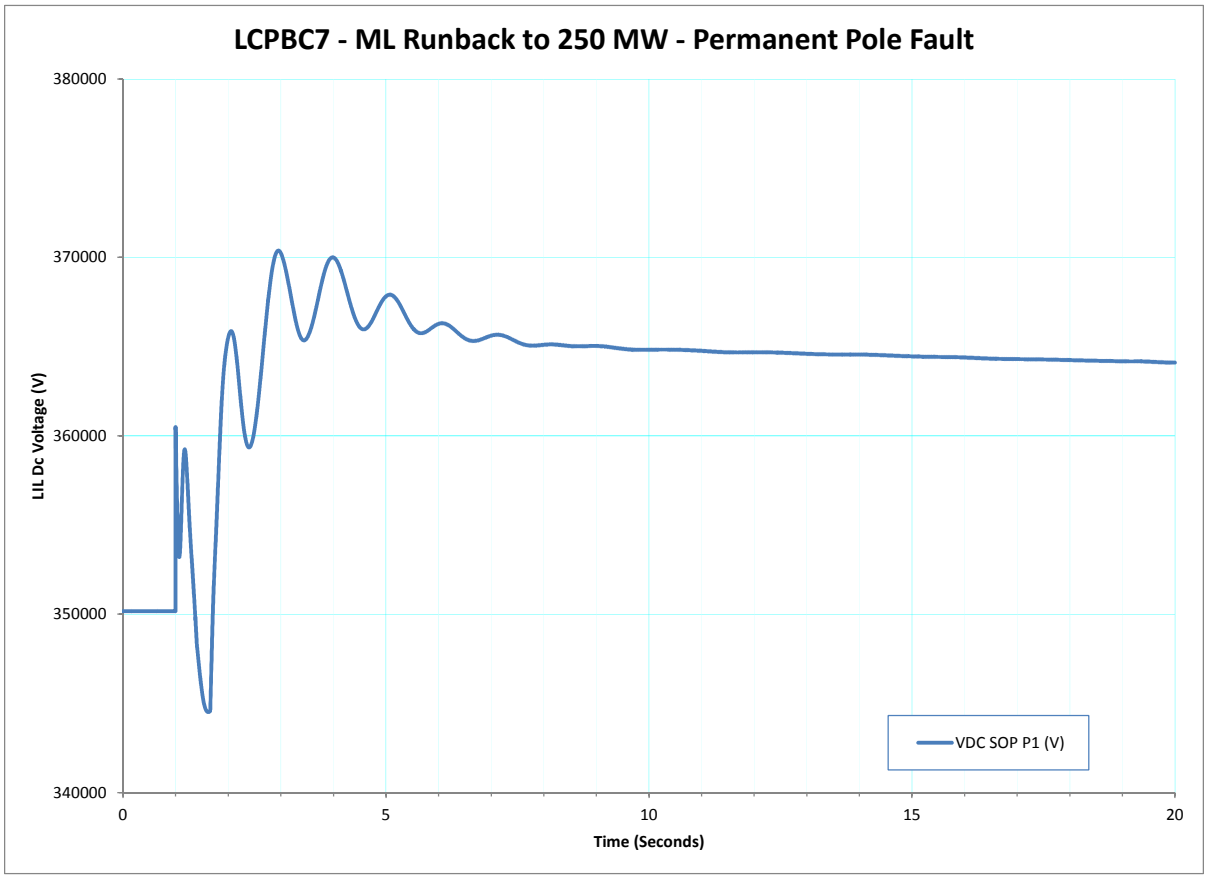

Figure 328 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - LIL Dc Voltage (V)

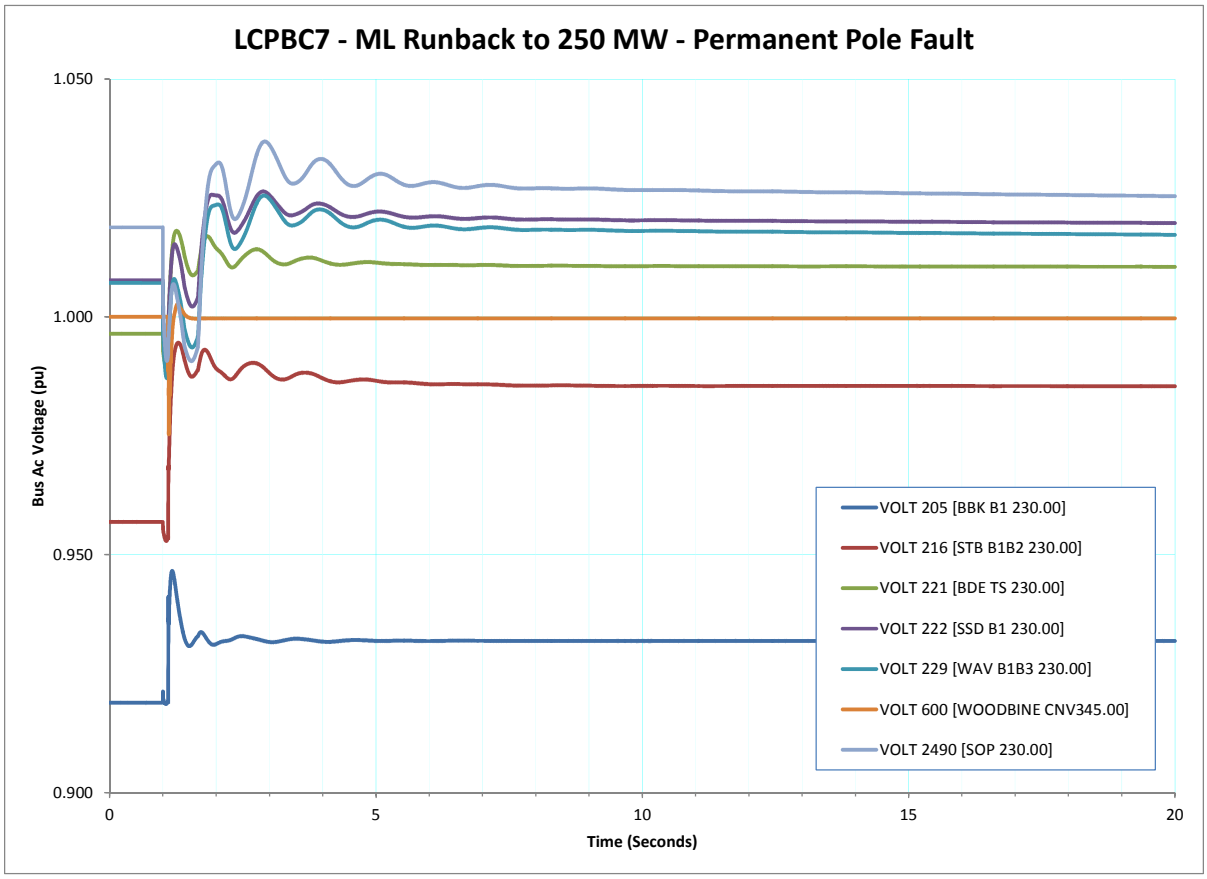

Figure 329 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

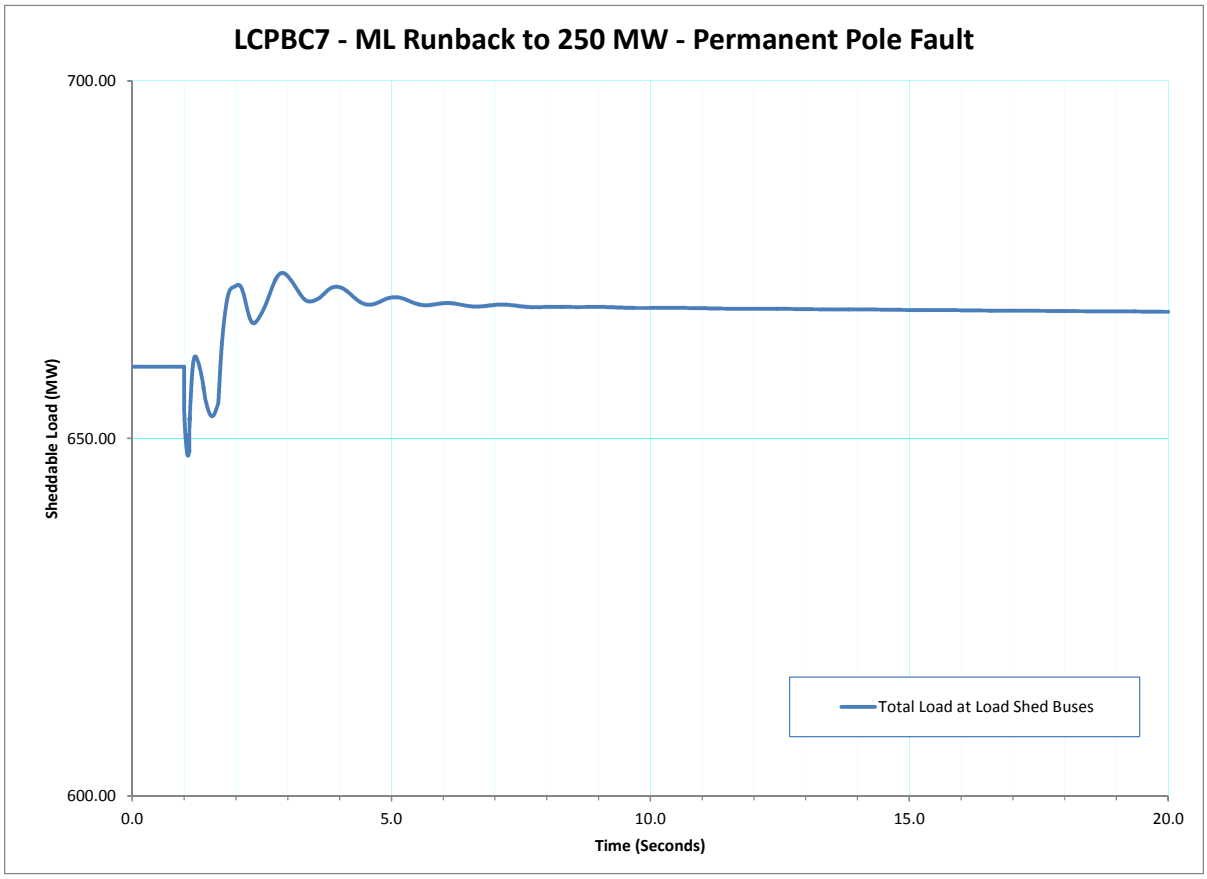

Figure 330 - LCPBC7 - ML Runback to 250 MW - Permanent Pole Fault - Sheddable Load (MW)

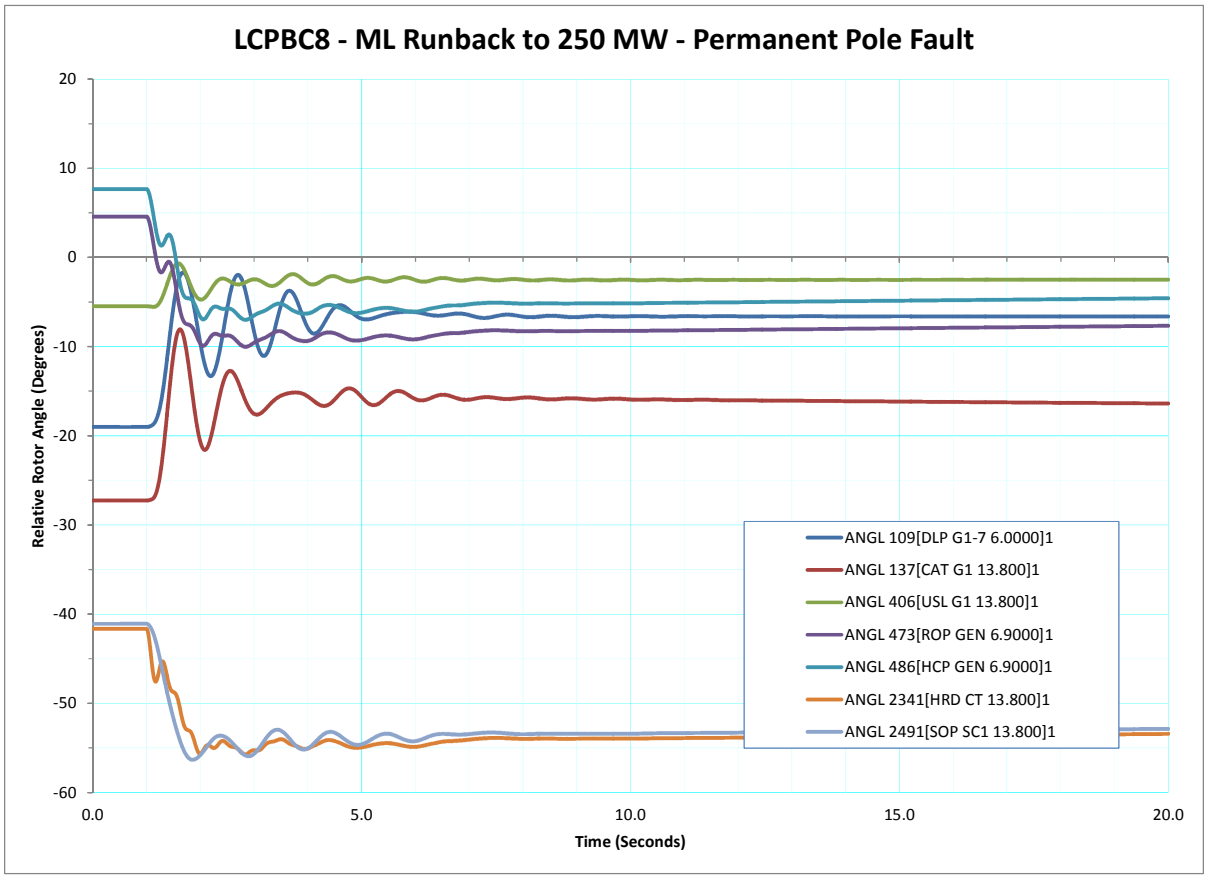

Figure 331 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

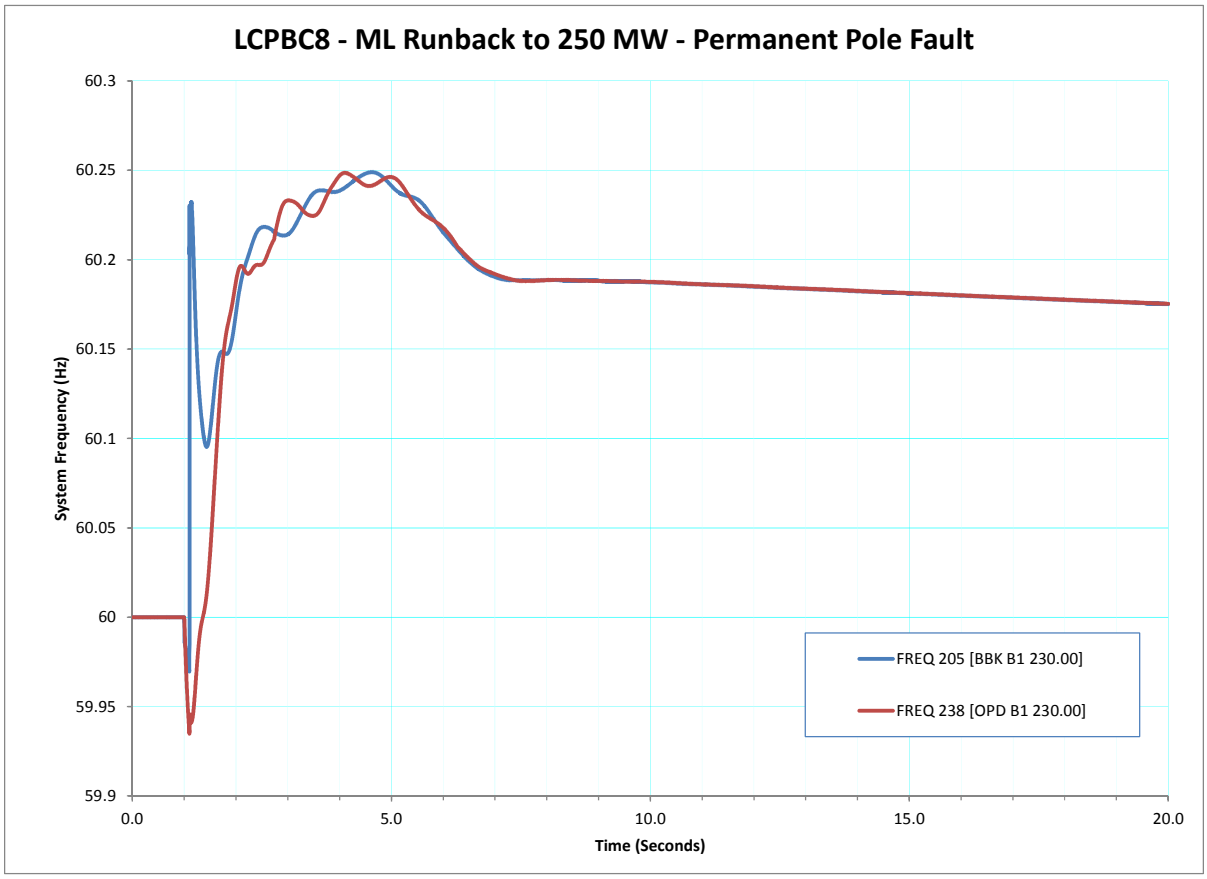

Figure 332 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - System Frequency (Hz)

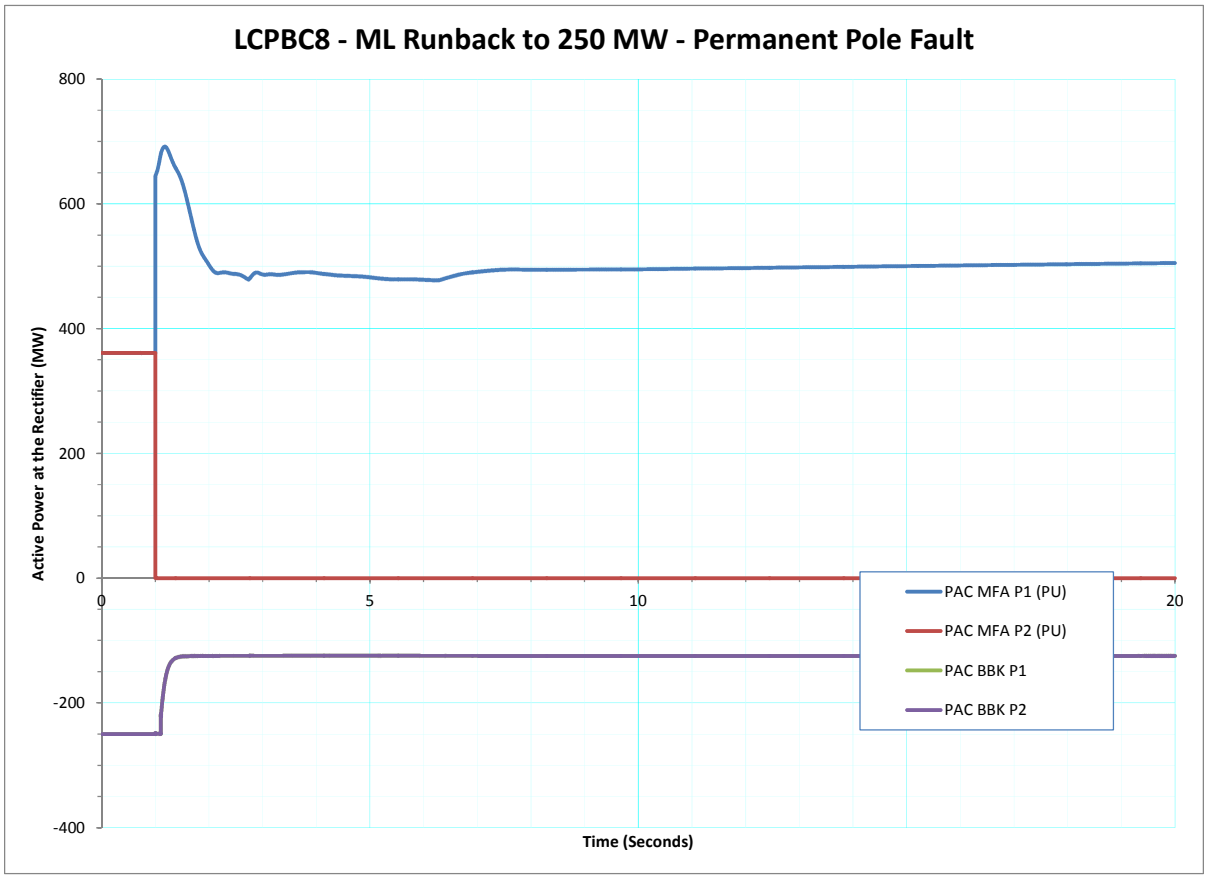

Figure 333 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

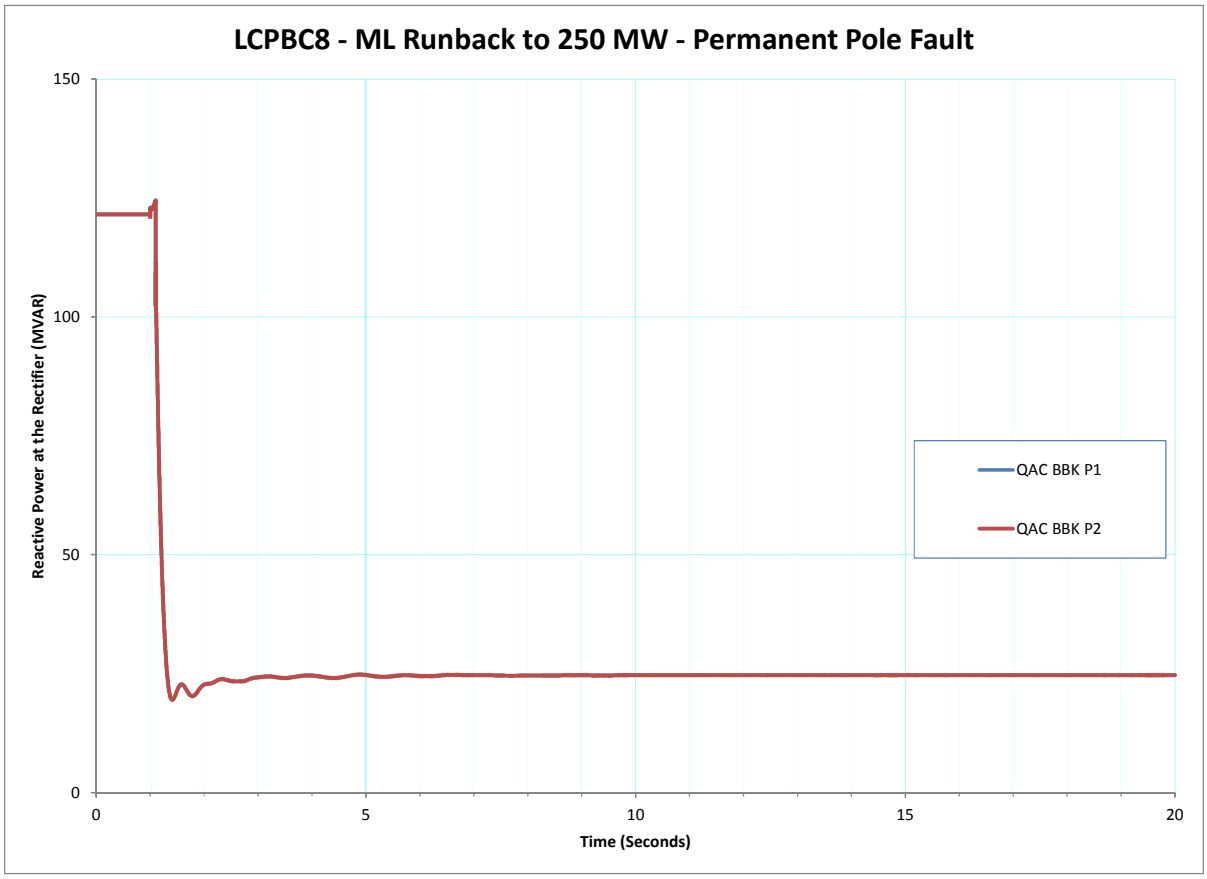

Figure 334 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

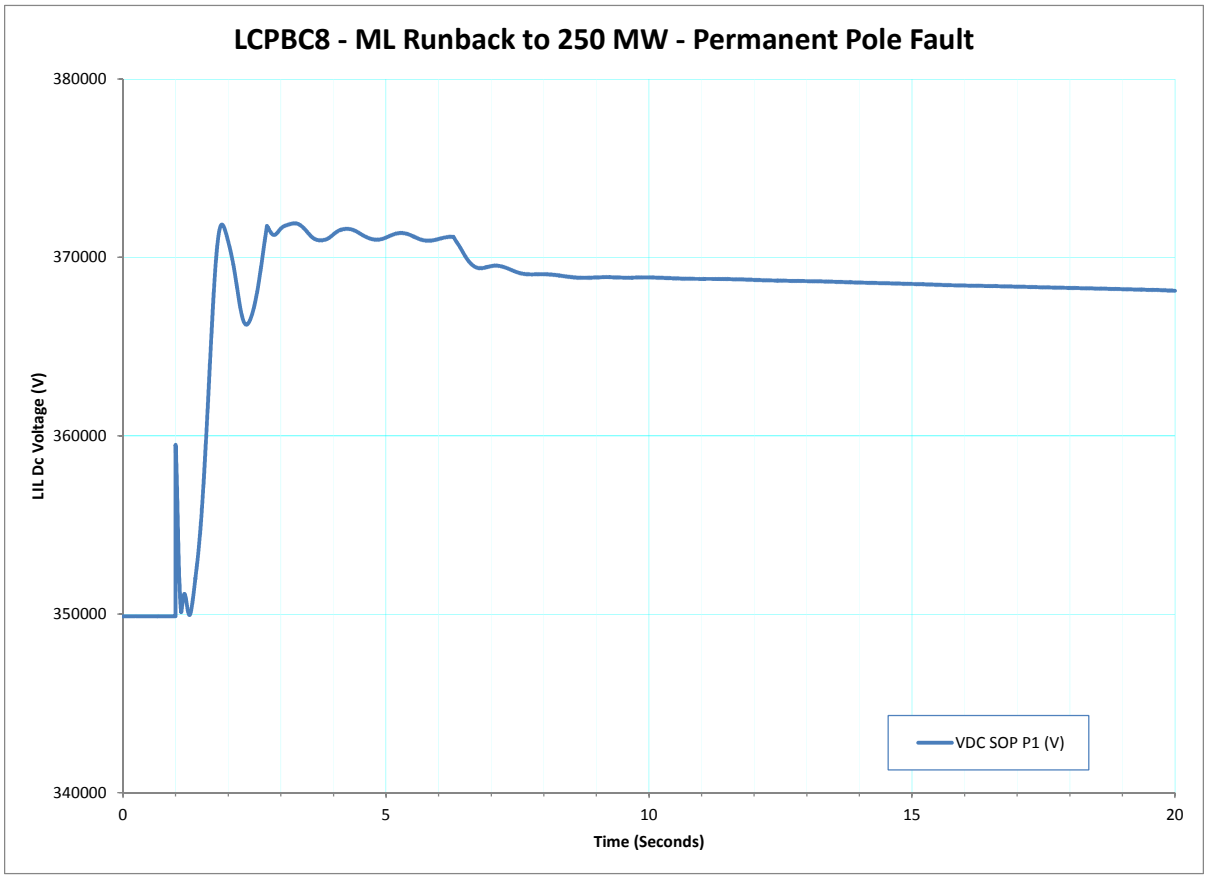

Figure 335 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - LIL Dc Voltage (V)

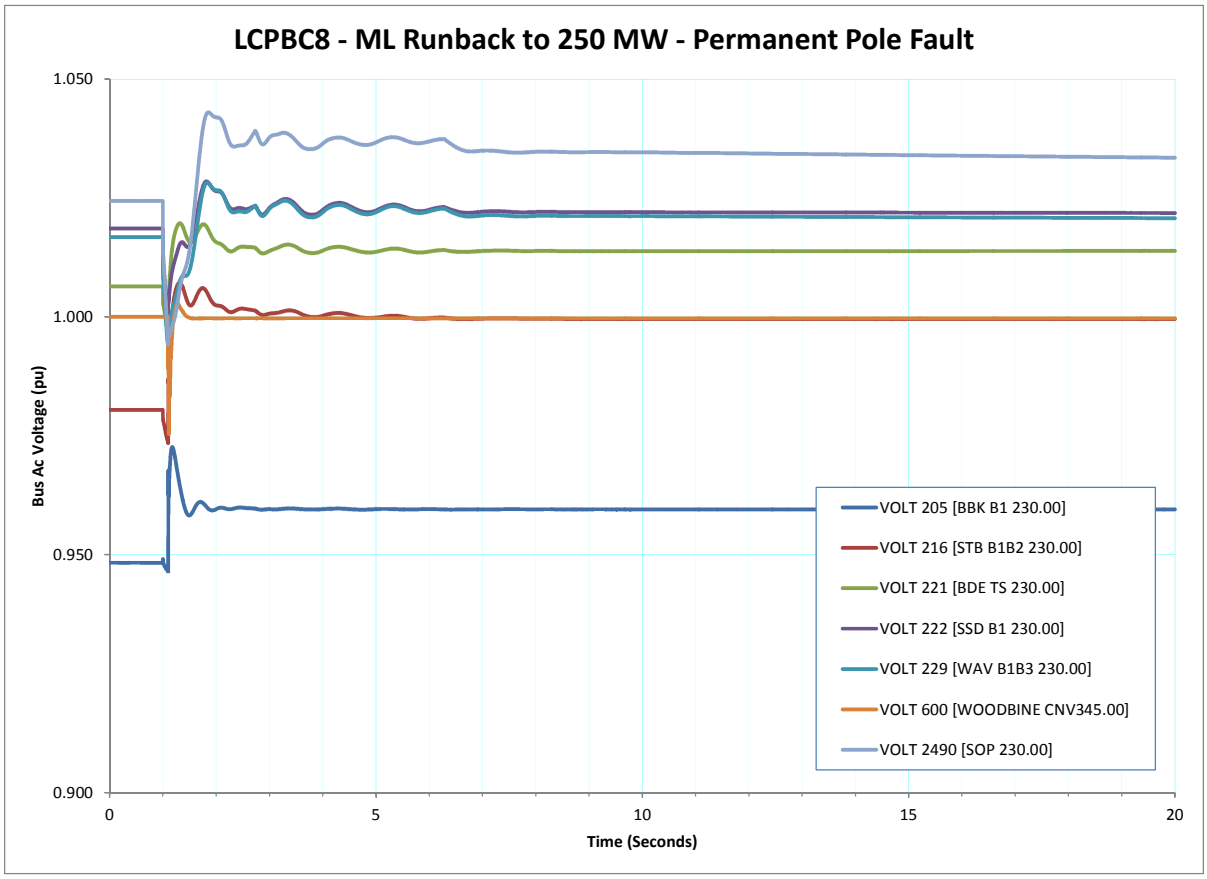

Figure 336 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

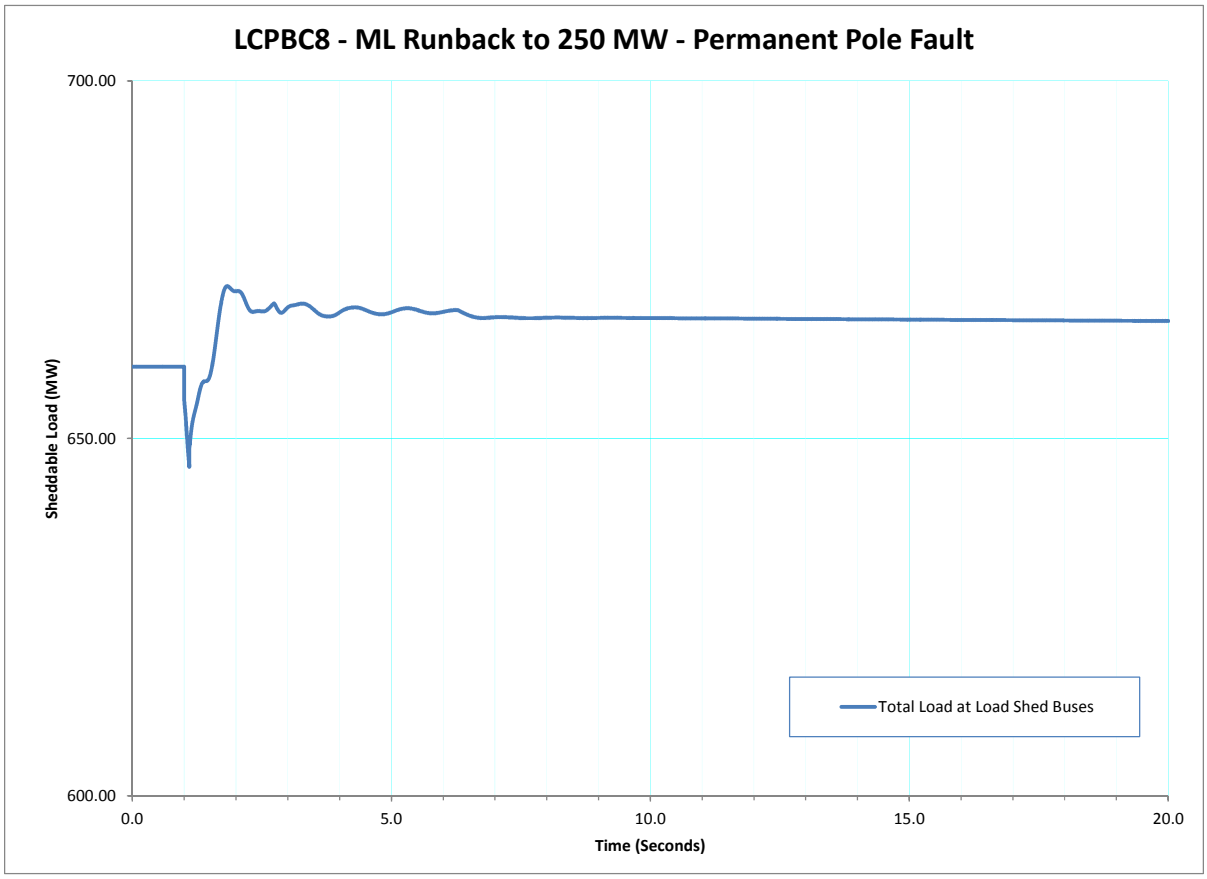

Figure 337 - LCPBC8 - ML Runback to 250 MW - Permanent Pole Fault - Sheddable Load (MW)

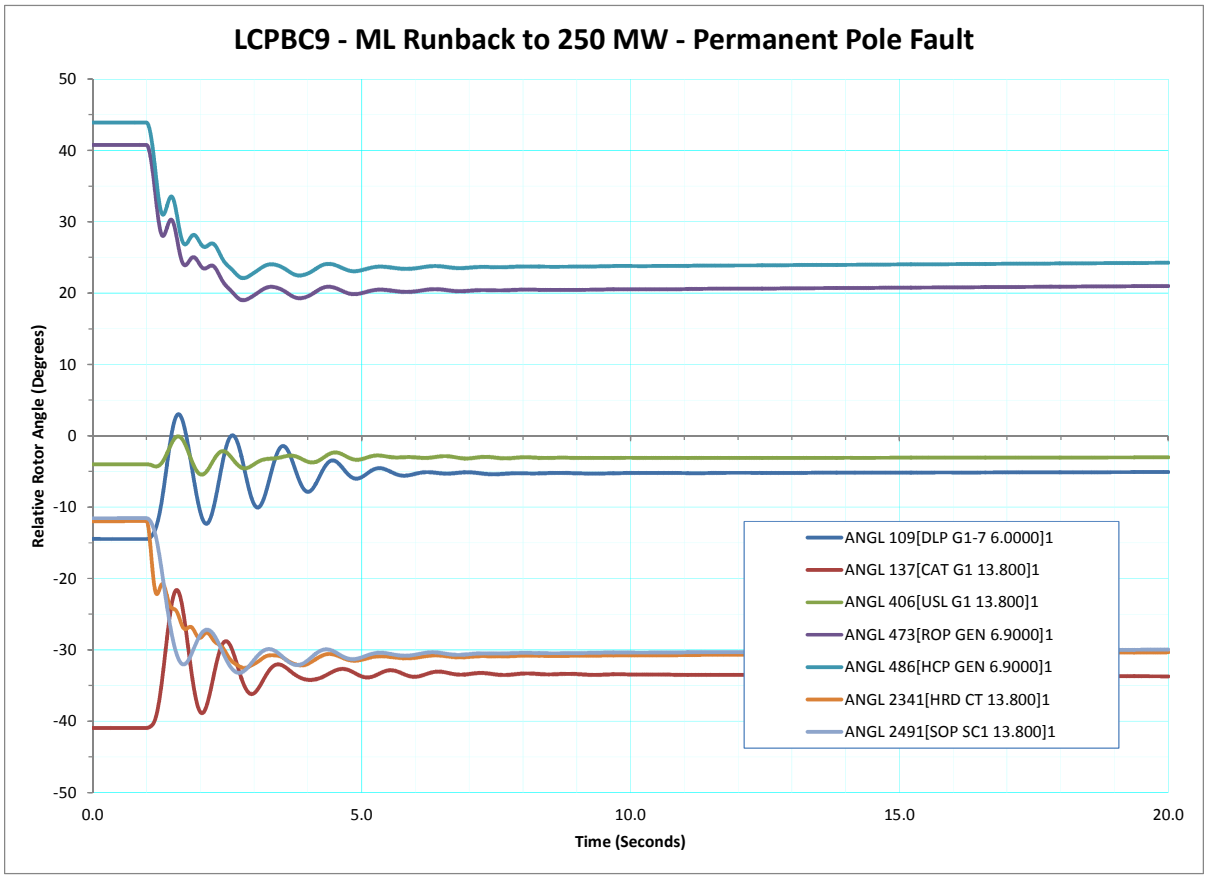

Figure 338 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

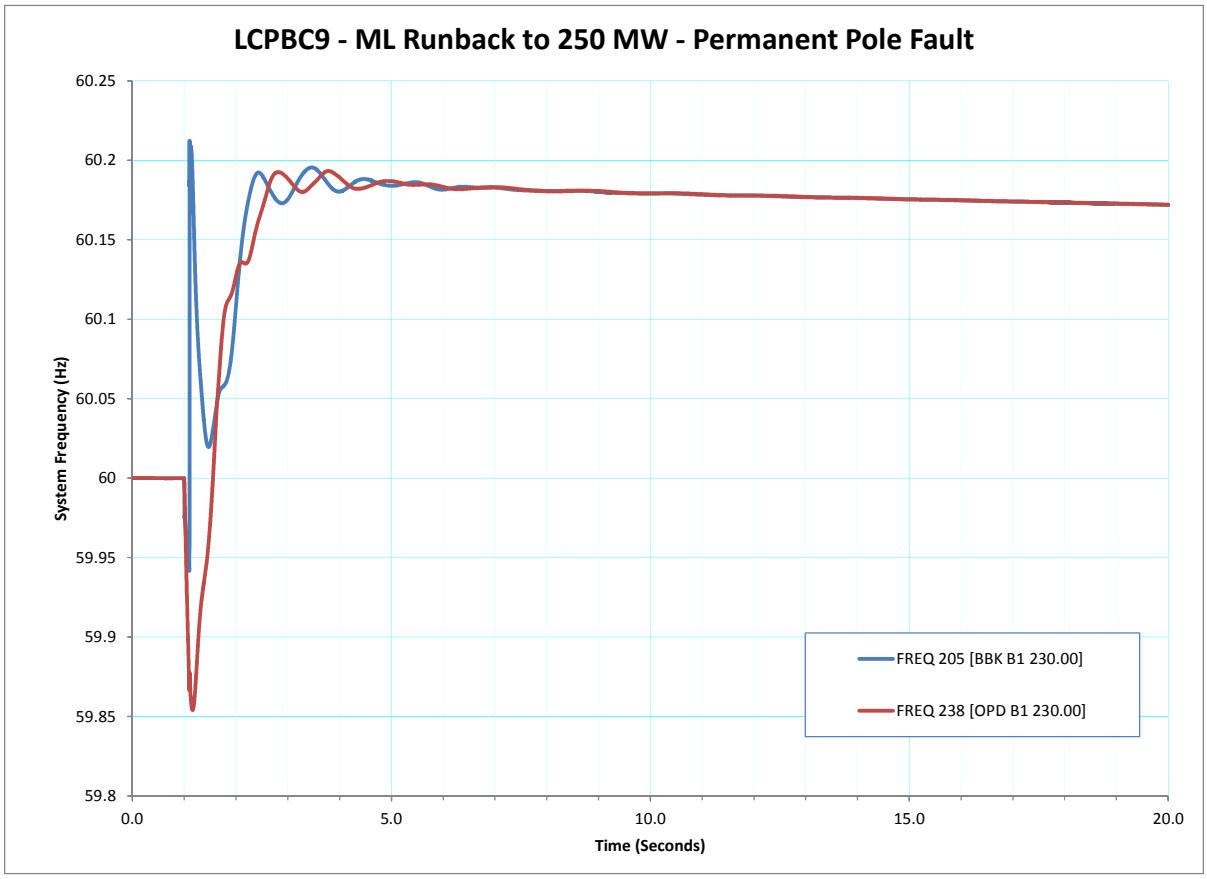

Figure 339 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - System Frequency (Hz)

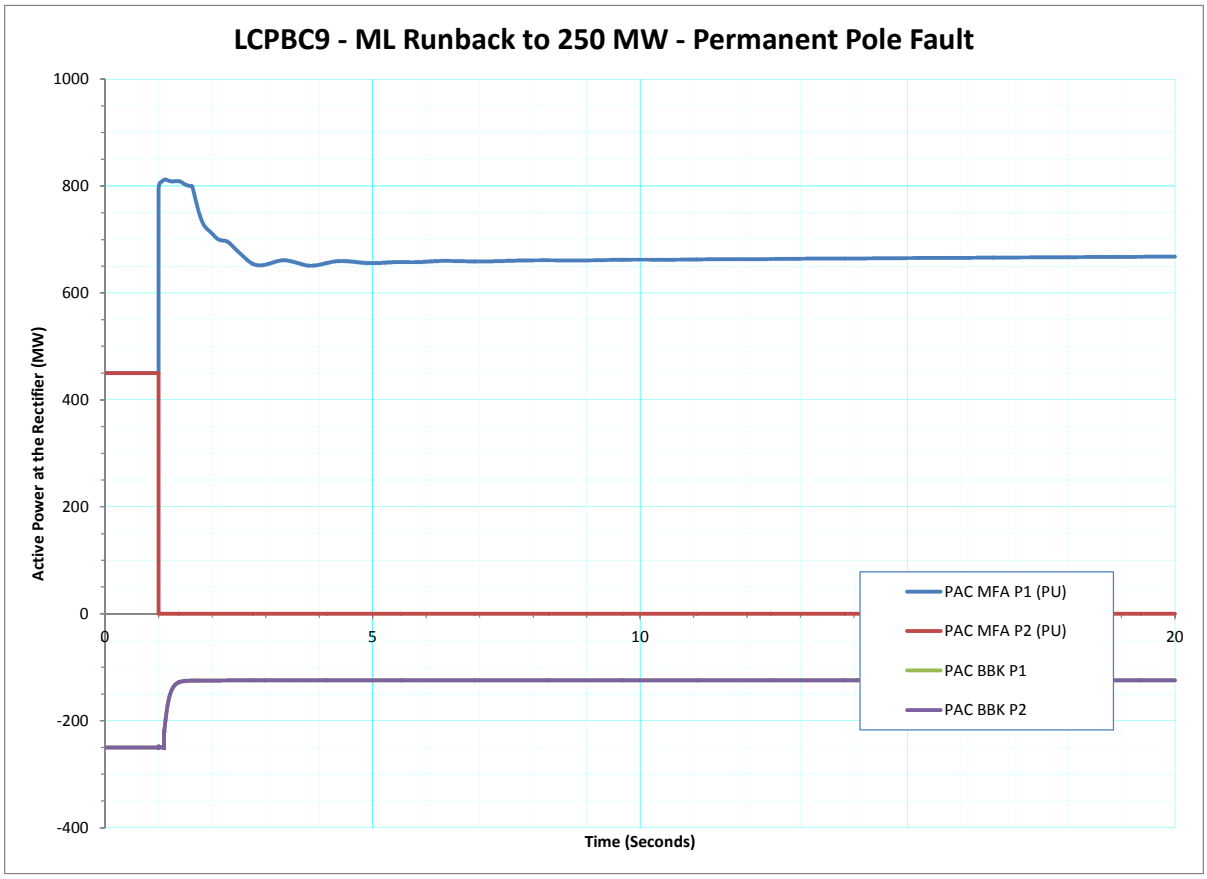

Figure 340 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

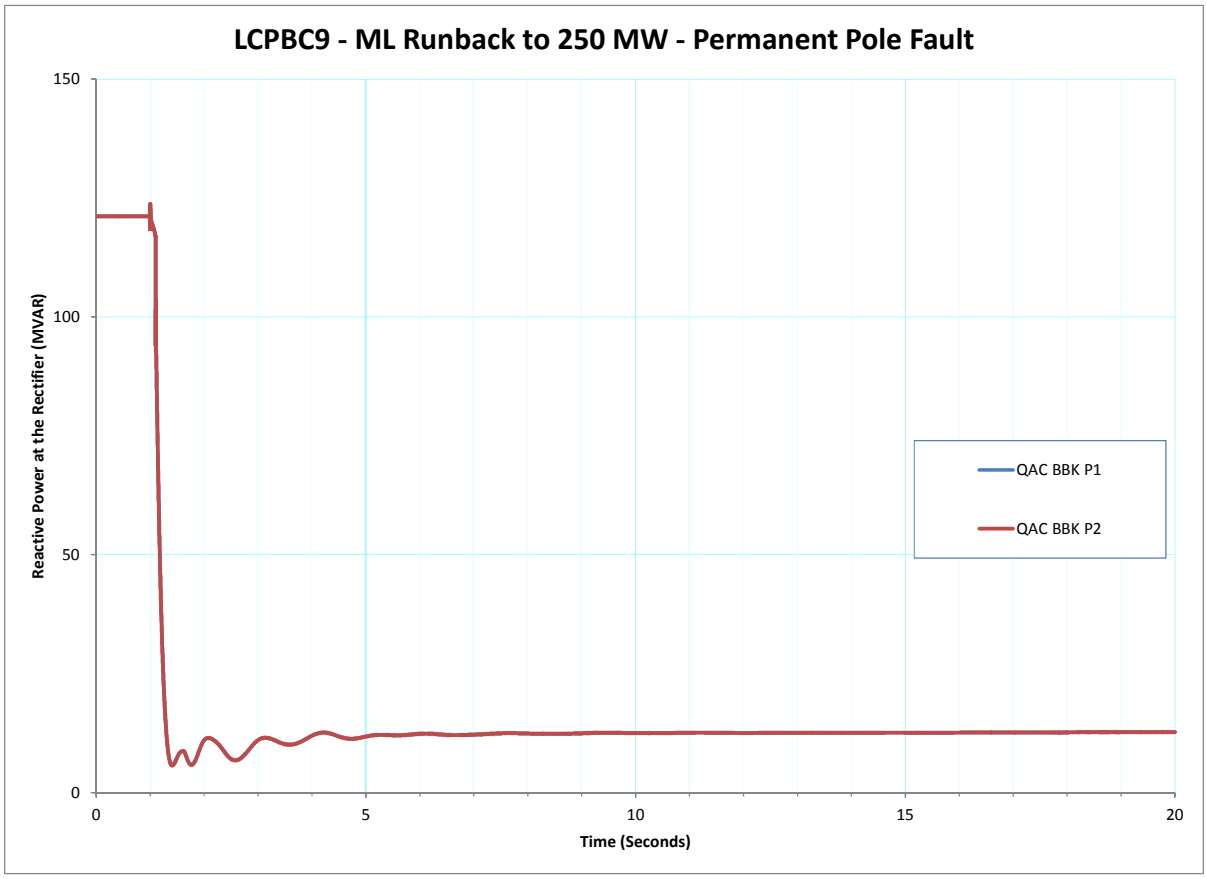

Figure 341 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

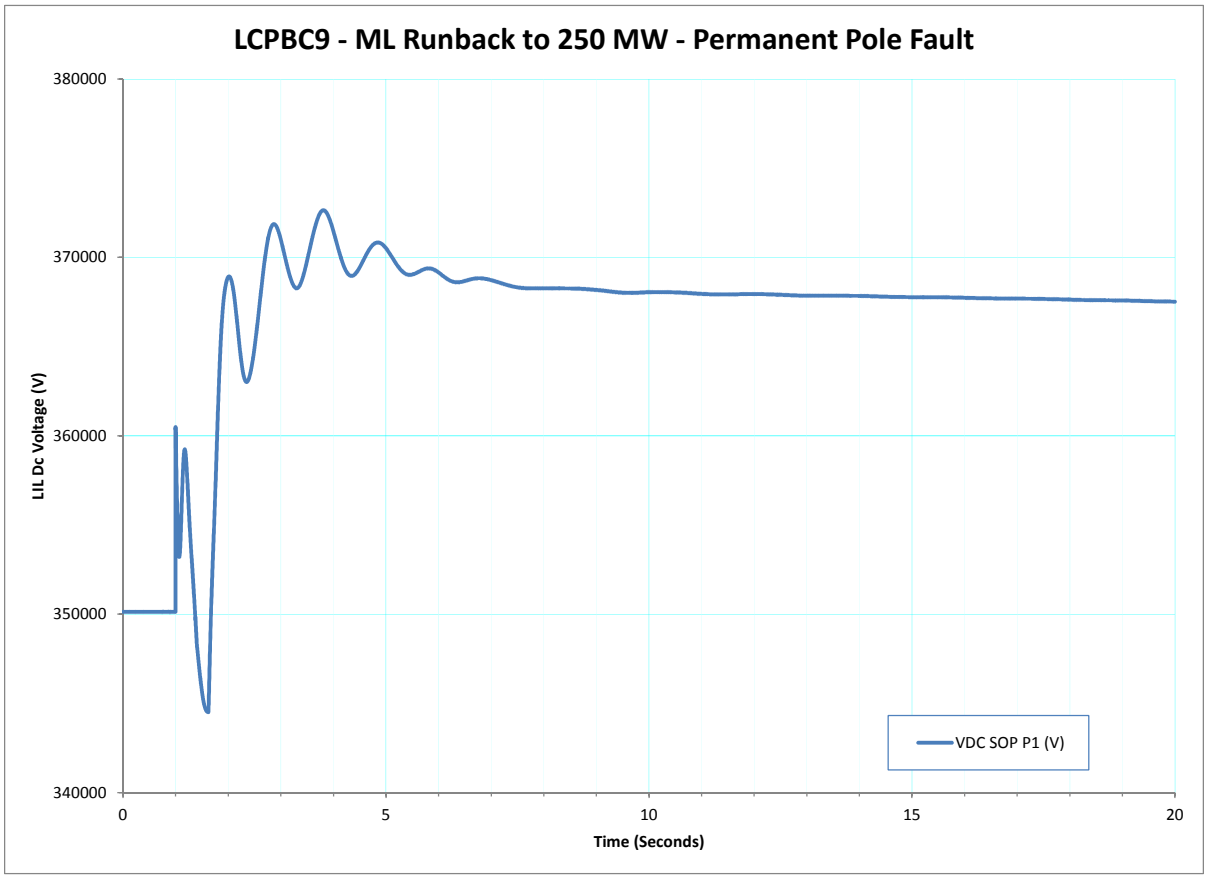

Figure 342 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - LIL Dc Voltage (V)

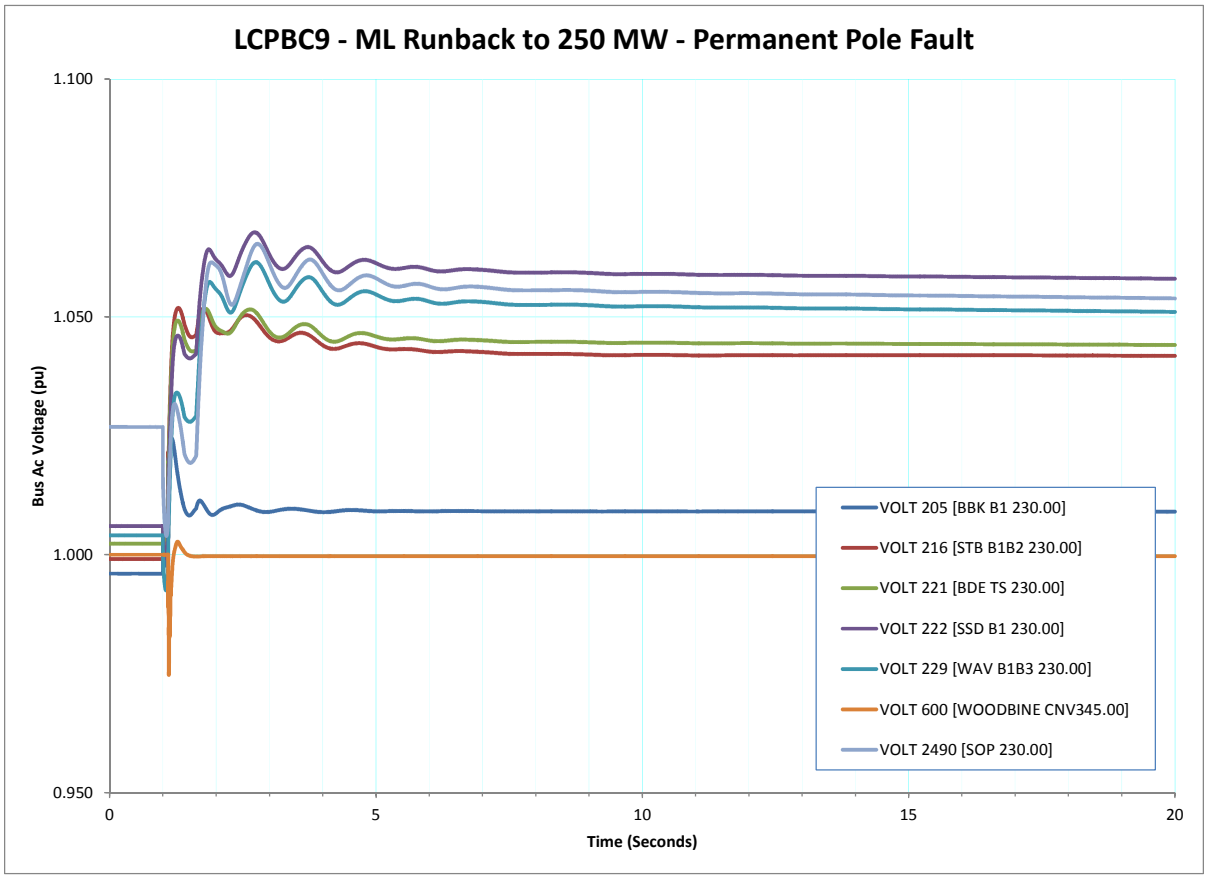

Figure 343 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

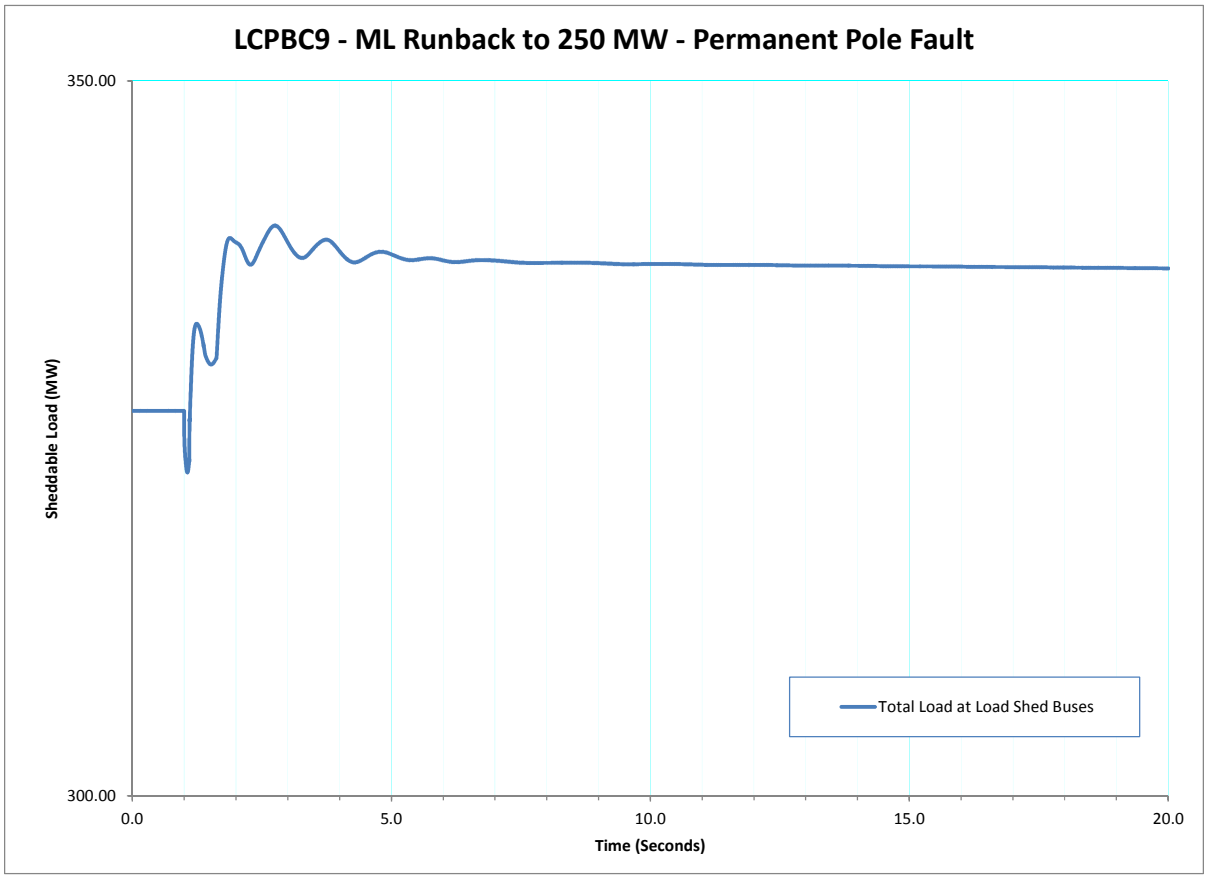

Figure 344 - LCPBC9 - ML Runback to 250 MW - Permanent Pole Fault - Sheddable Load (MW)

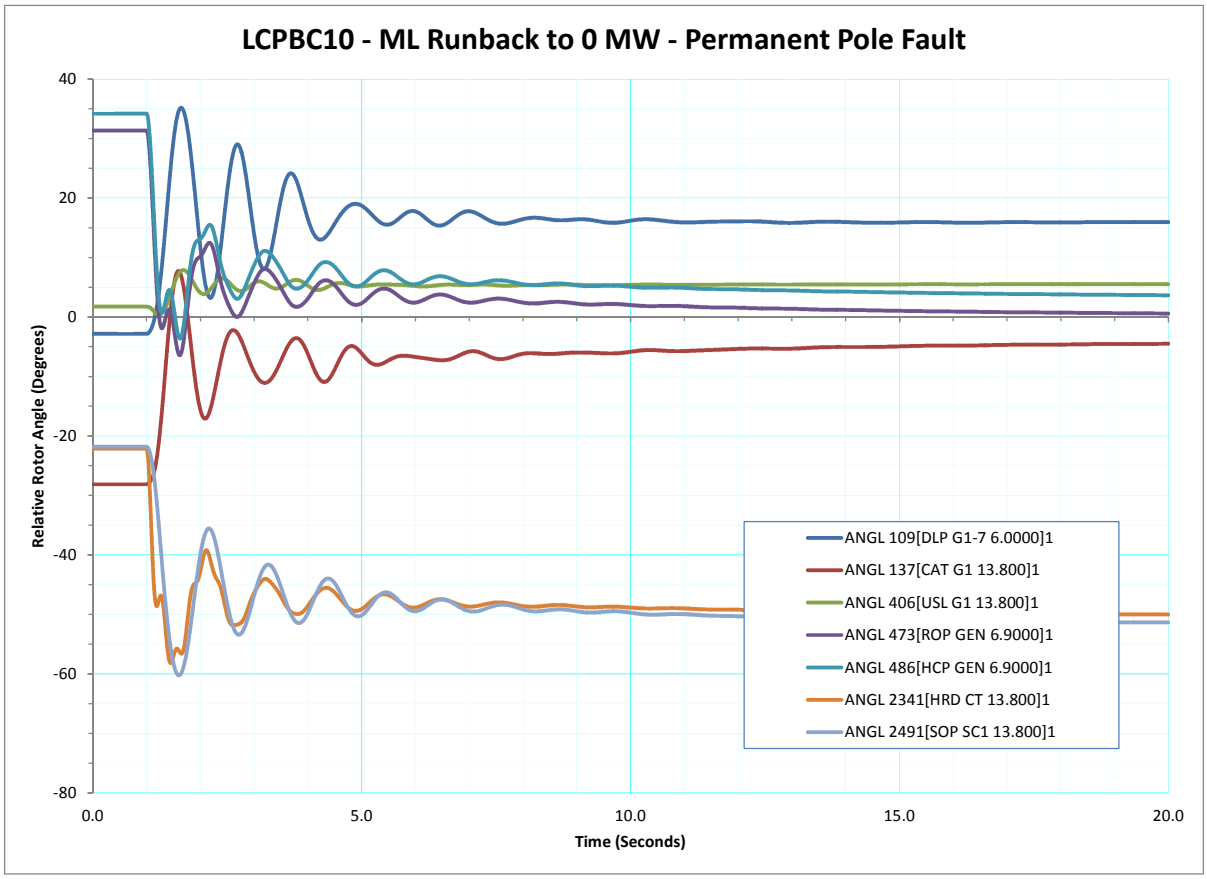

Figure 345 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

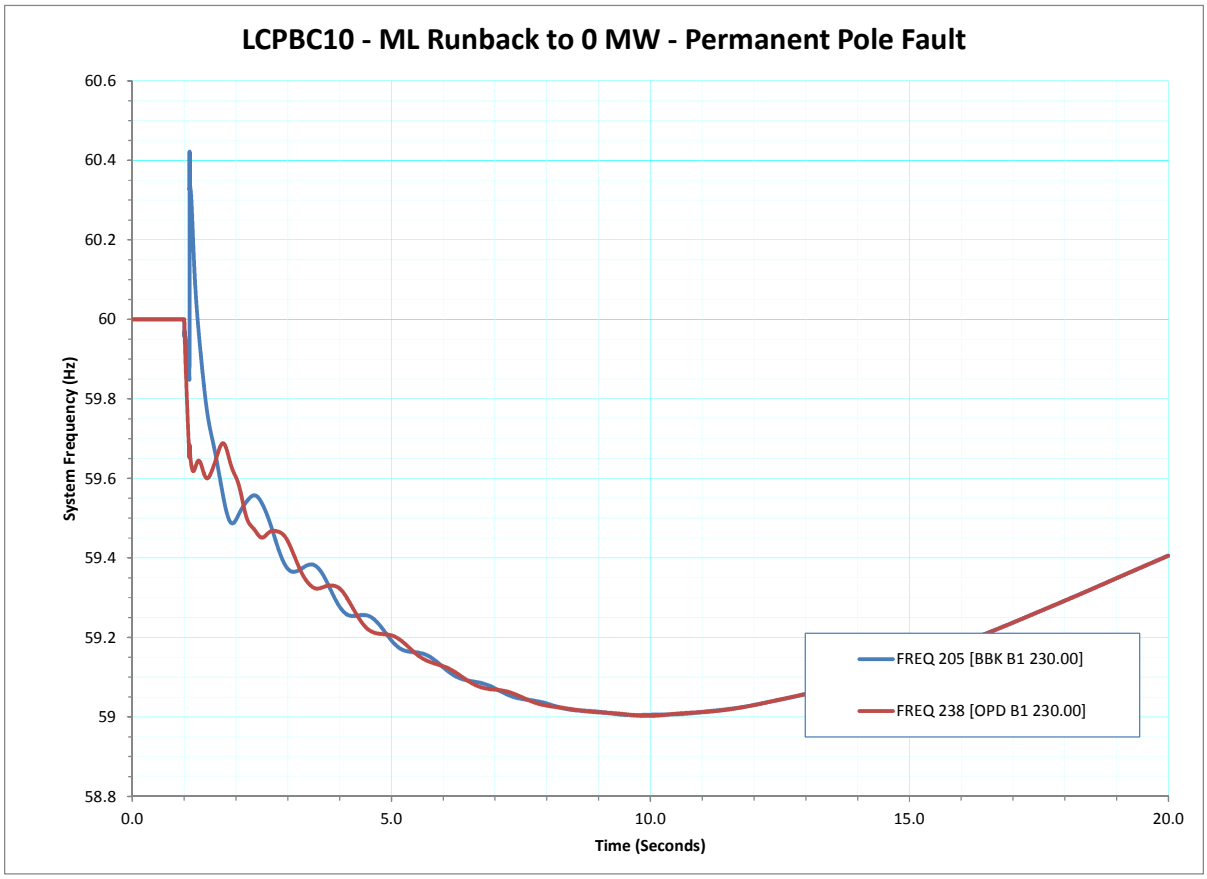

Figure 346 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

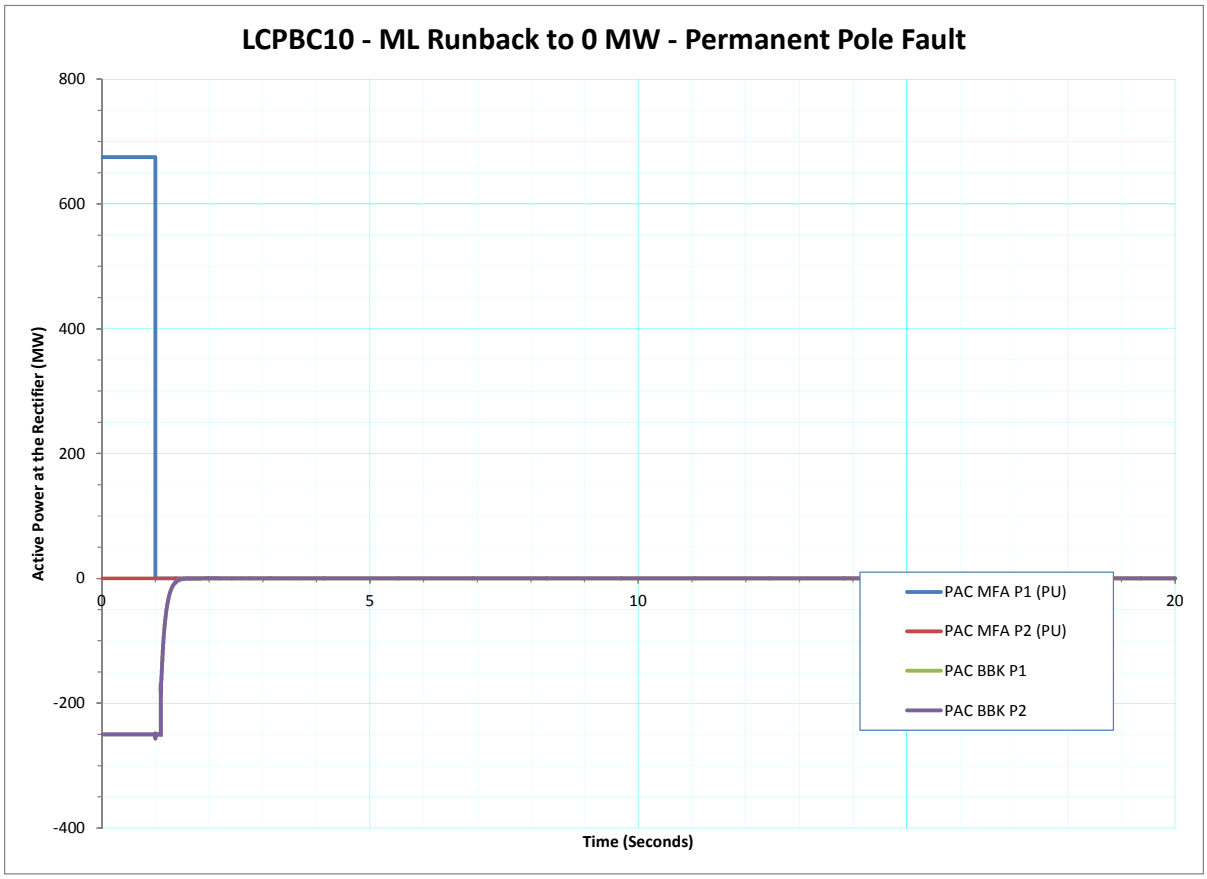

Figure 347 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

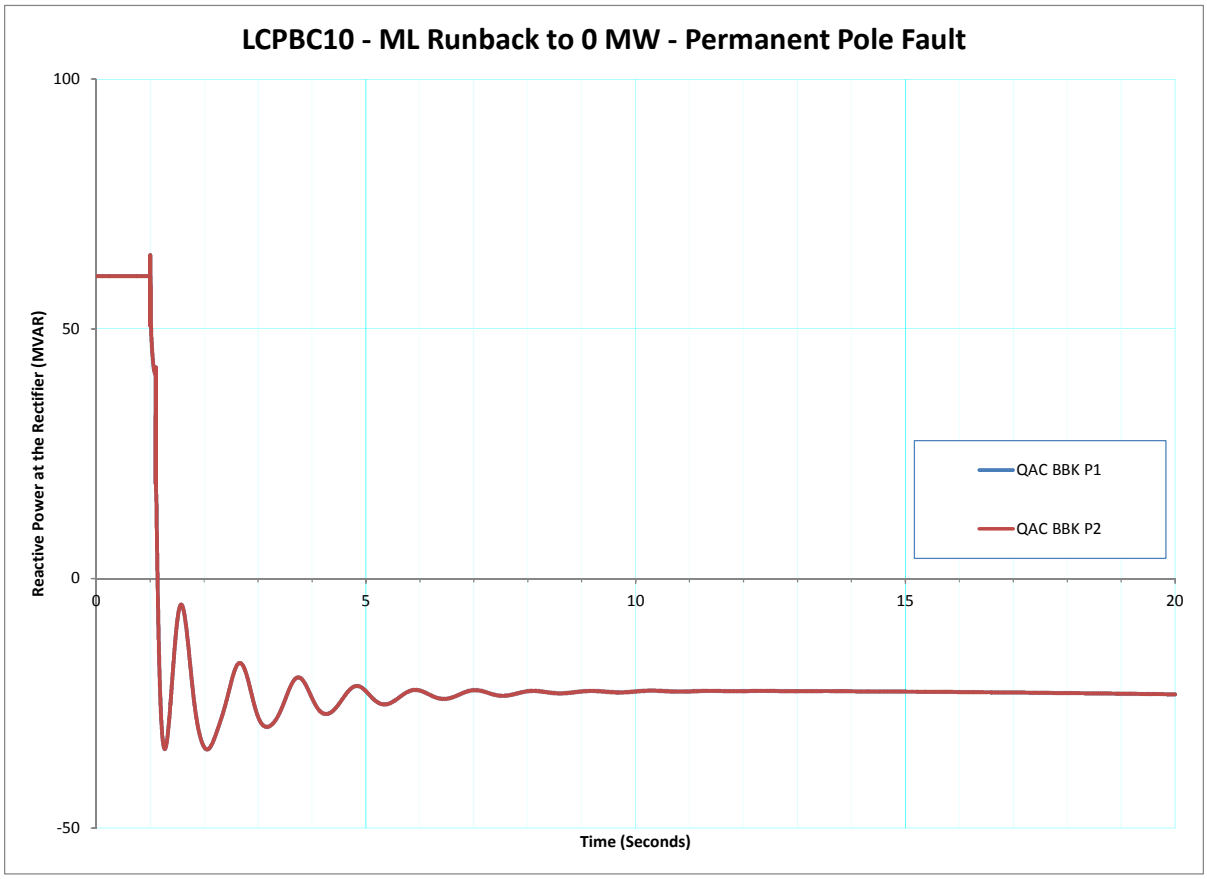

Figure 348 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

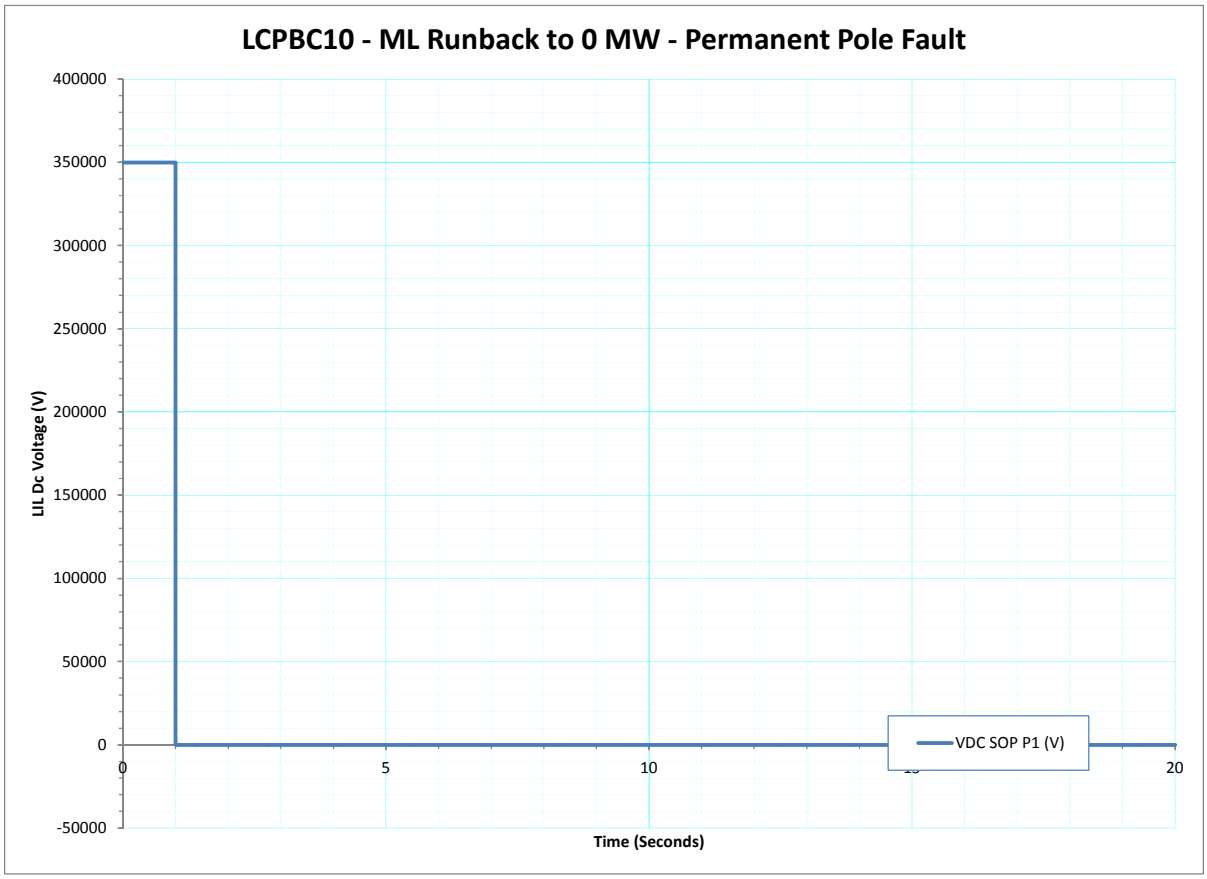

Figure 349 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

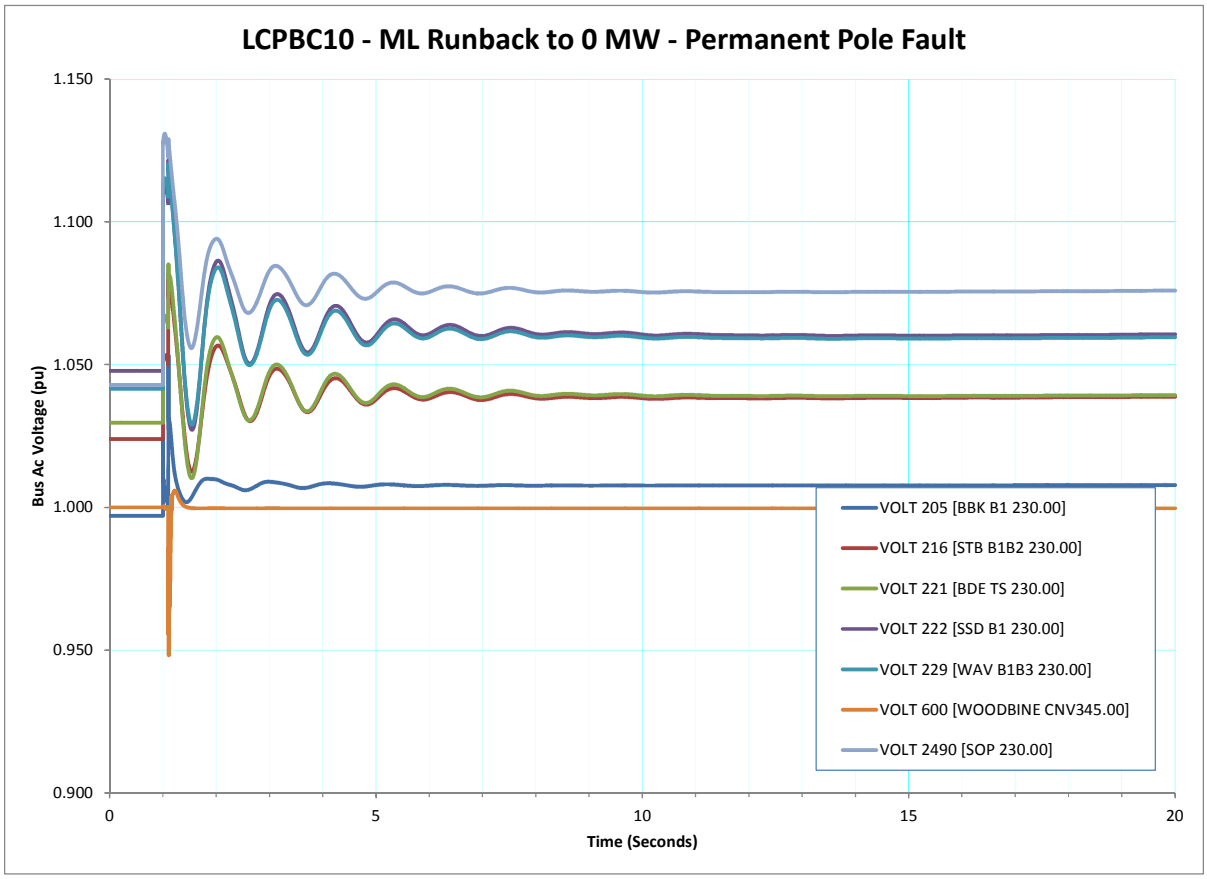

Figure 350 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

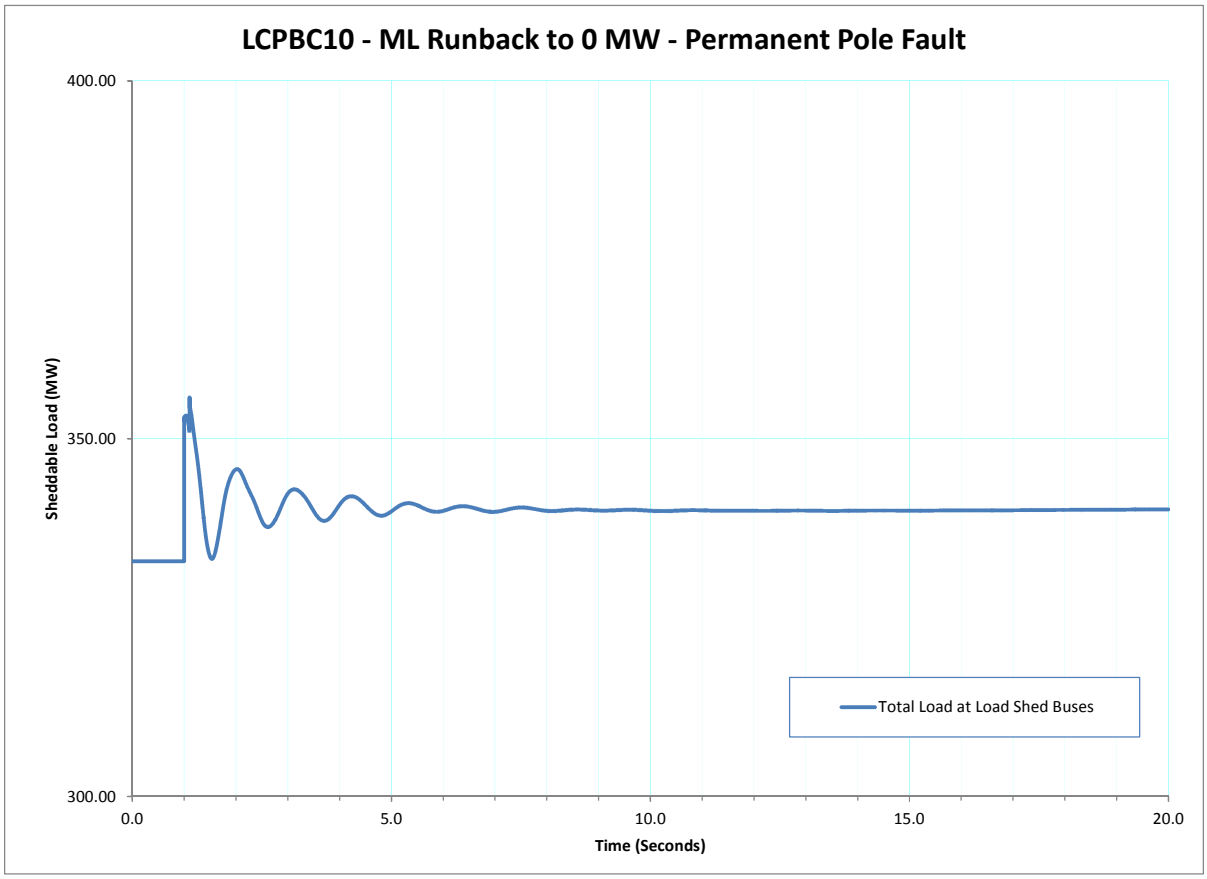

Figure 351 - LCPBC10 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

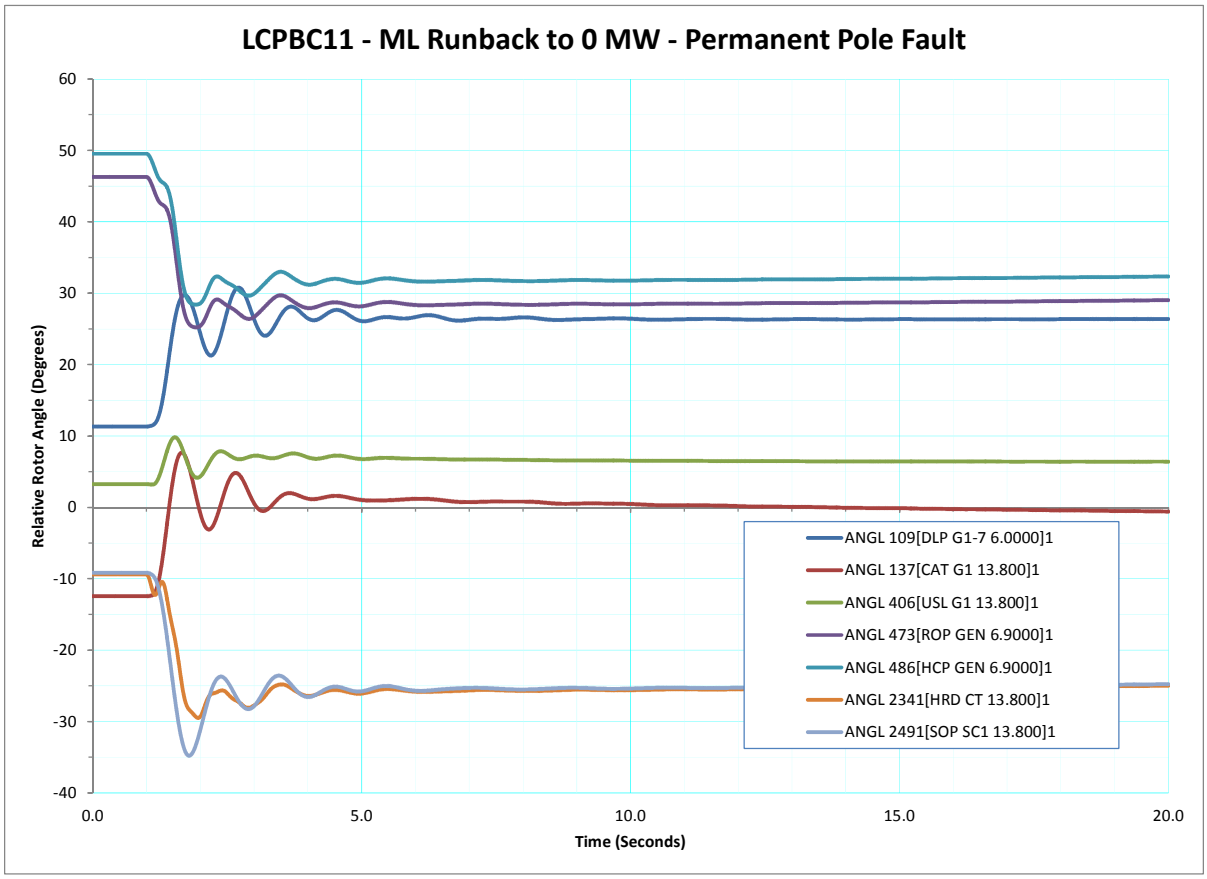

Figure 352 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - Relative Rotor Angle (Degrees)

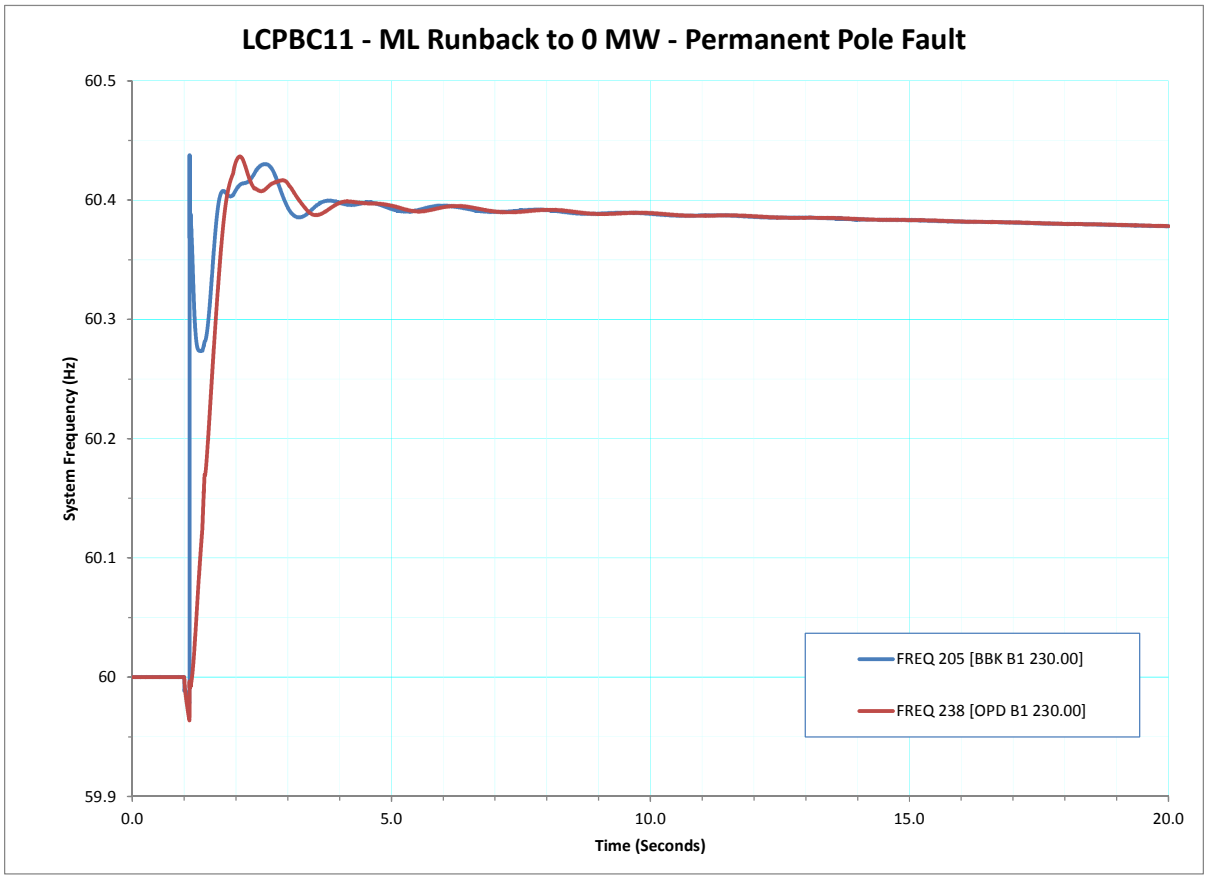

Figure 353 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - System Frequency (Hz)

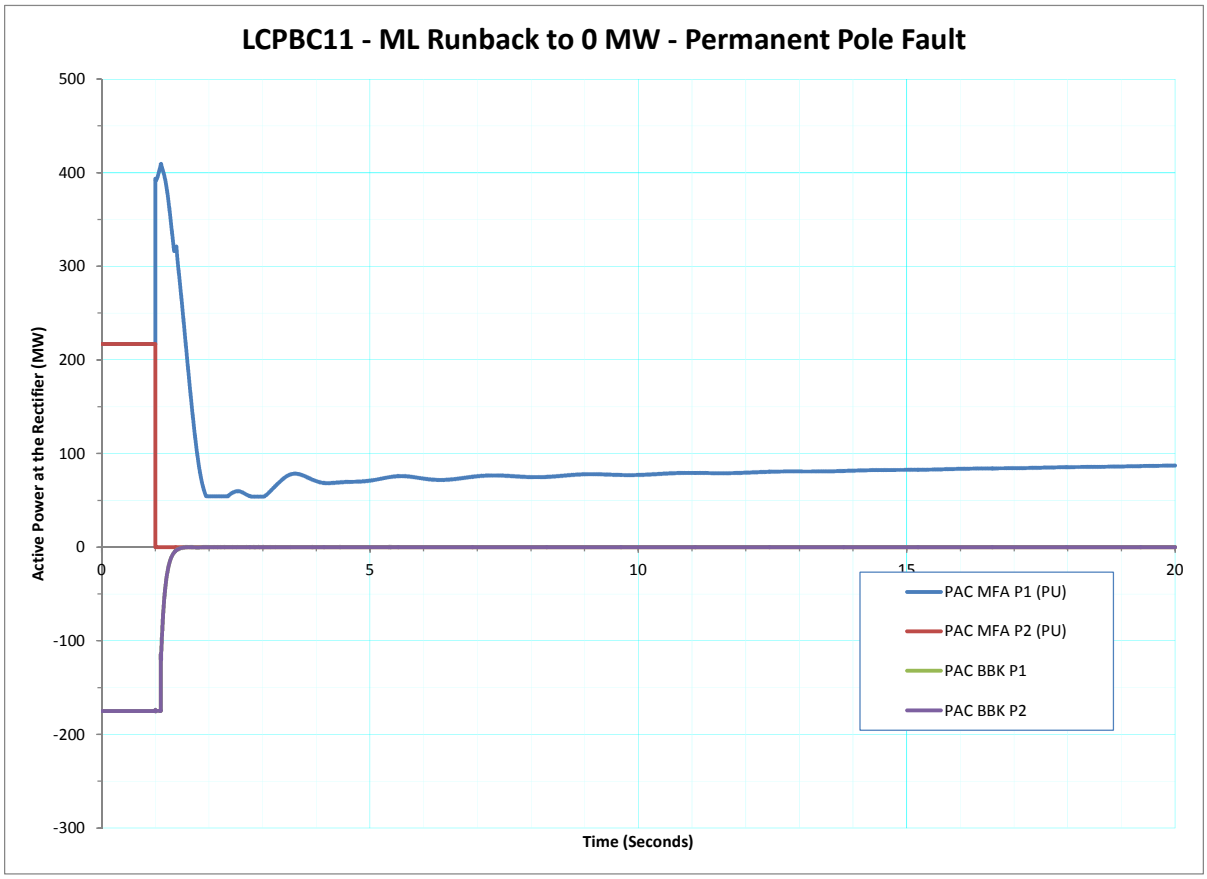

Figure 354 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - Active Power at the Rectifier (MW)

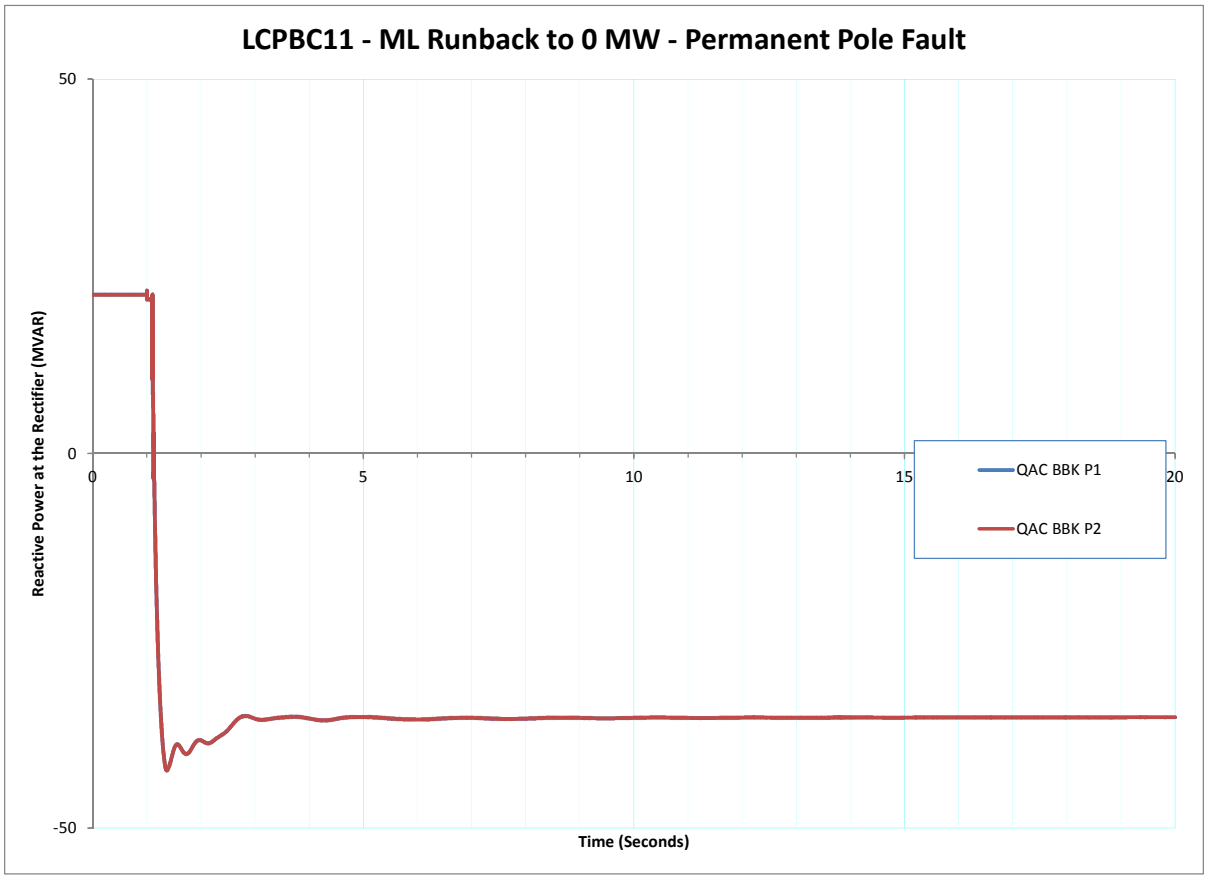

Figure 355 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - Reactive Power at the Rectifier (MVAR)

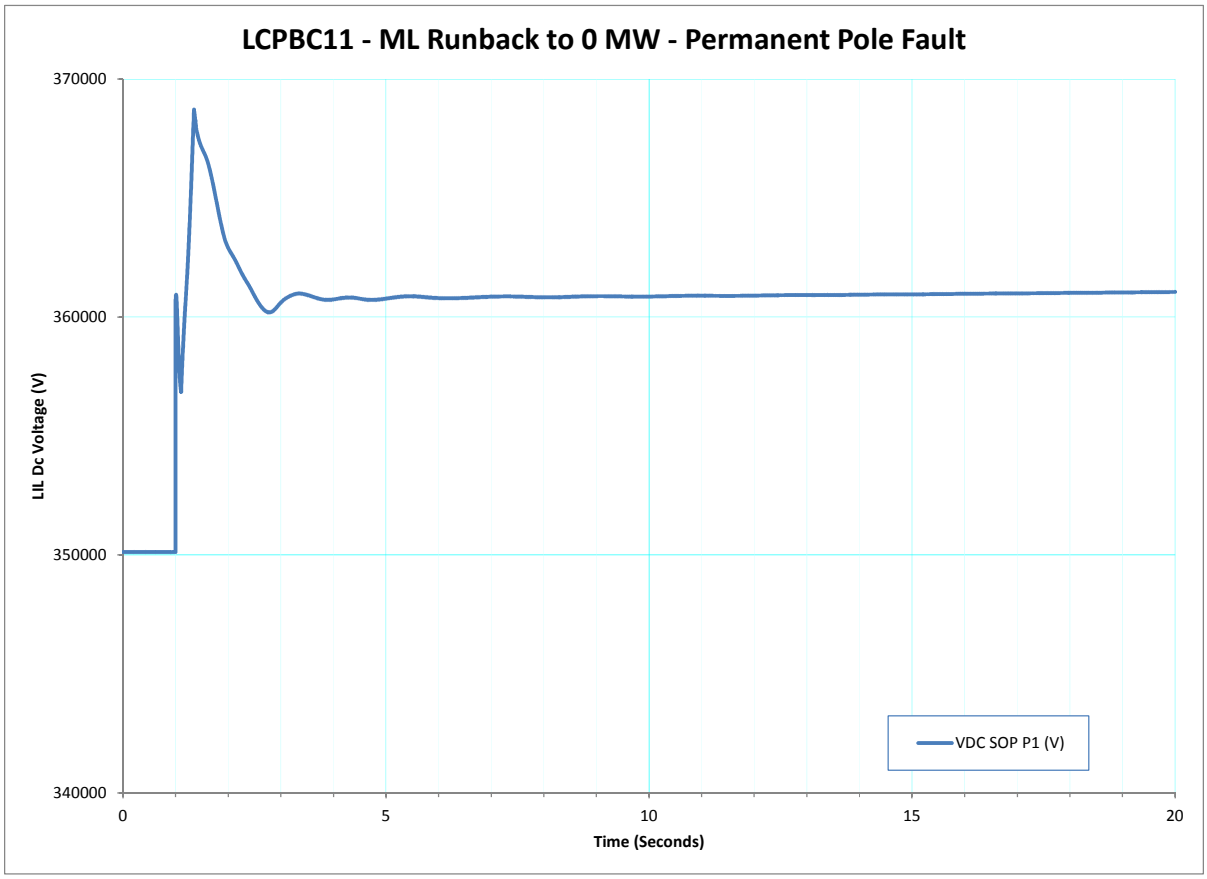

Figure 356 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - LIL Dc Voltage (V)

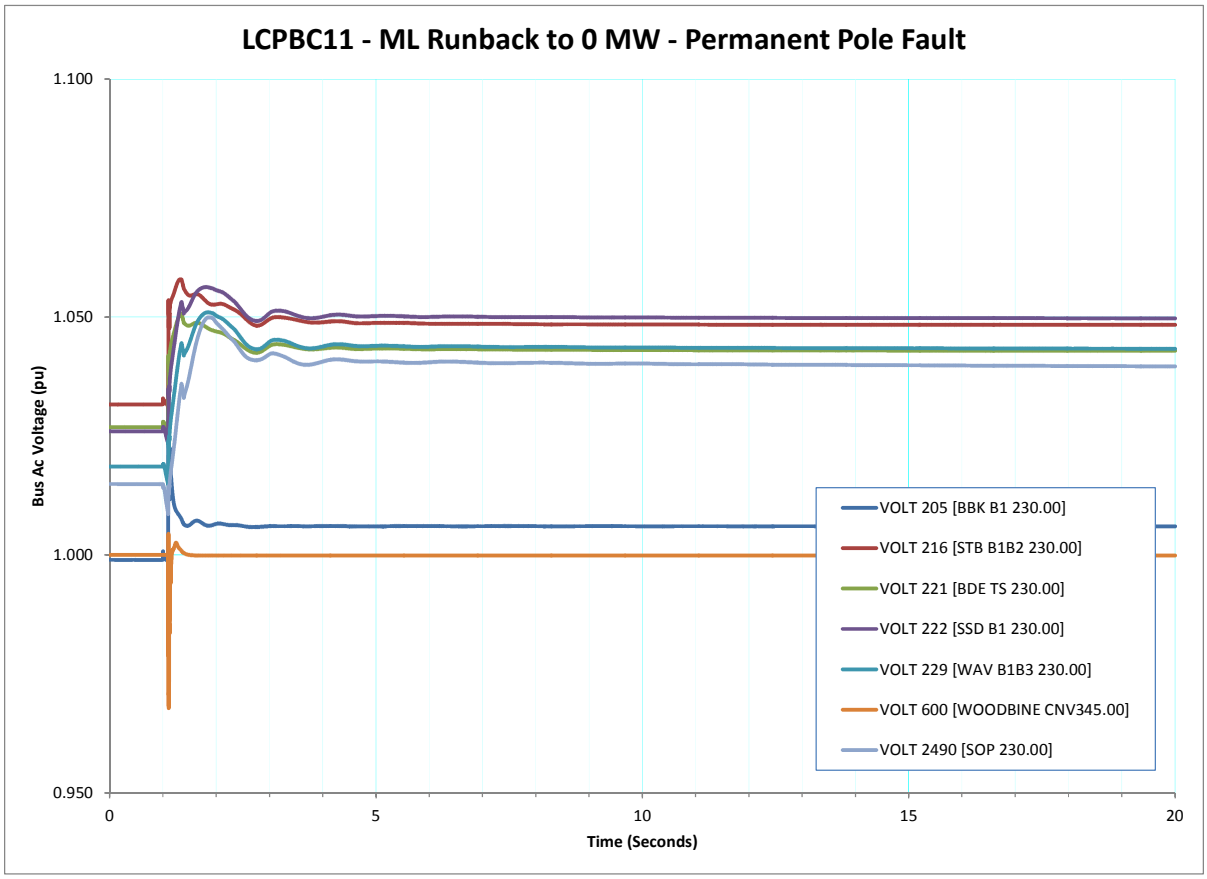

Figure 357 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - Bus Ac Voltage (pu)

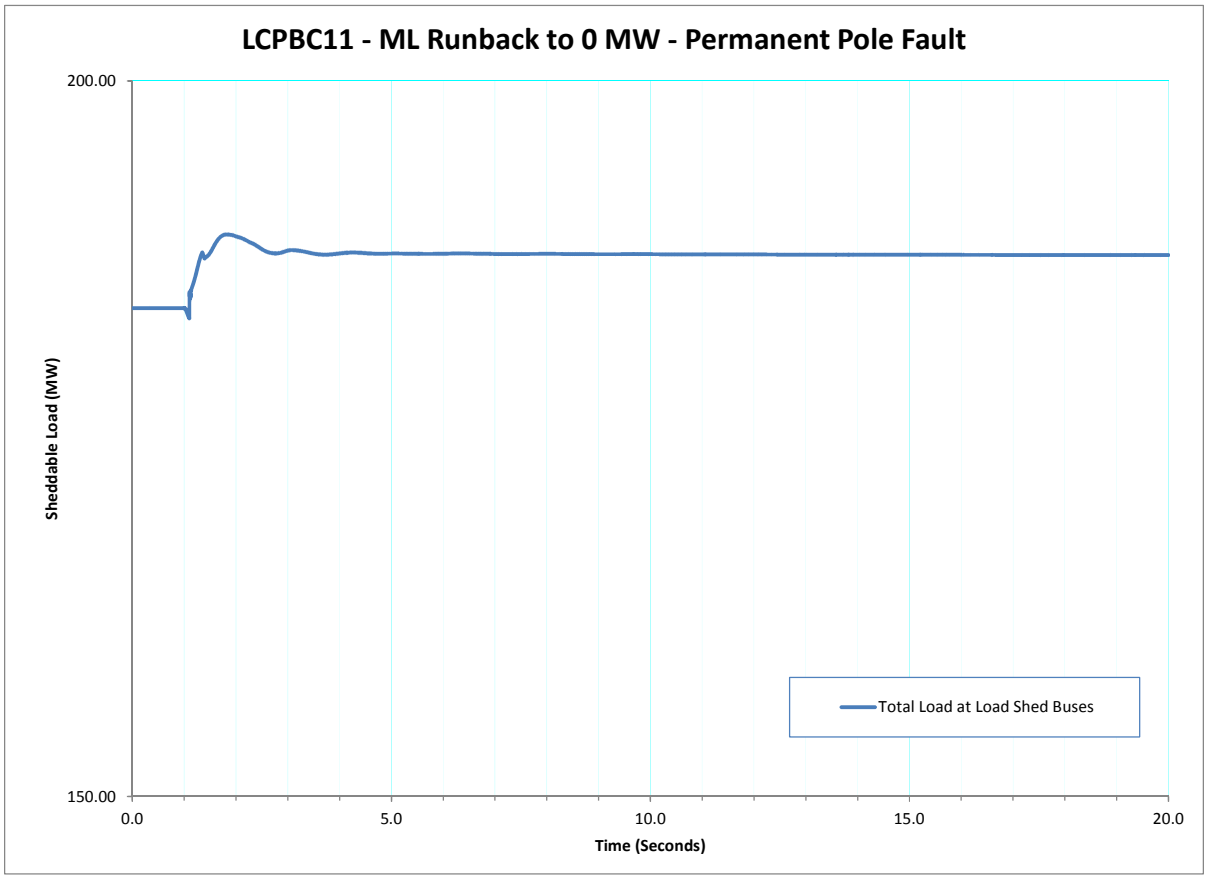

Figure 358 - LCPBC11 - ML Runback to 0 MW - Permanent Pole Fault - Sheddable Load (MW)

APPENDIX F Remedial ML Curtailment for Loss of Island Generation

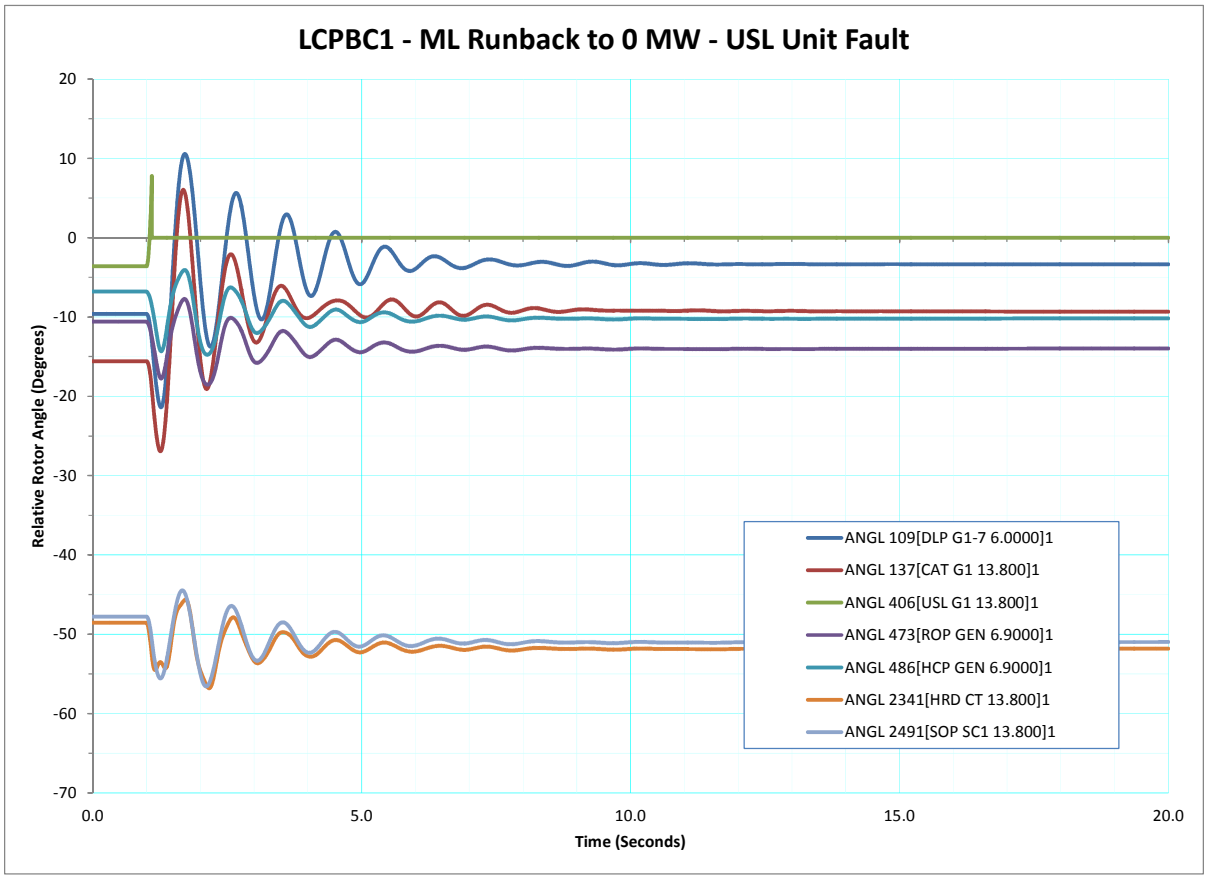

Figure 359 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

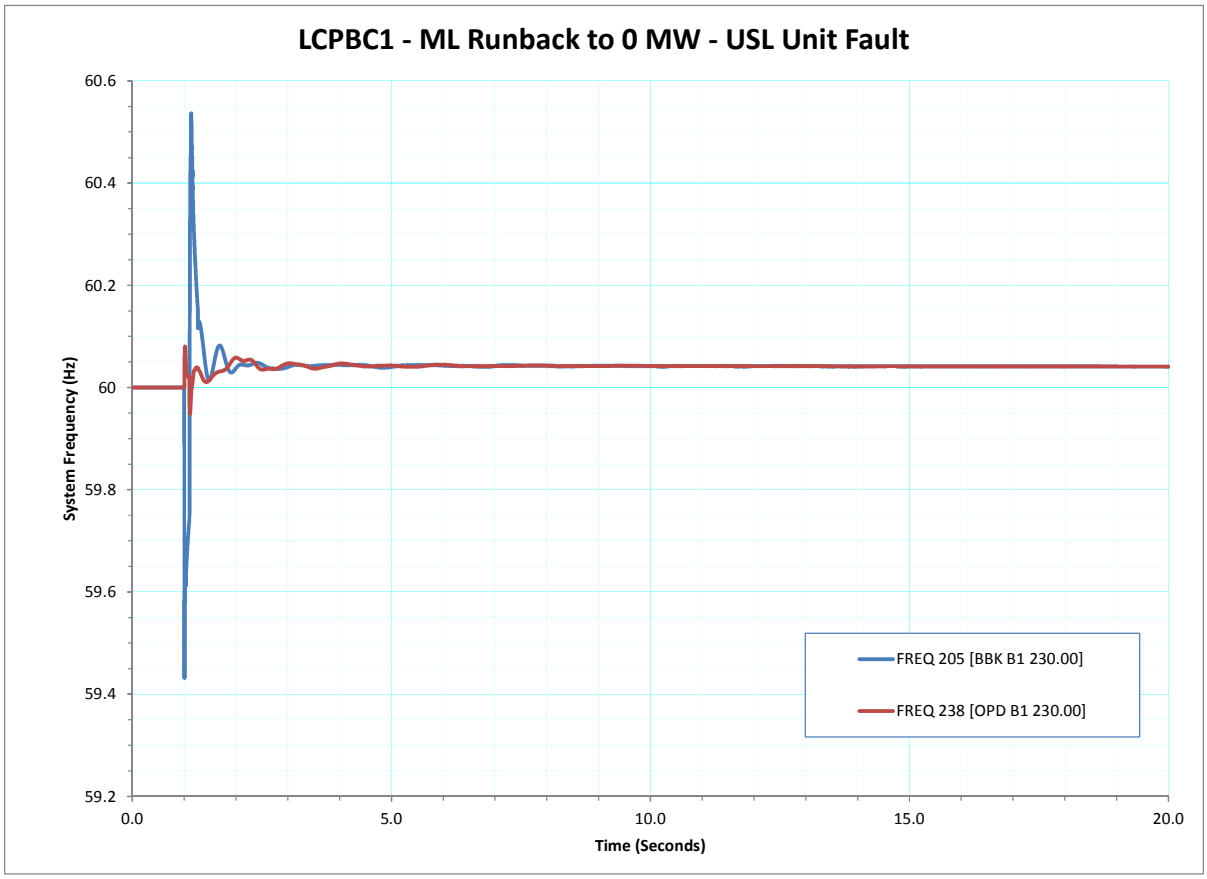

Figure 360 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - System Frequency (Hz)

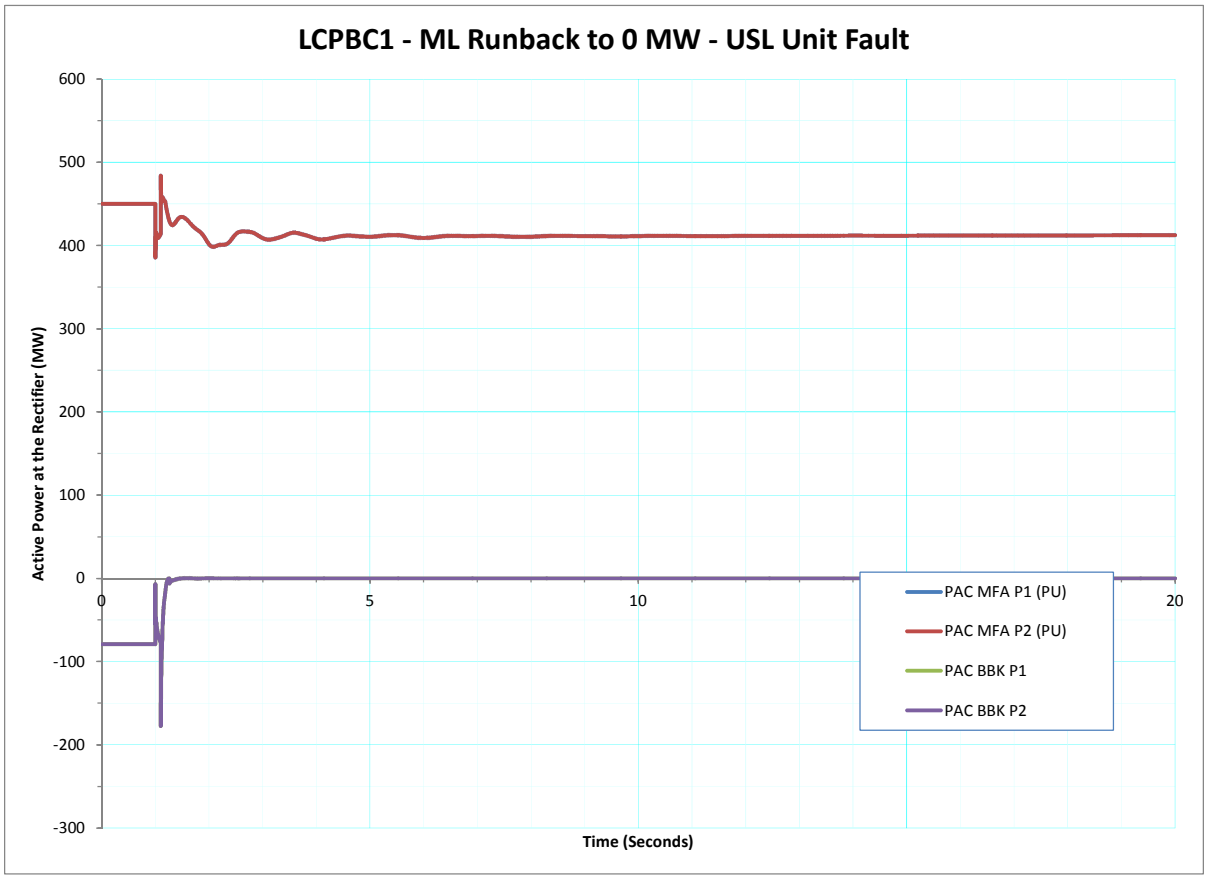

Figure 361 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - Active Power at the Rectifier (MW)

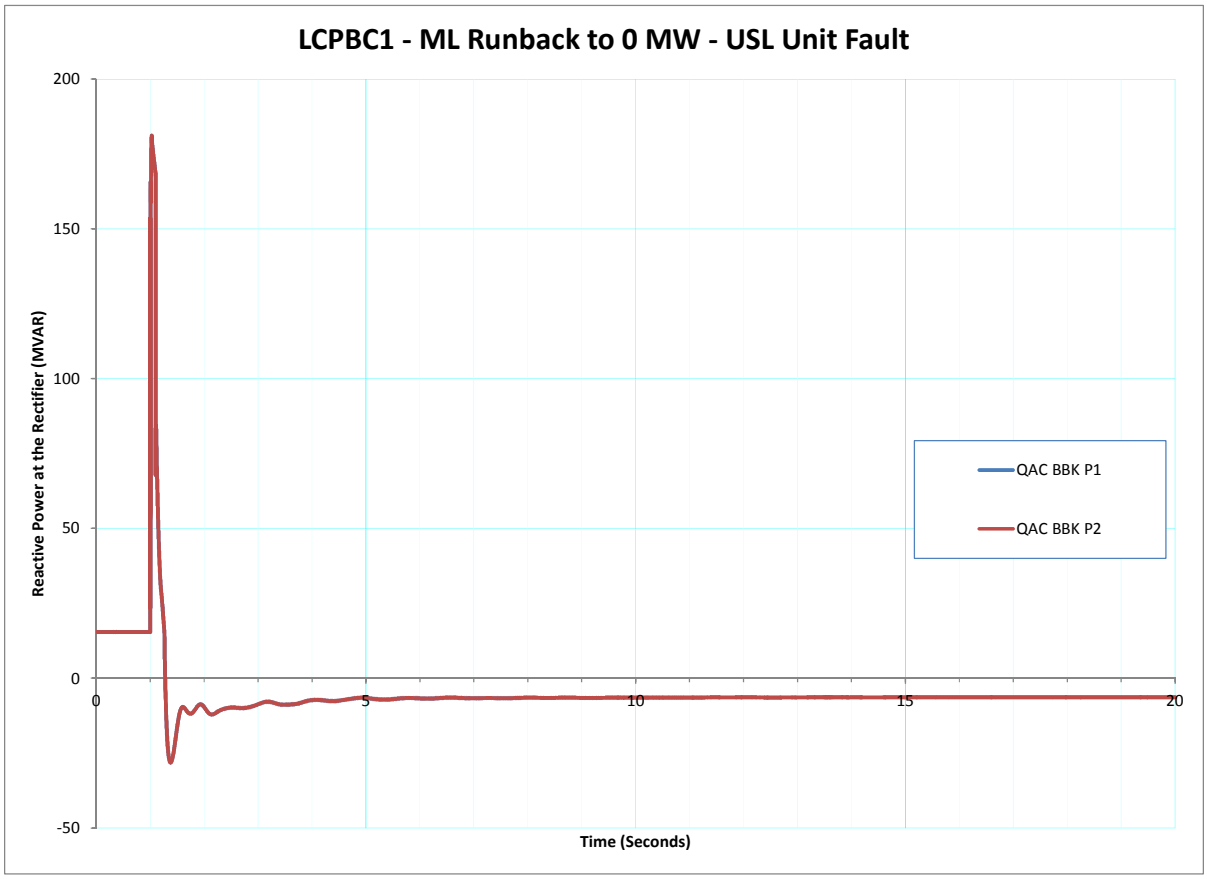

Figure 362 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

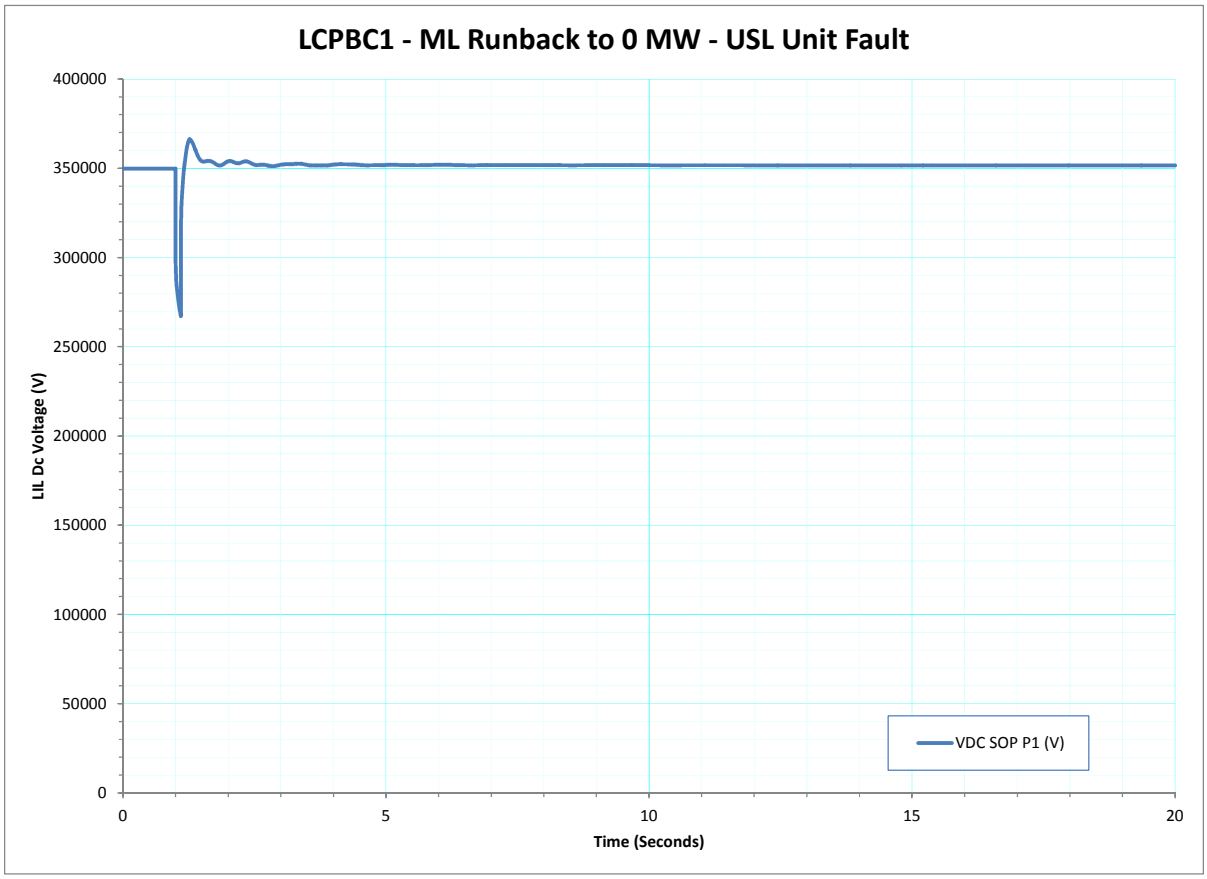

Figure 363 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - LIL Dc Voltage (V)

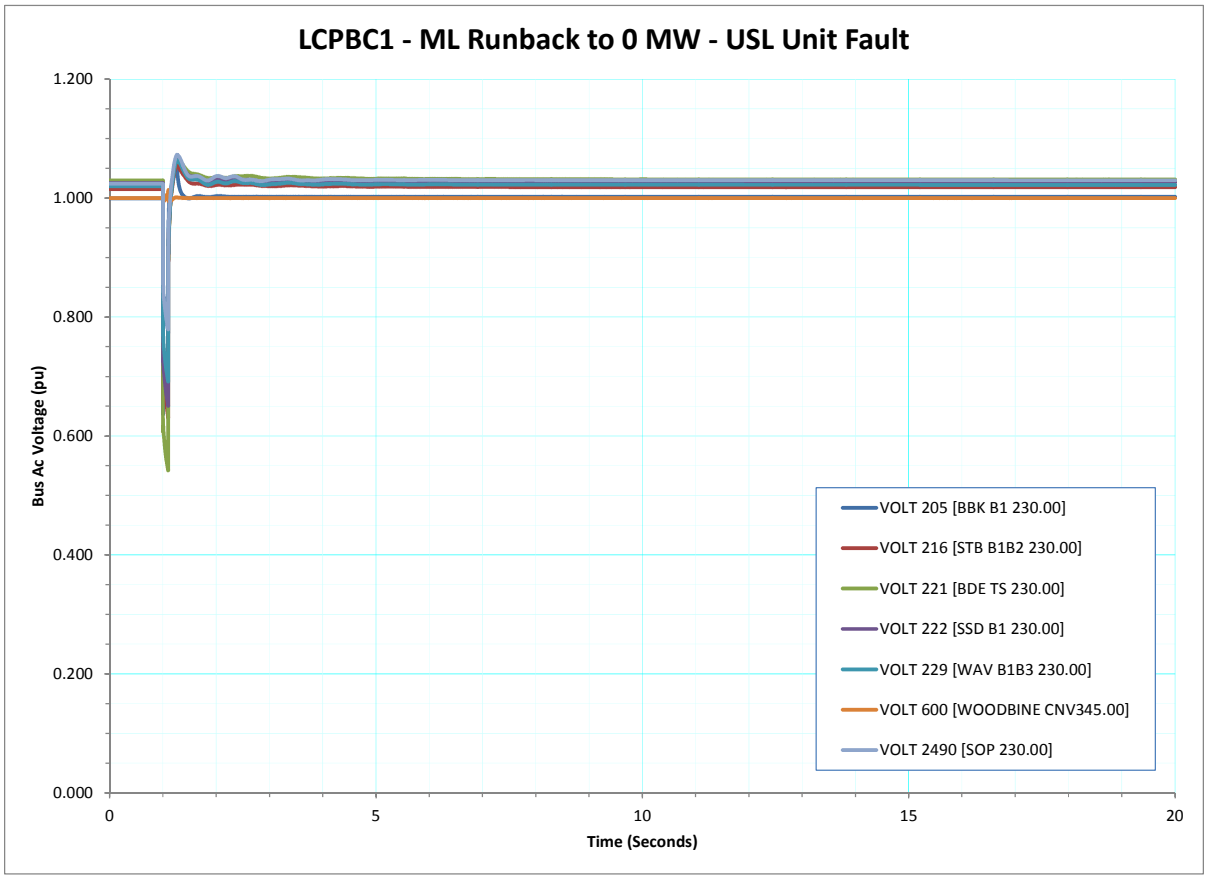

Figure 364 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - Bus Ac Voltage (pu)

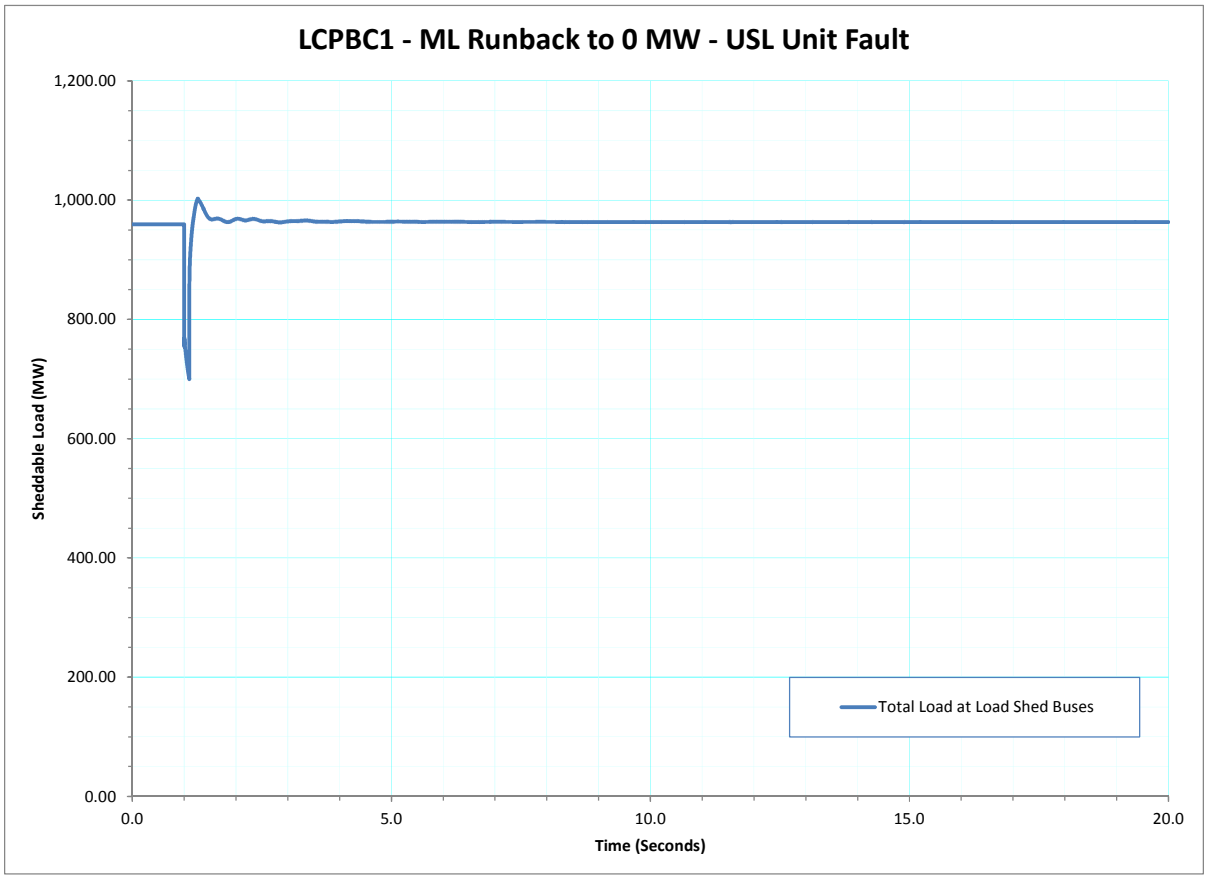

Figure 365 - LCPBC1 - ML Runback to 0 MW - USL Unit Fault - Sheddable Load (MW)

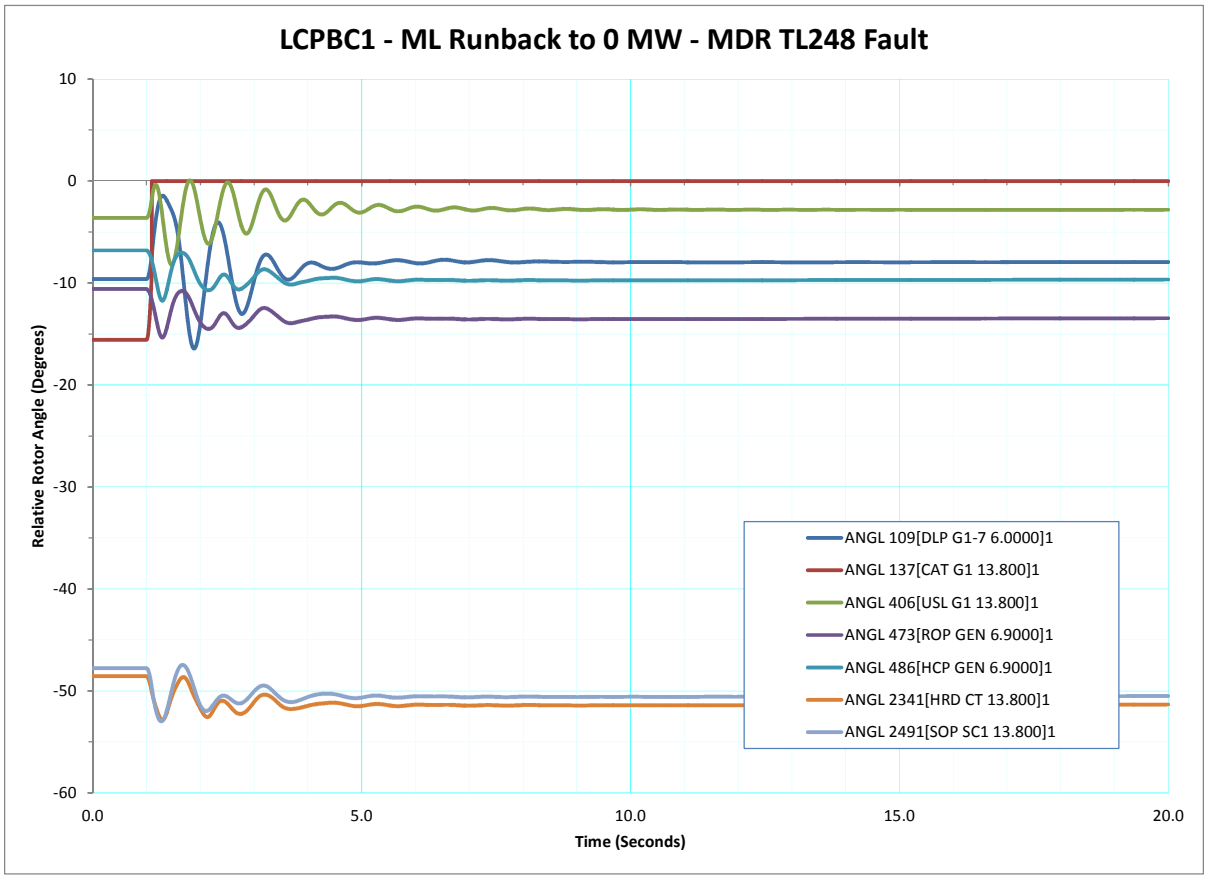

Figure 366 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

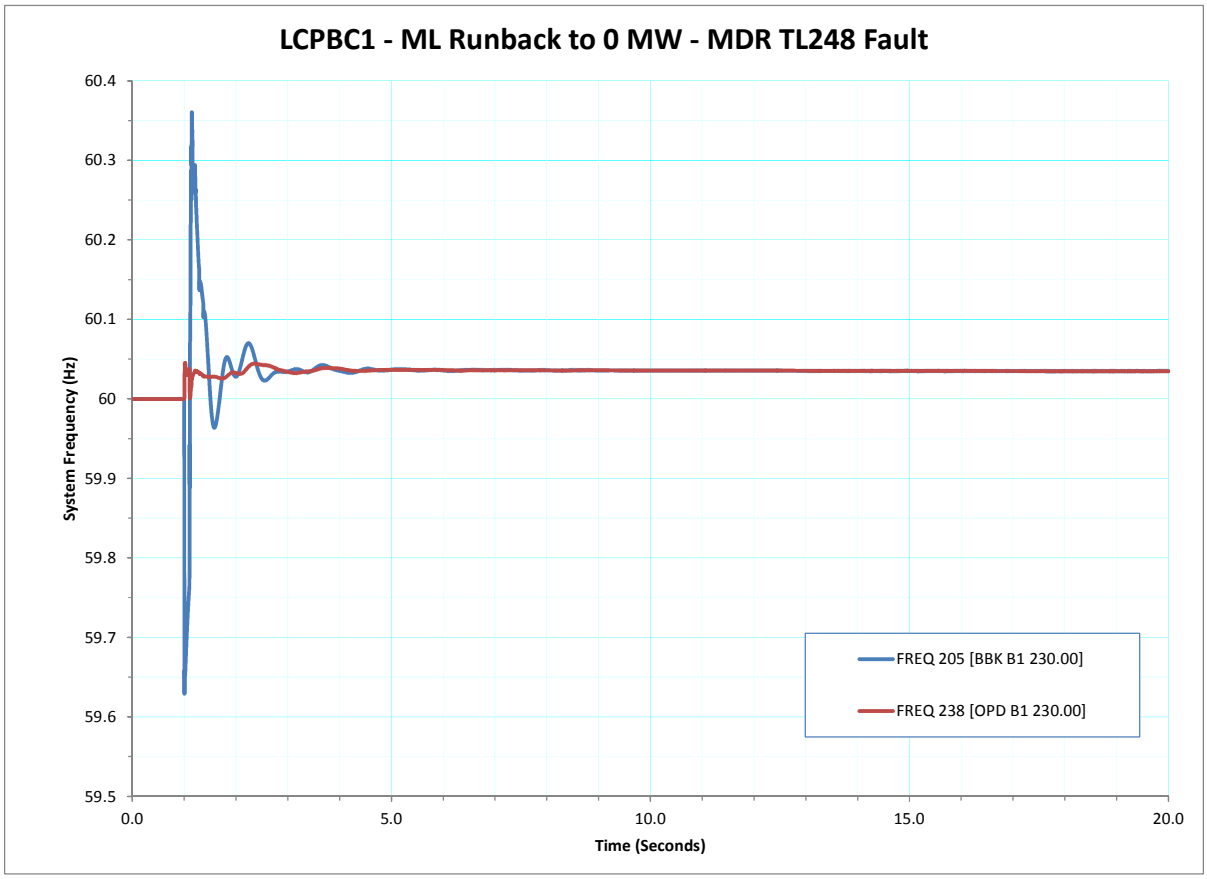

Figure 367 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - System Frequency (Hz)

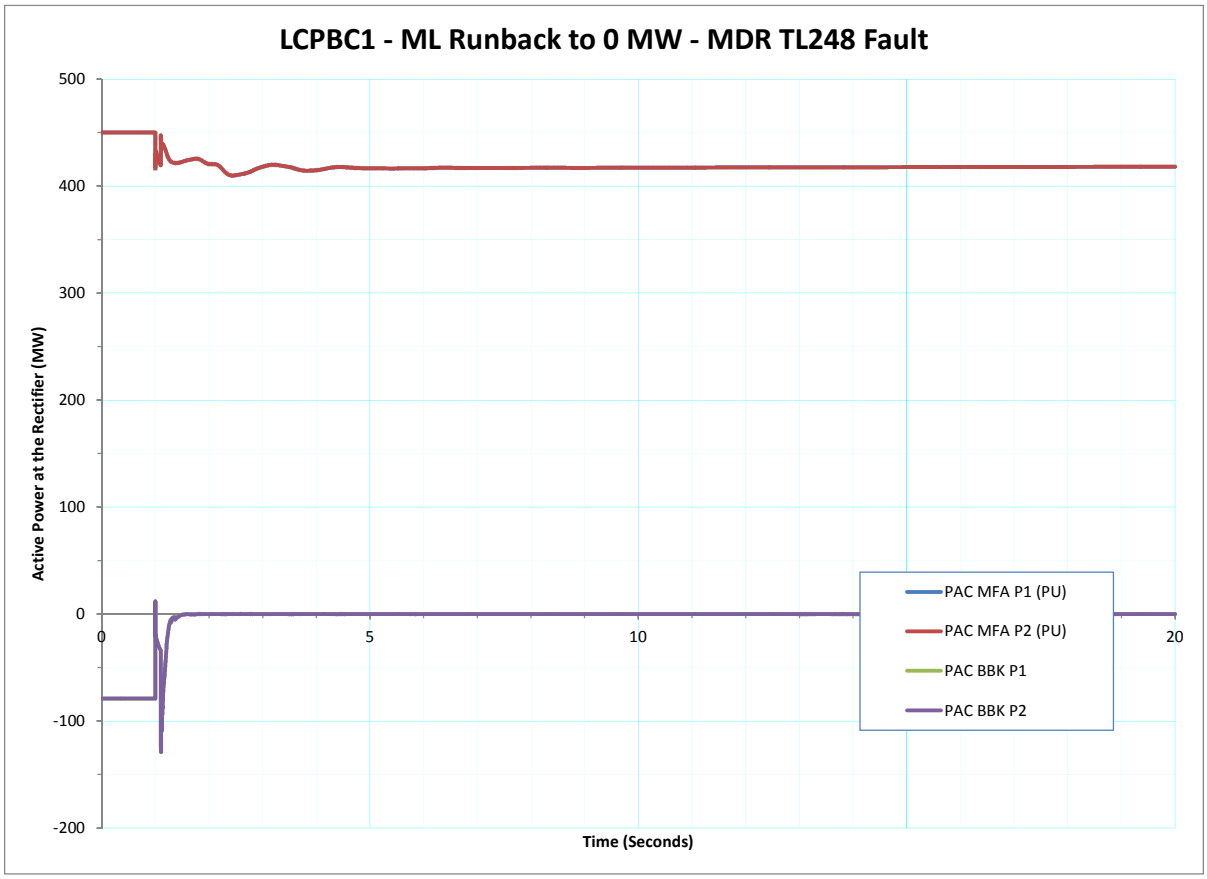

Figure 368 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

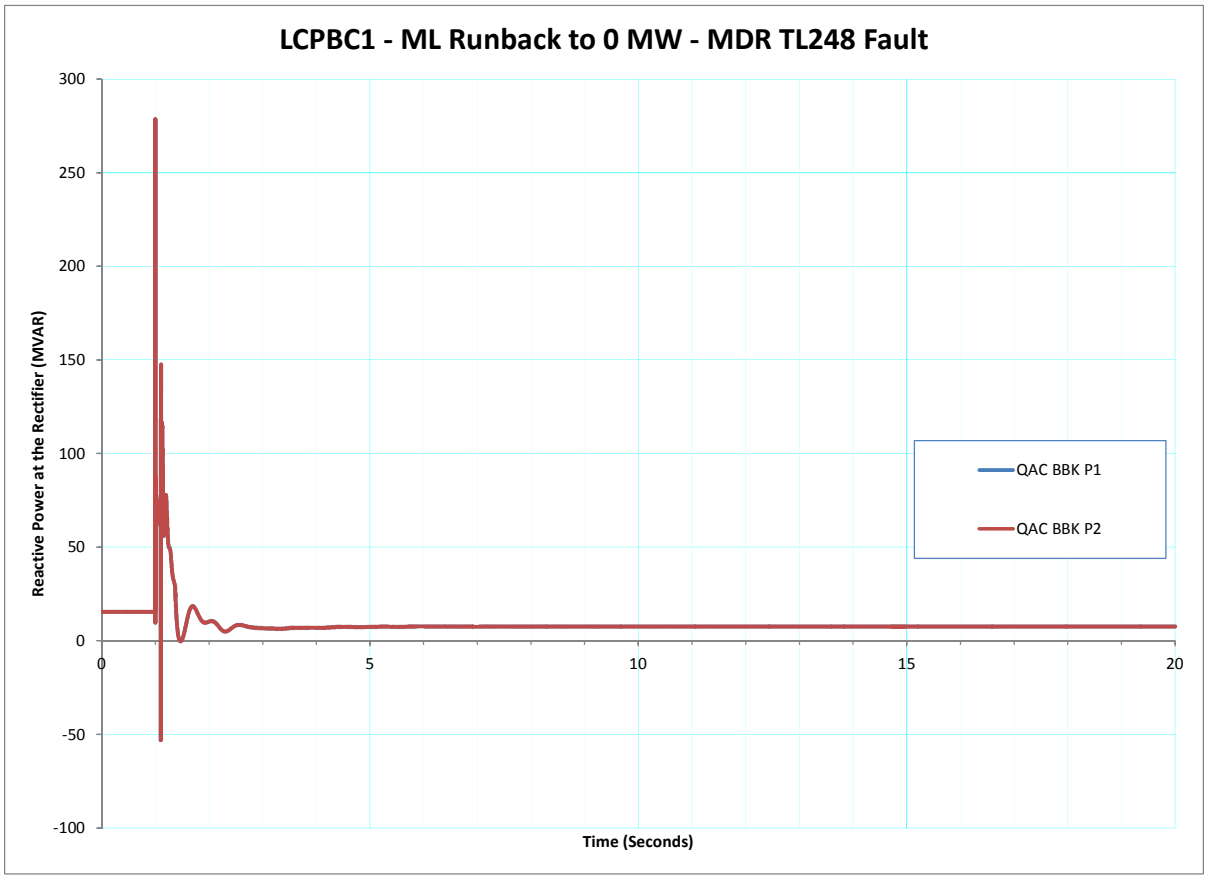

Figure 369 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

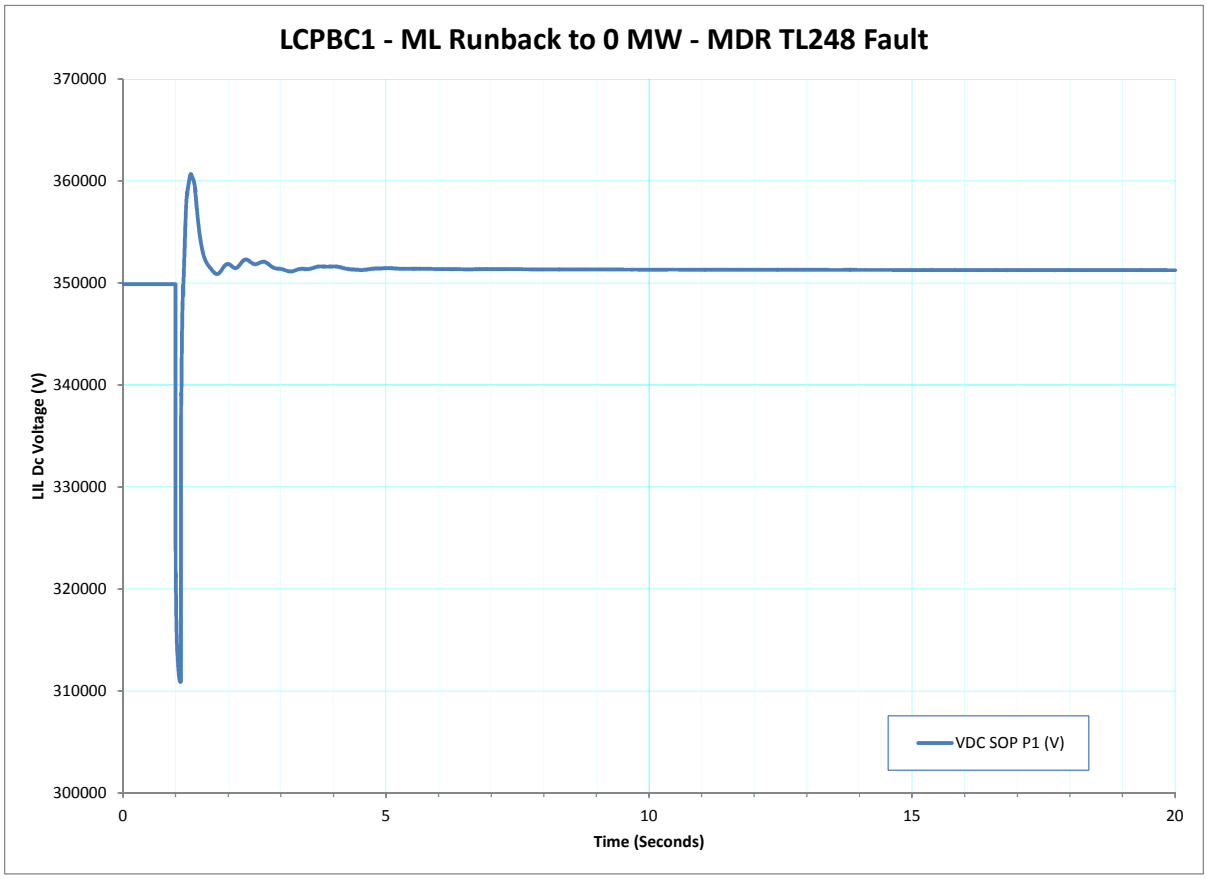

Figure 370 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - LIL Dc Voltage (V)

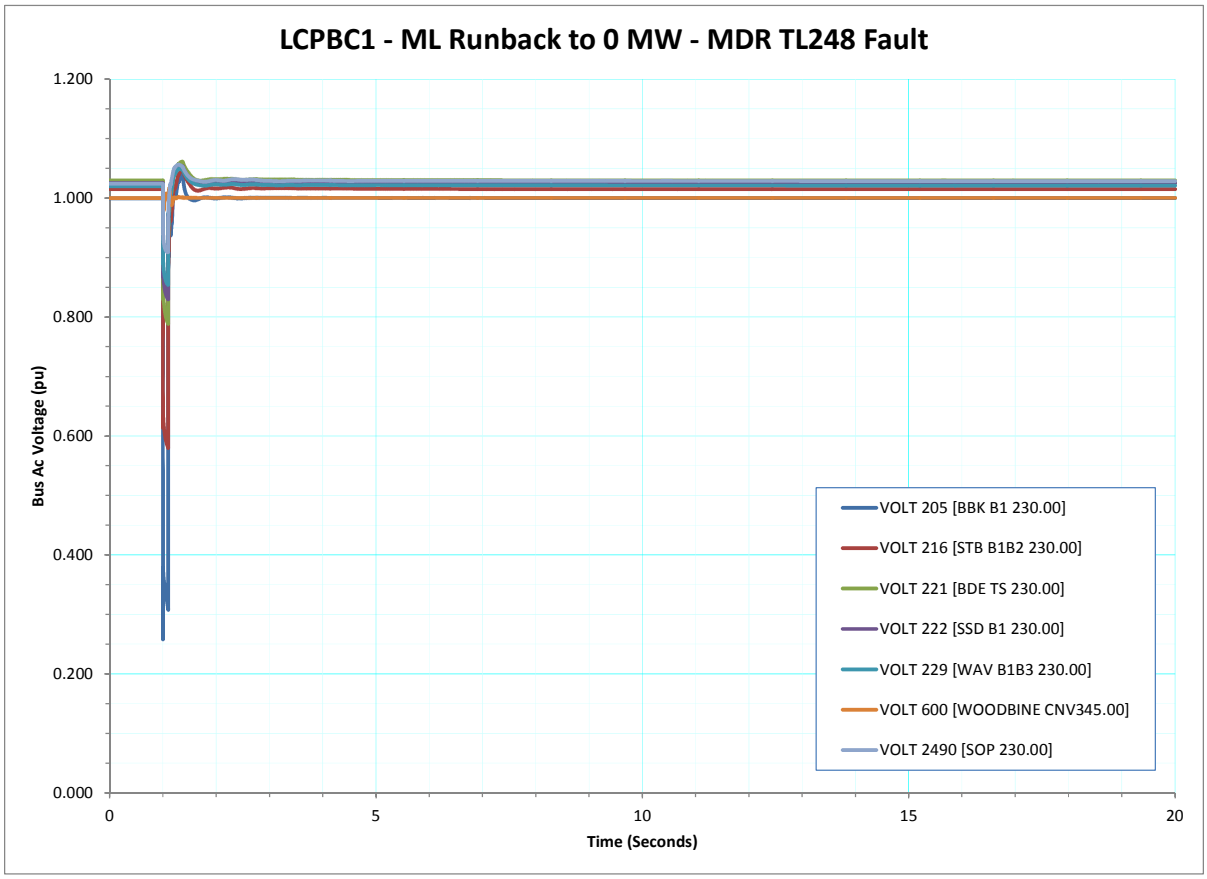

Figure 371 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

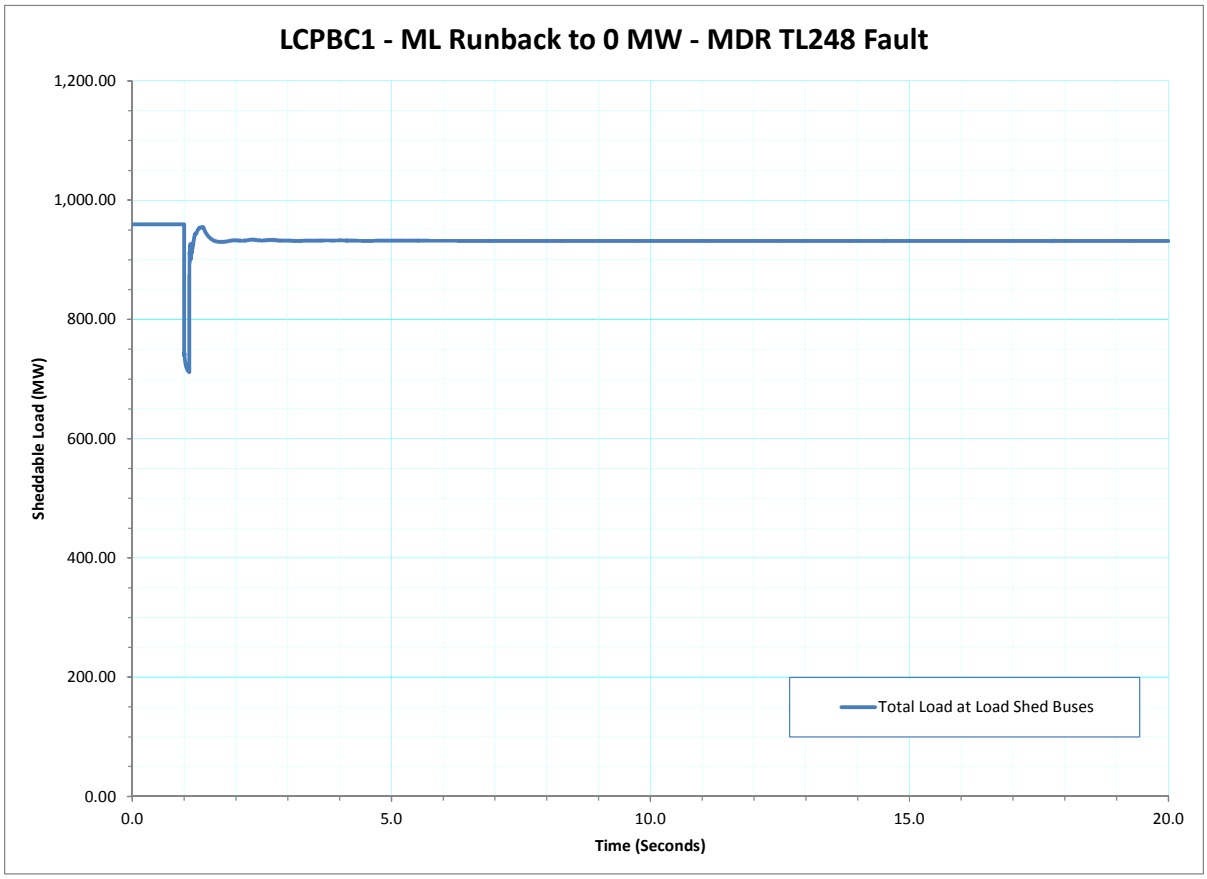

Figure 372 - LCPBC1 - ML Runback to 0 MW - MDR TL248 Fault - Sheddable Load (MW)

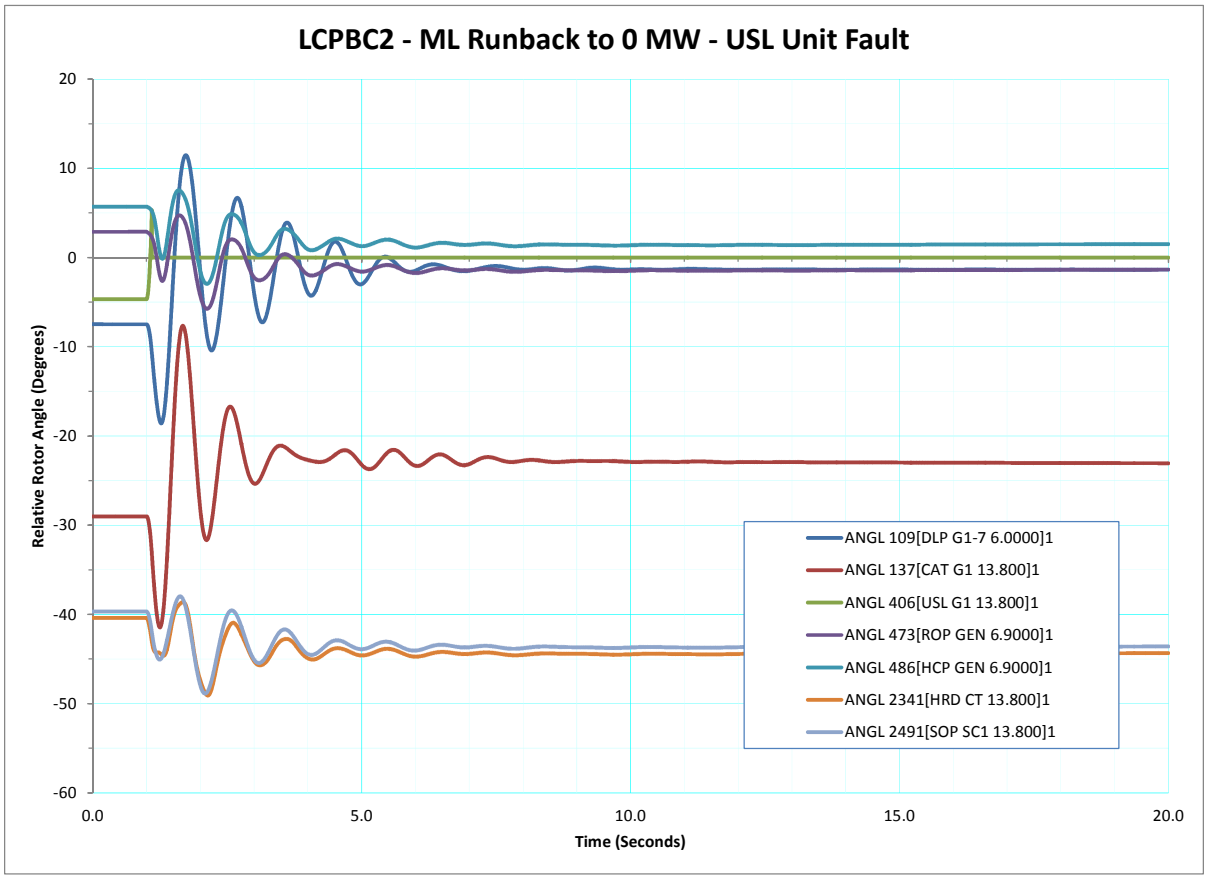

Figure 373 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

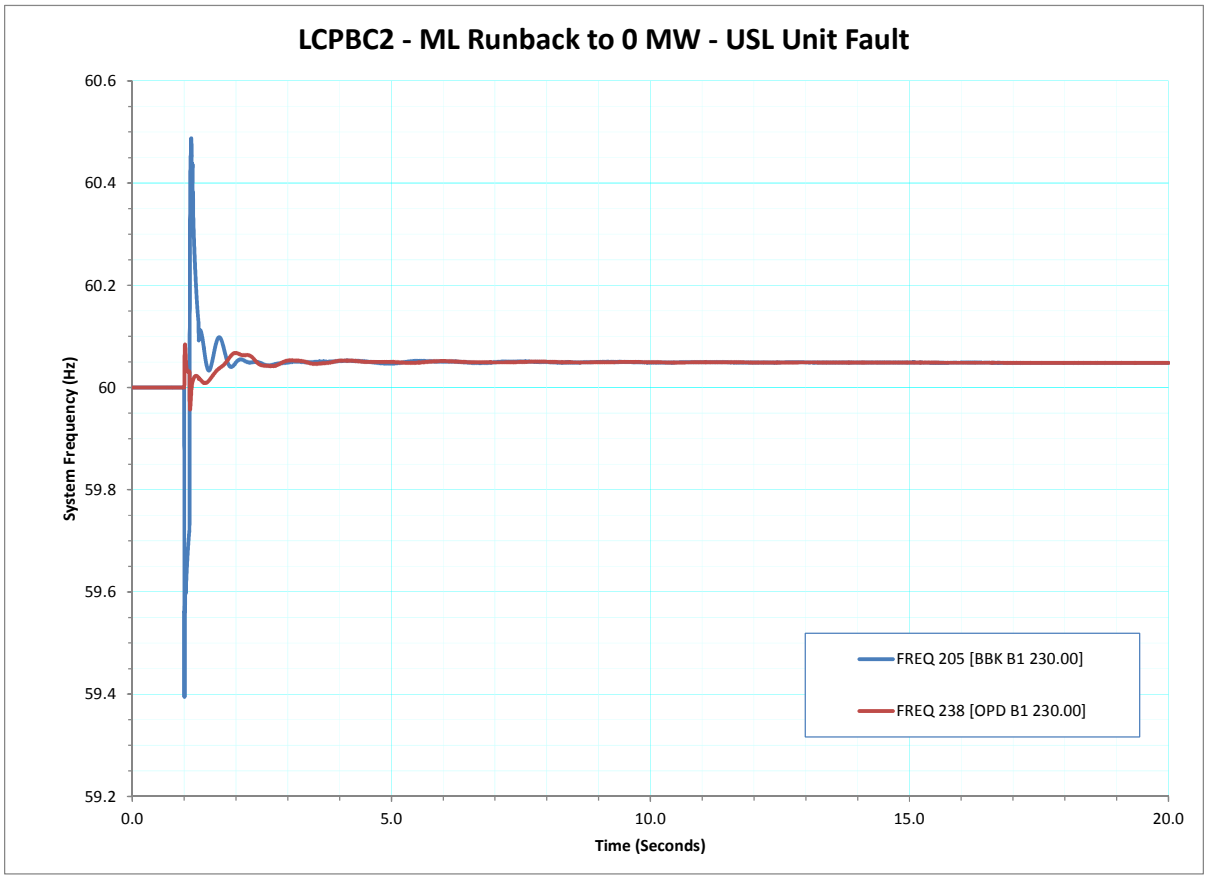

Figure 374 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - System Frequency (Hz)

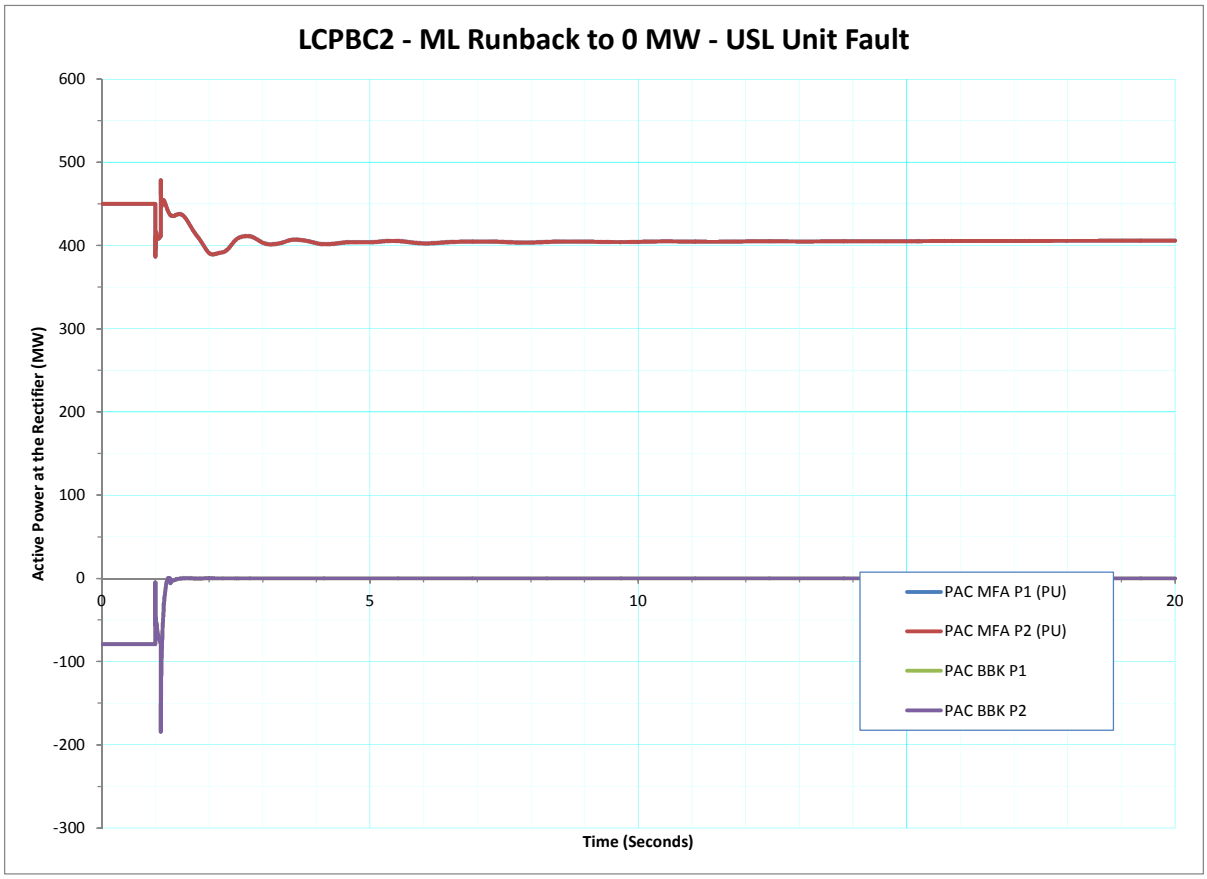

Figure 375 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - Active Power at the Rectifier (MW)

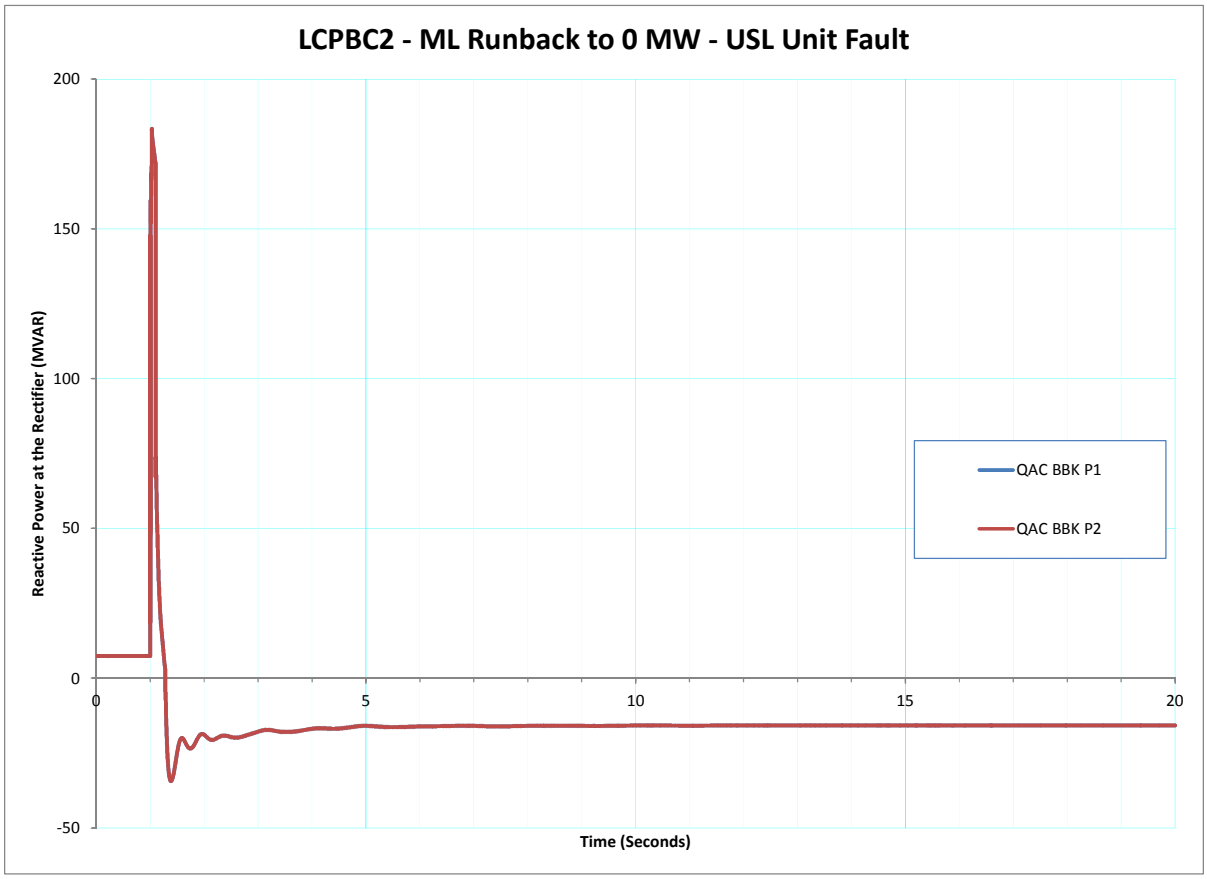

Figure 376 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

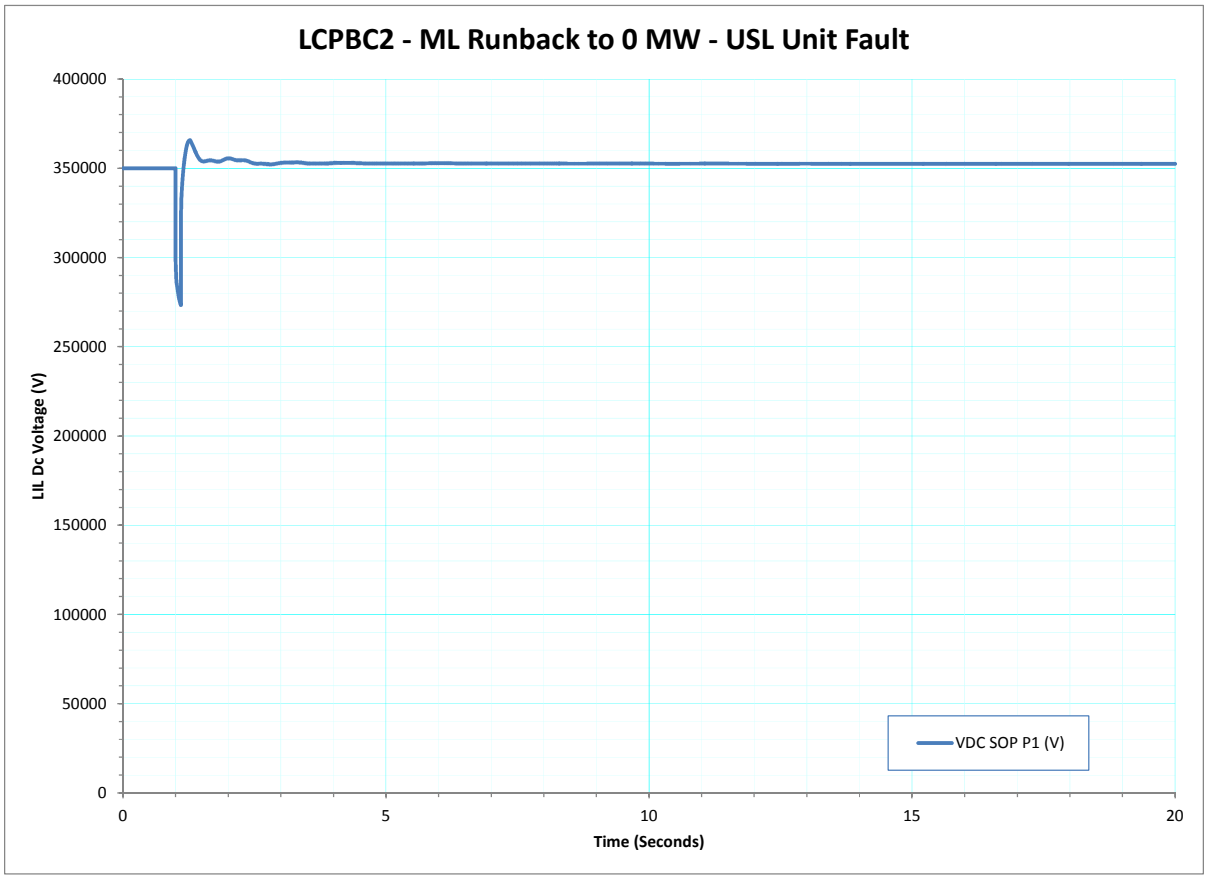

Figure 377 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - LIL Dc Voltage (V)

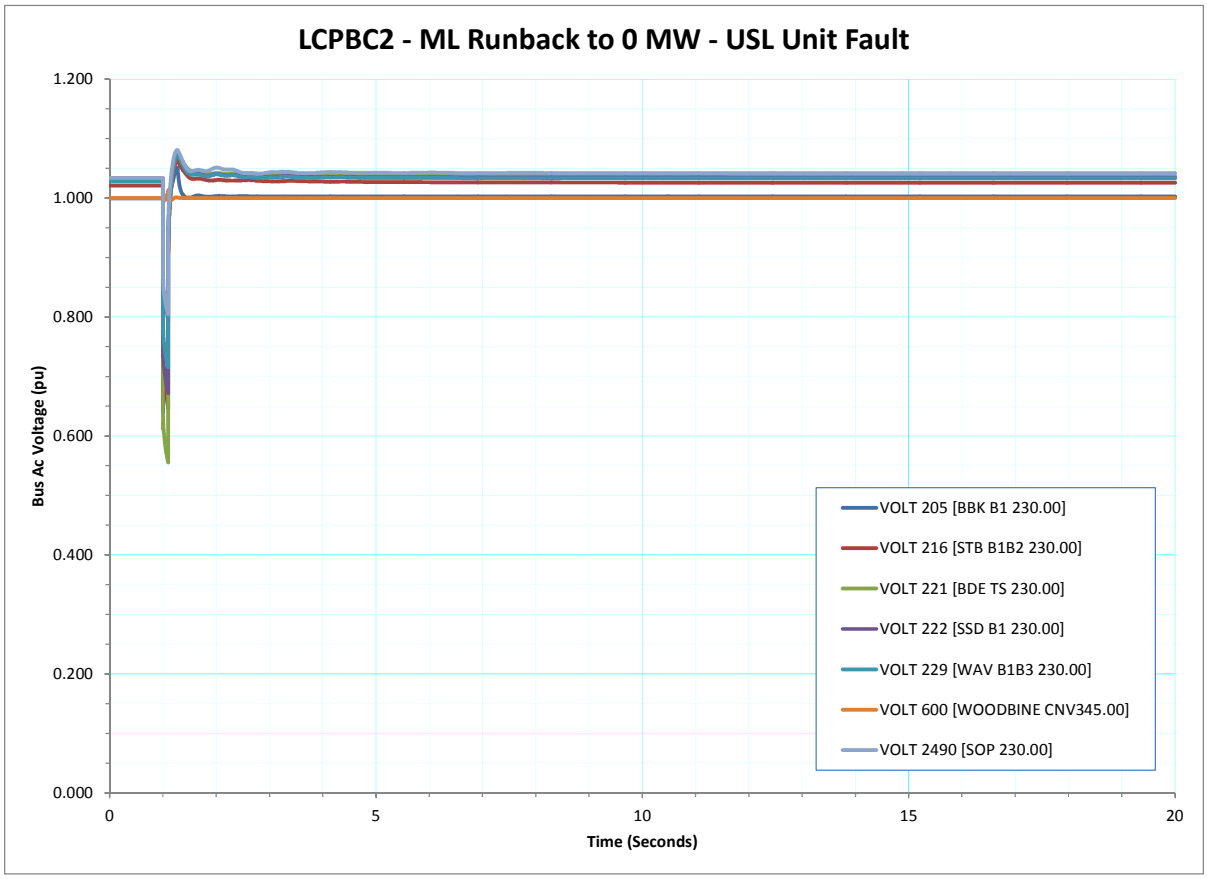

Figure 378 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - Bus Ac Voltage (pu)

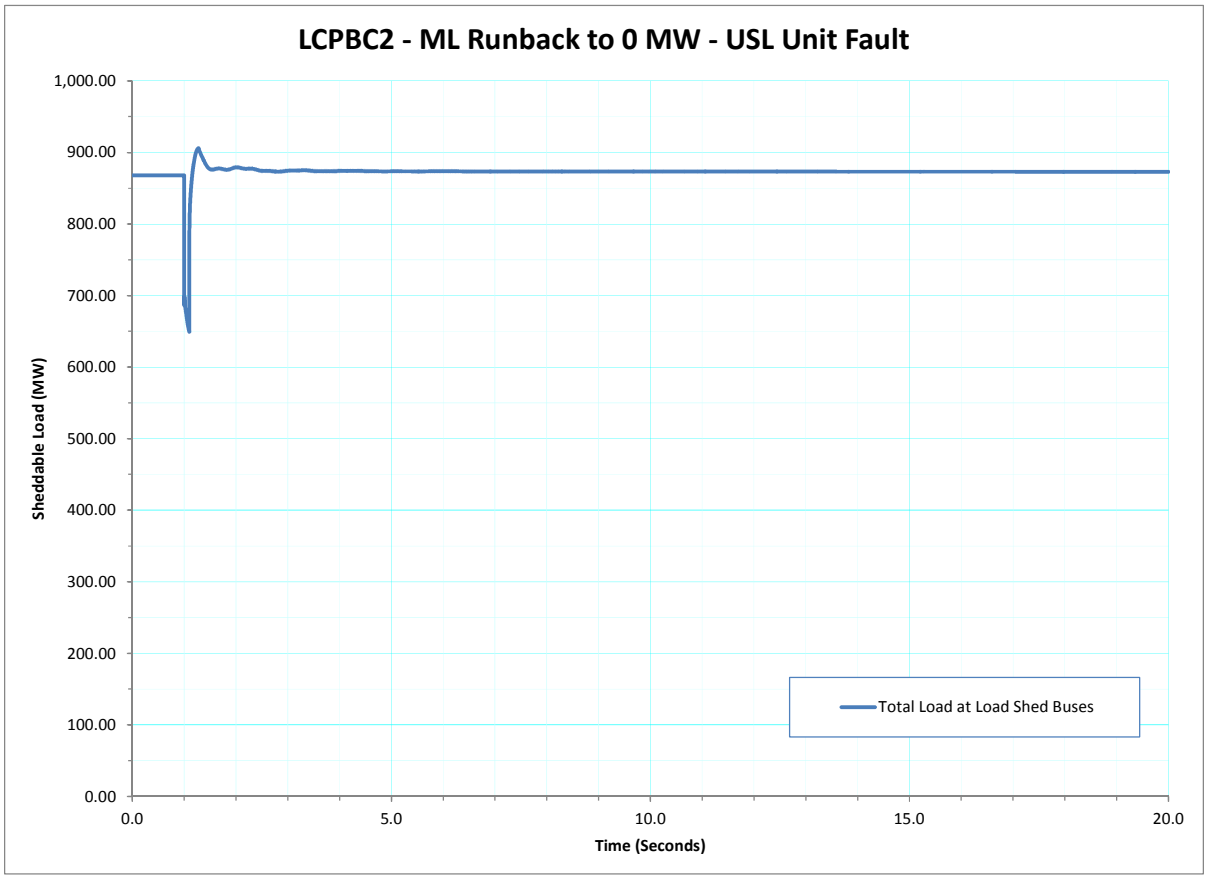

Figure 379 - LCPBC2 - ML Runback to 0 MW - USL Unit Fault - Sheddable Load (MW)

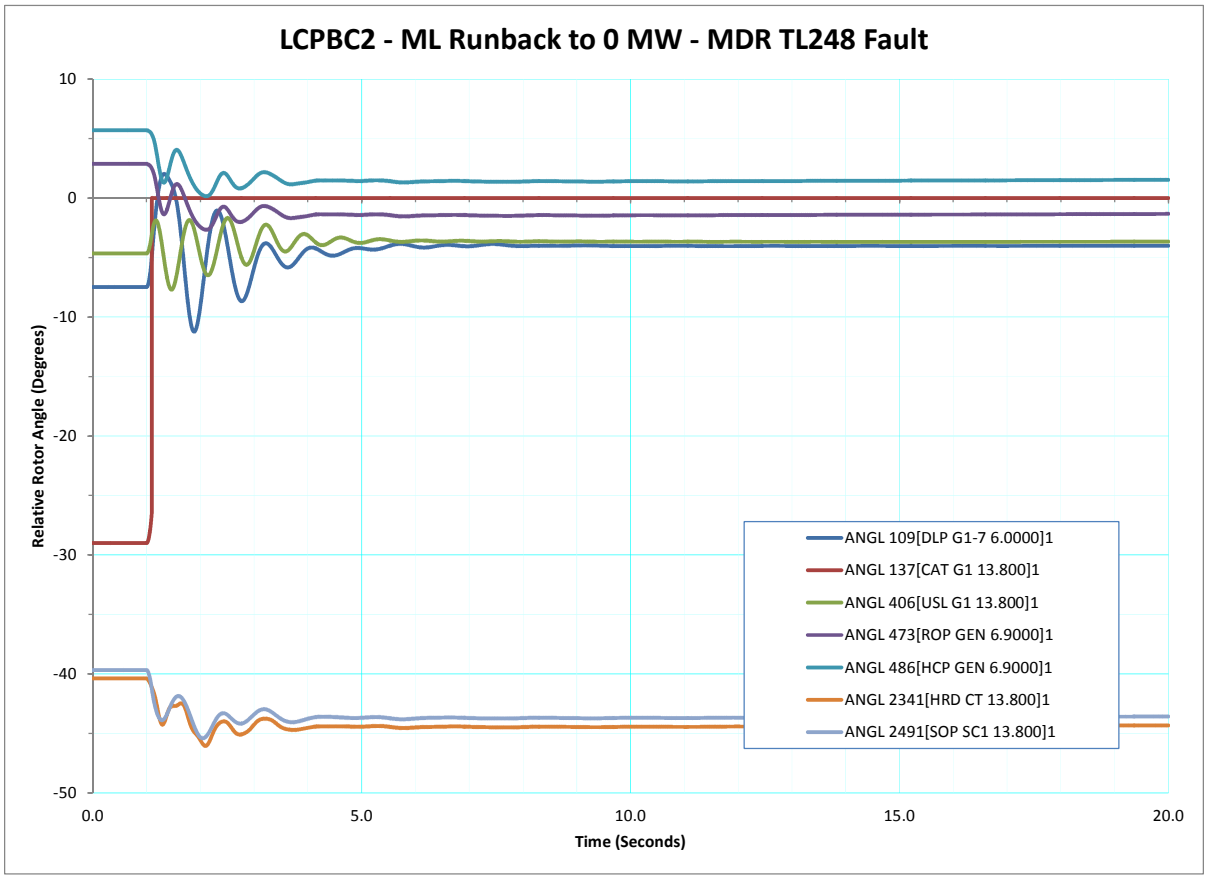

Figure 380 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

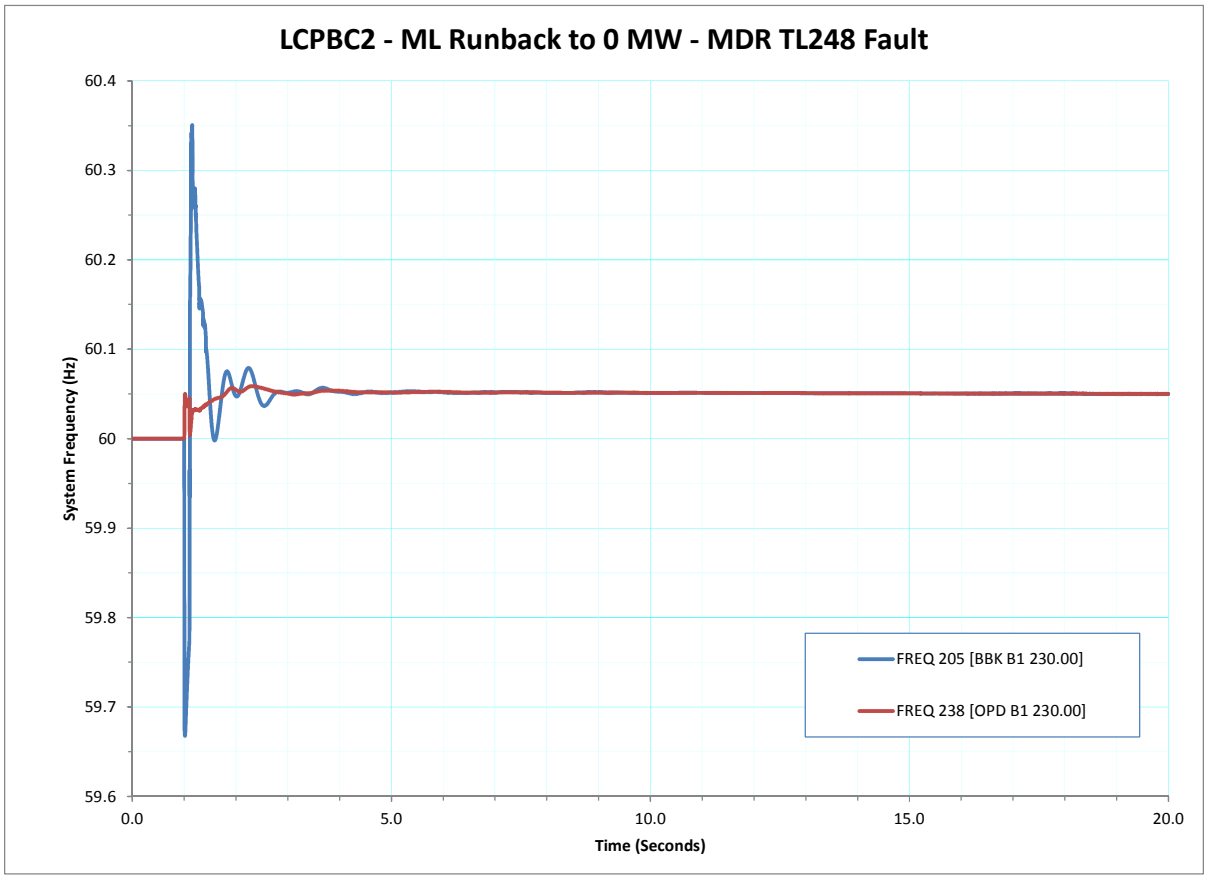

Figure 381 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - System Frequency (Hz)

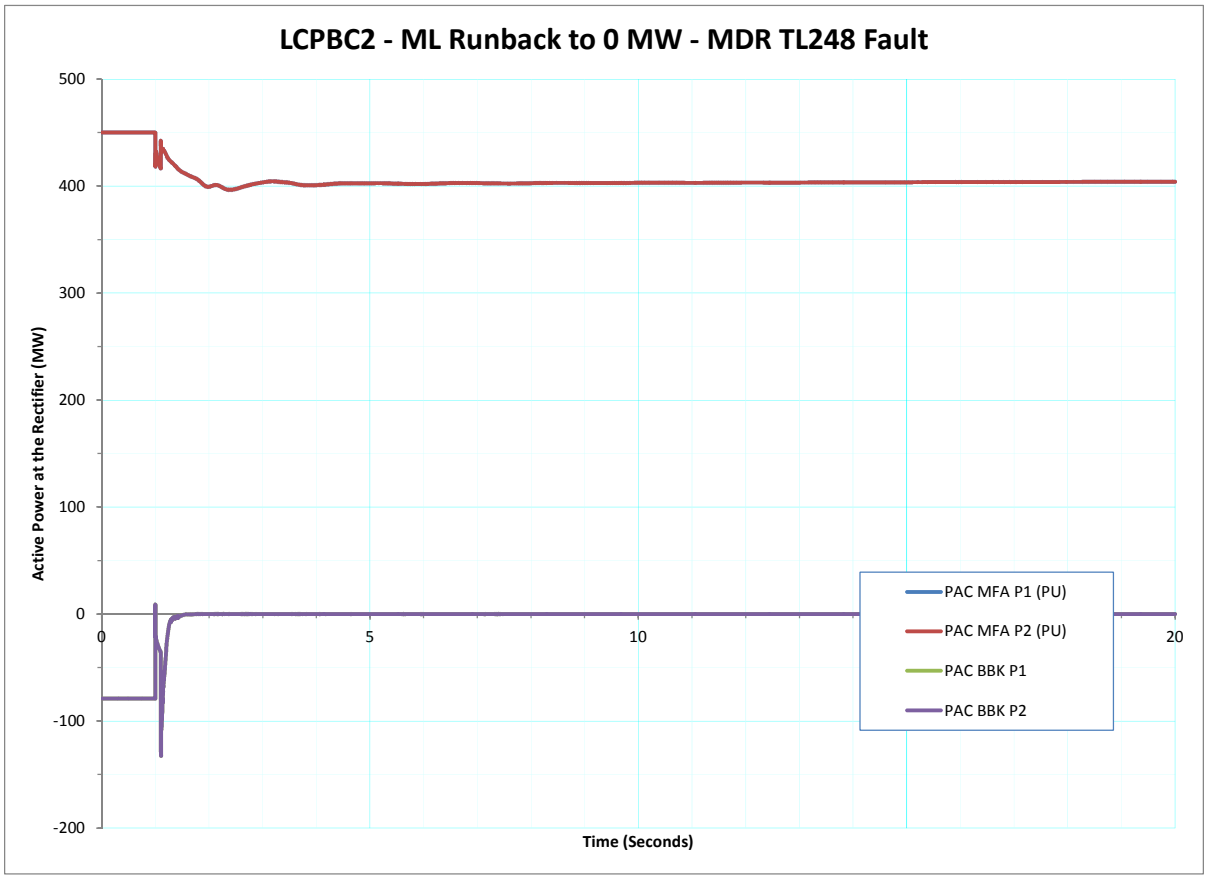

Figure 382 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

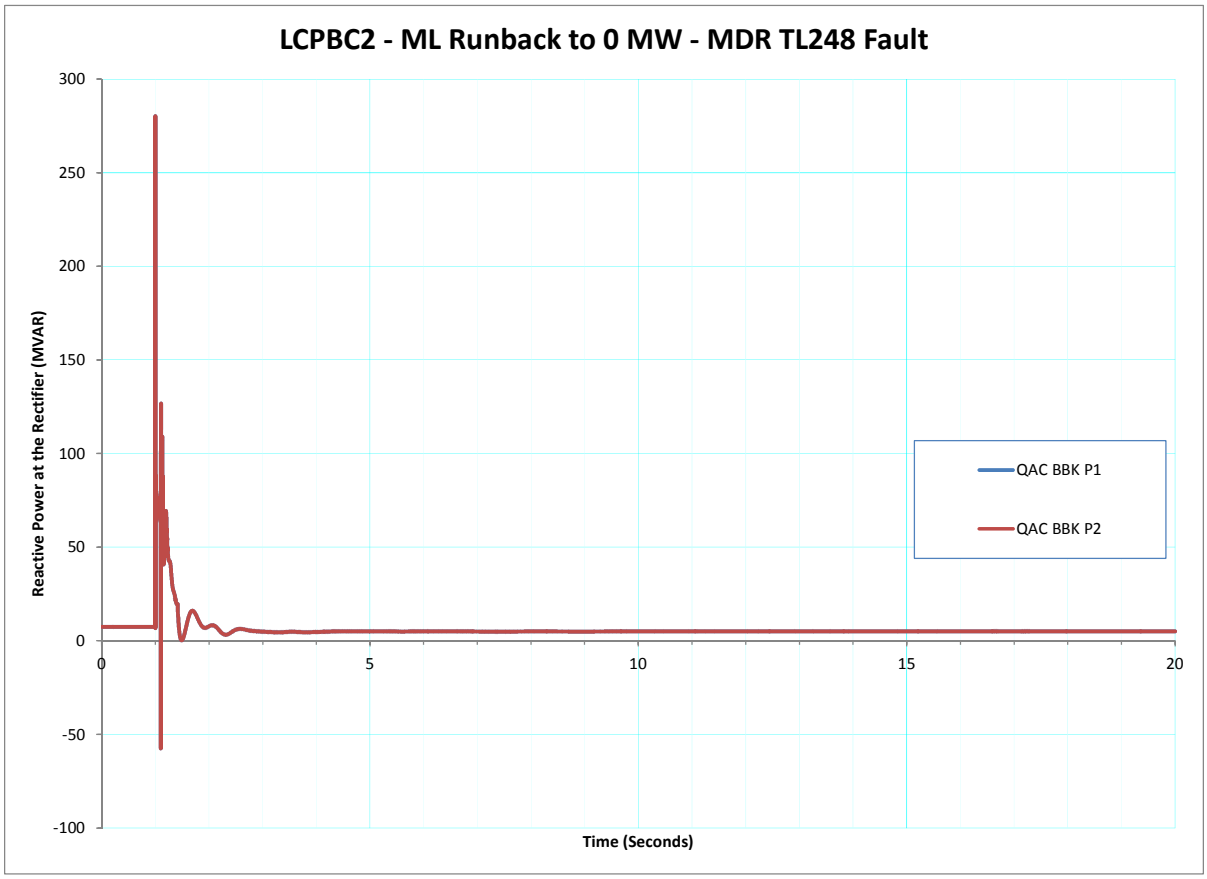

Figure 383 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

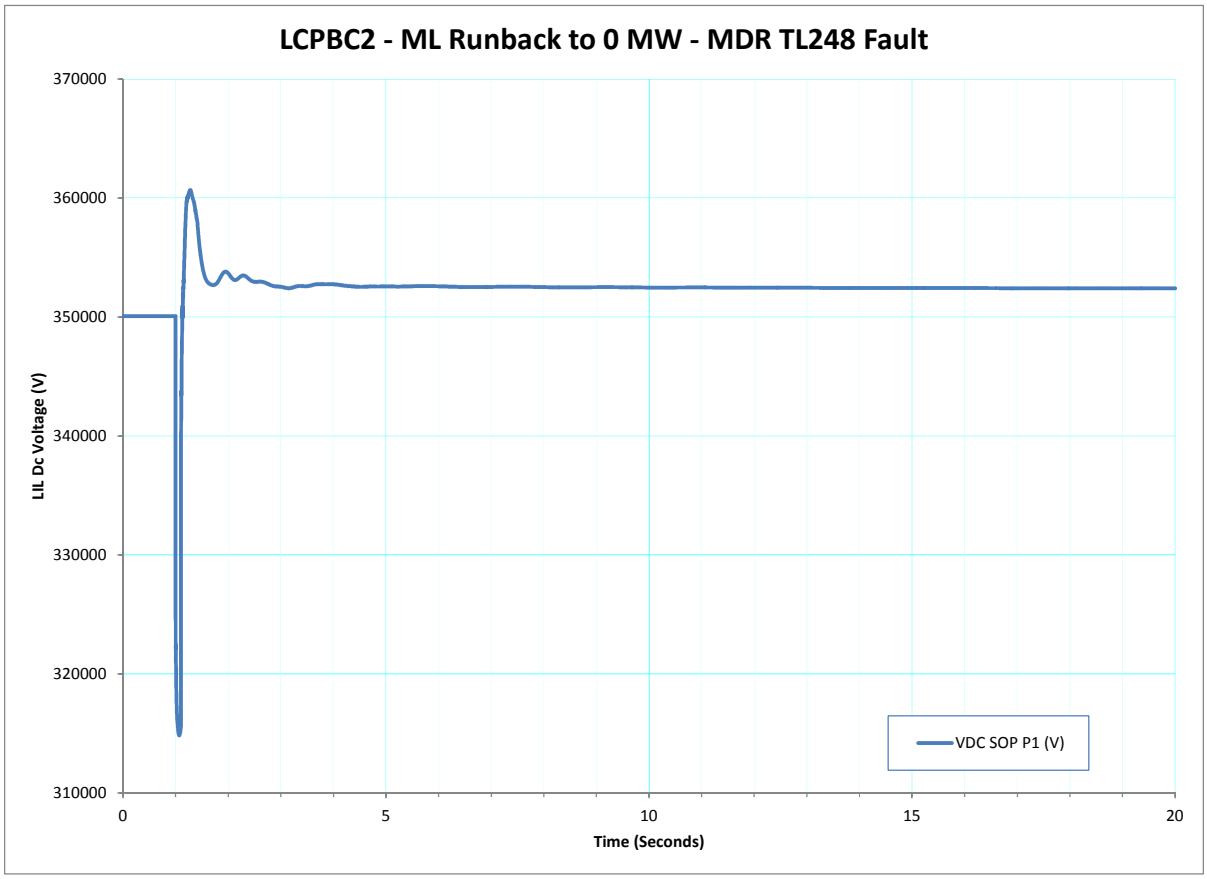

Figure 384 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - LIL Dc Voltage (V)

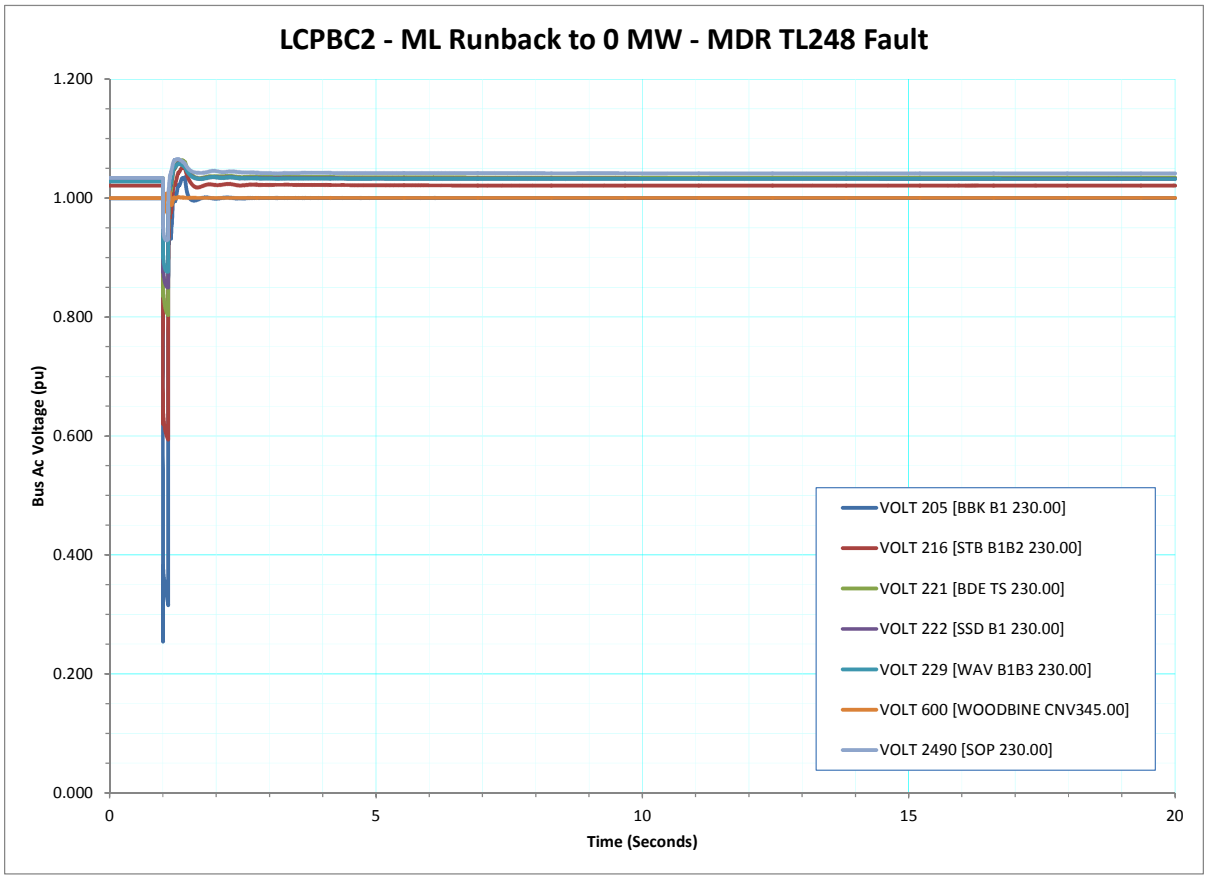

Figure 385 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

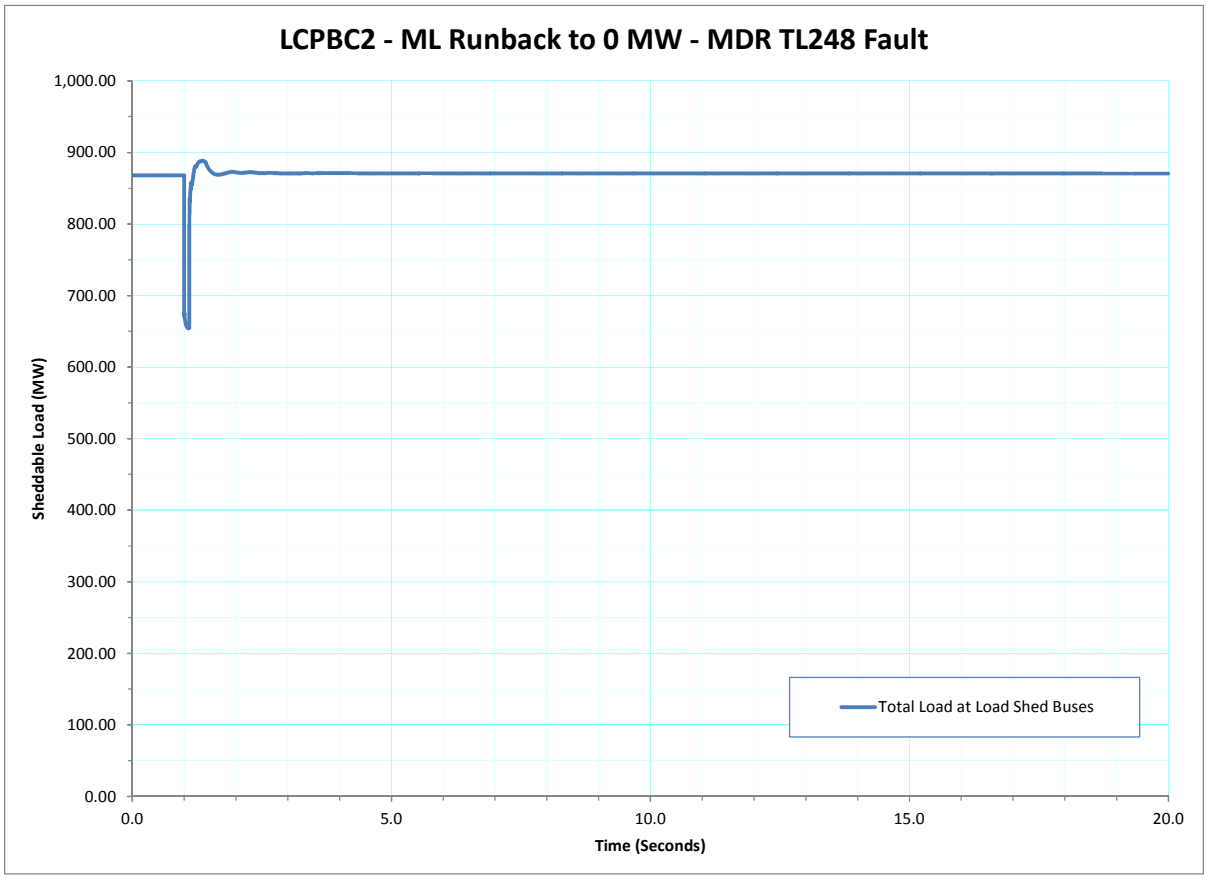

Figure 386 - LCPBC2 - ML Runback to 0 MW - MDR TL248 Fault - Sheddable Load (MW)

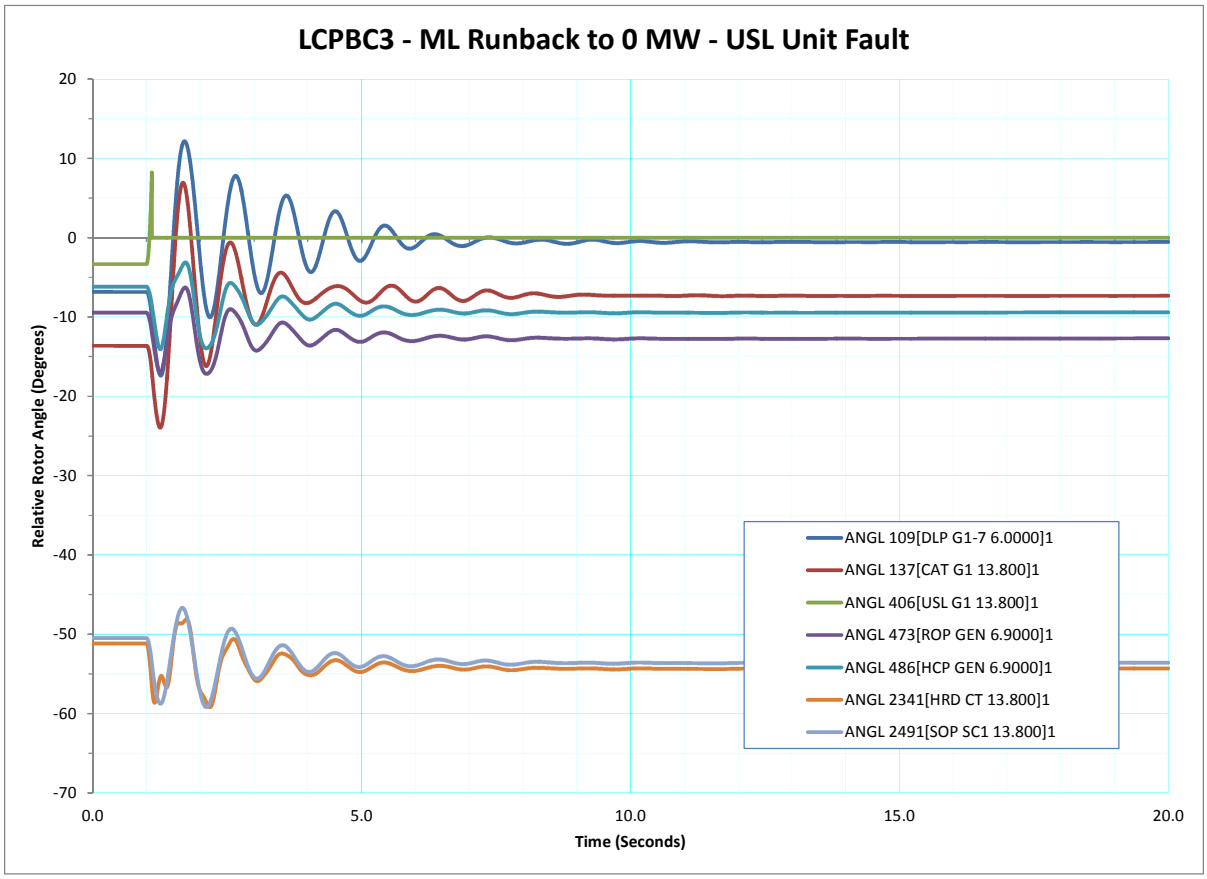

Figure 387 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

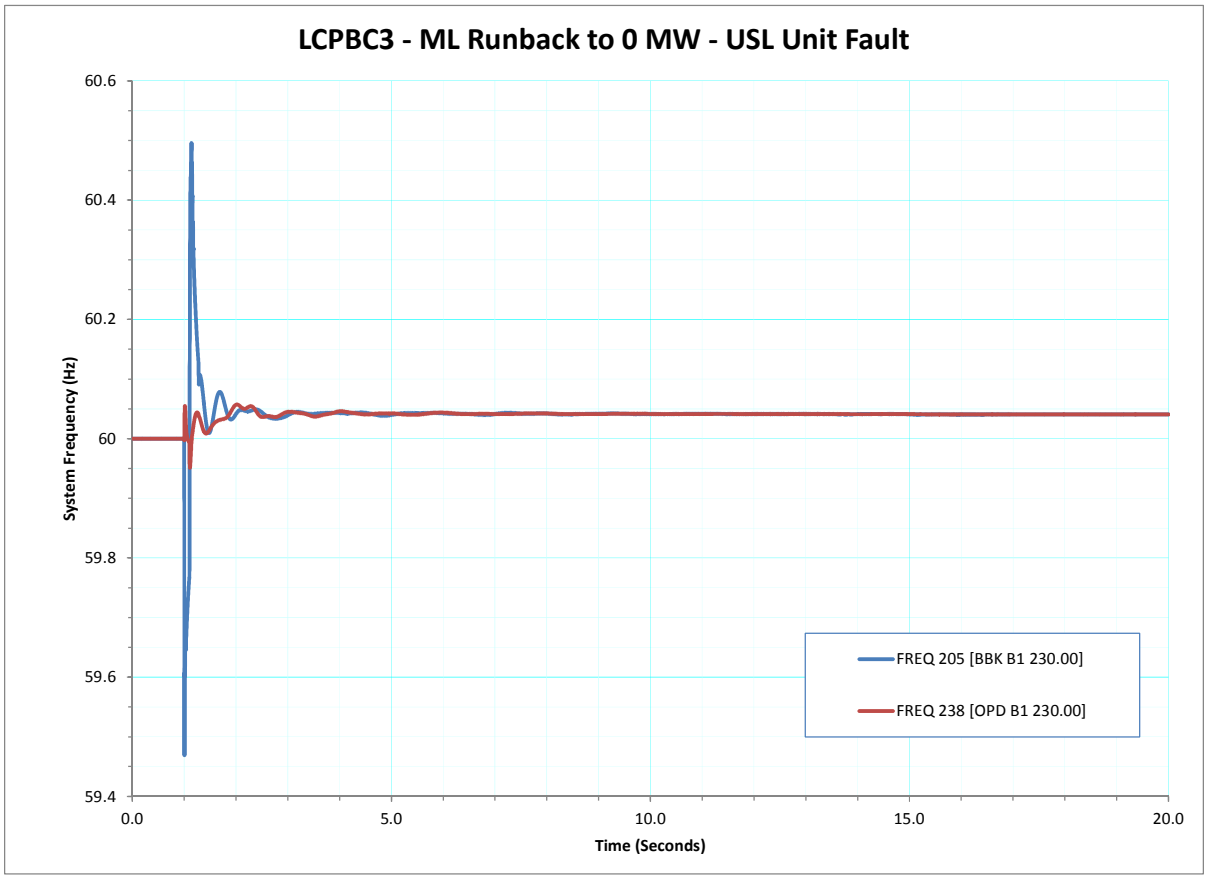

Figure 388 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - System Frequency (Hz)

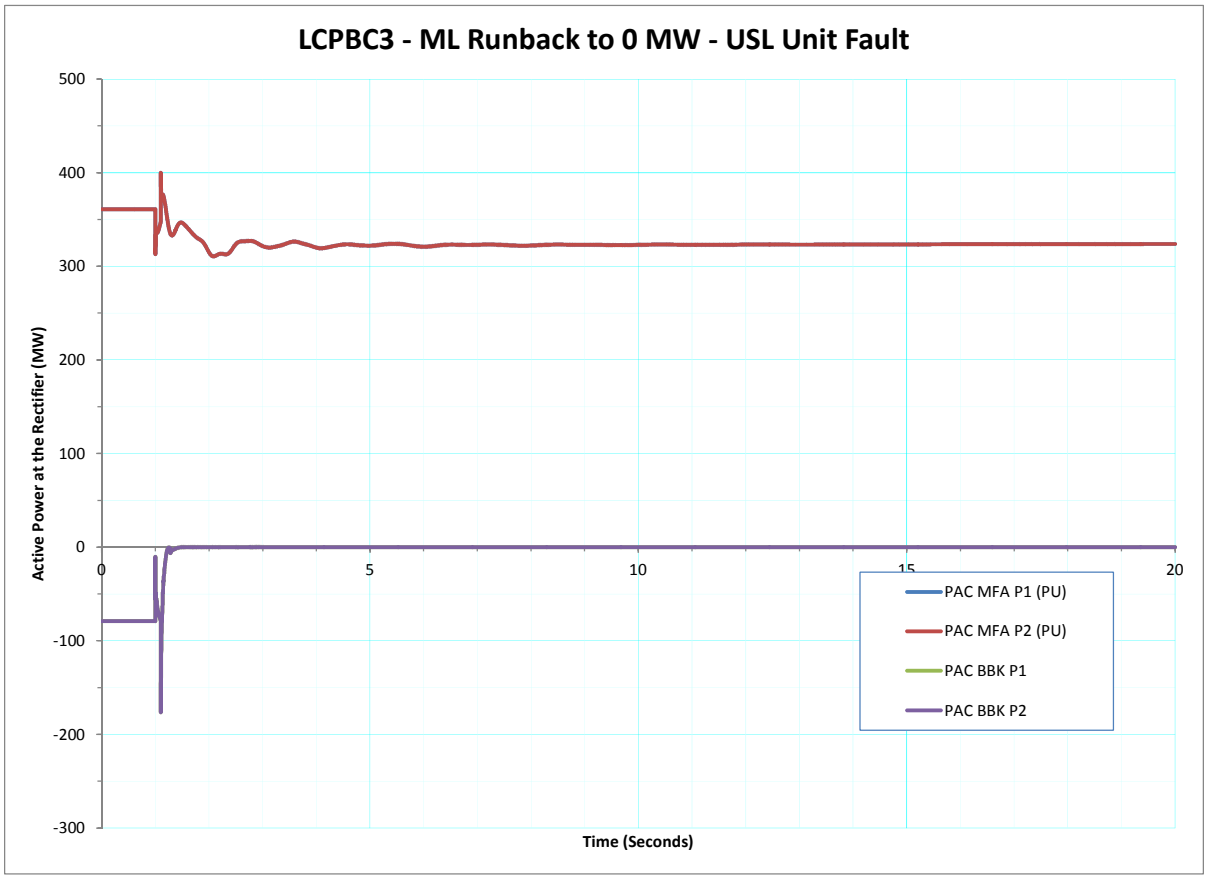

Figure 389 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - Active Power at the Rectifier (MW)

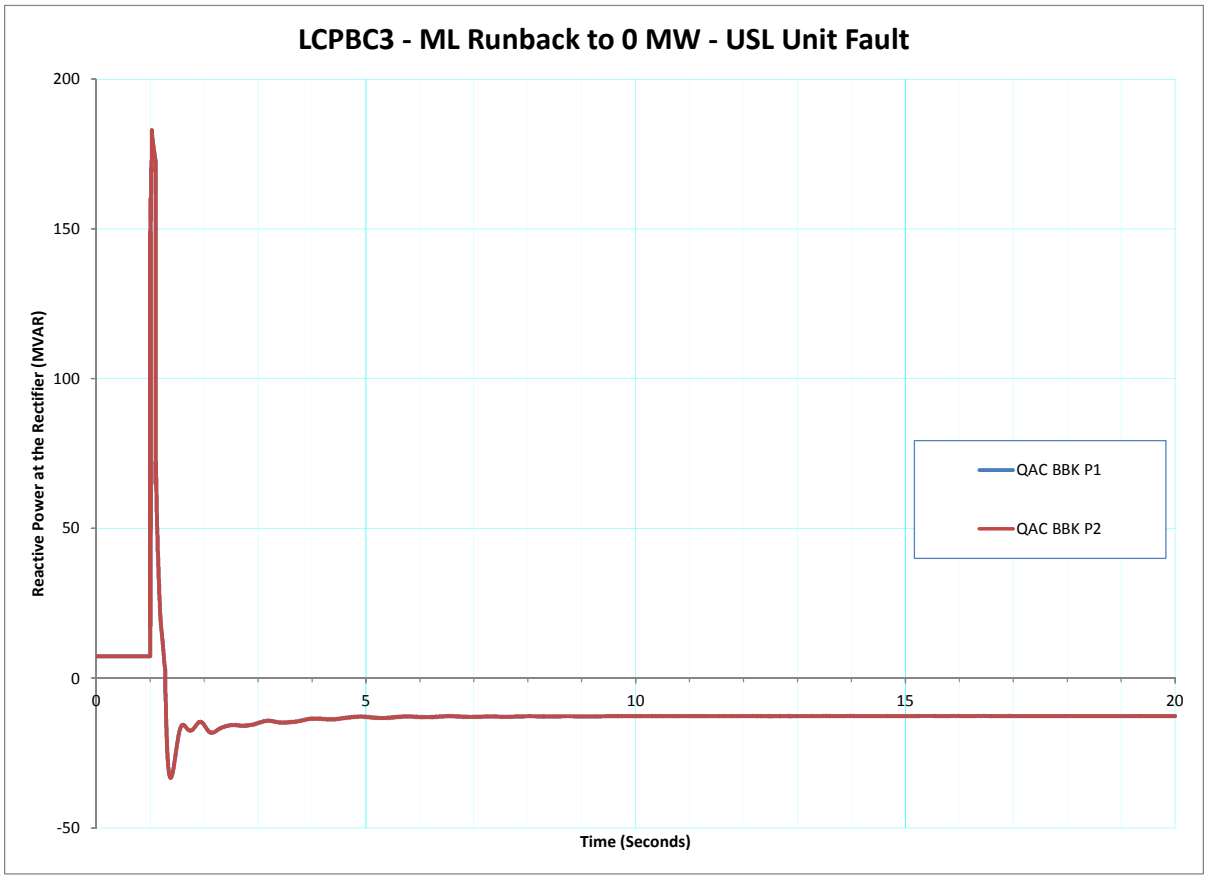

Figure 390 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

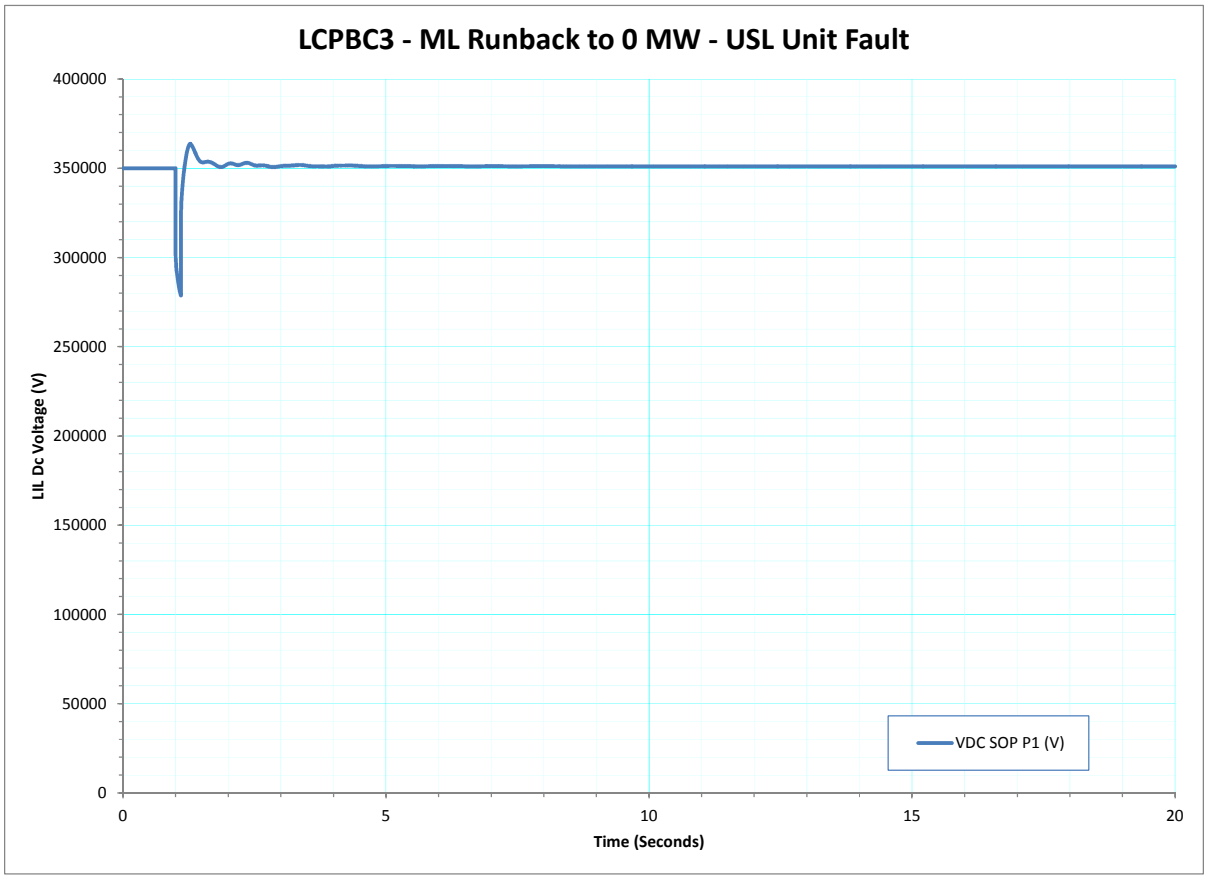

Figure 391 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - LIL Dc Voltage (V)

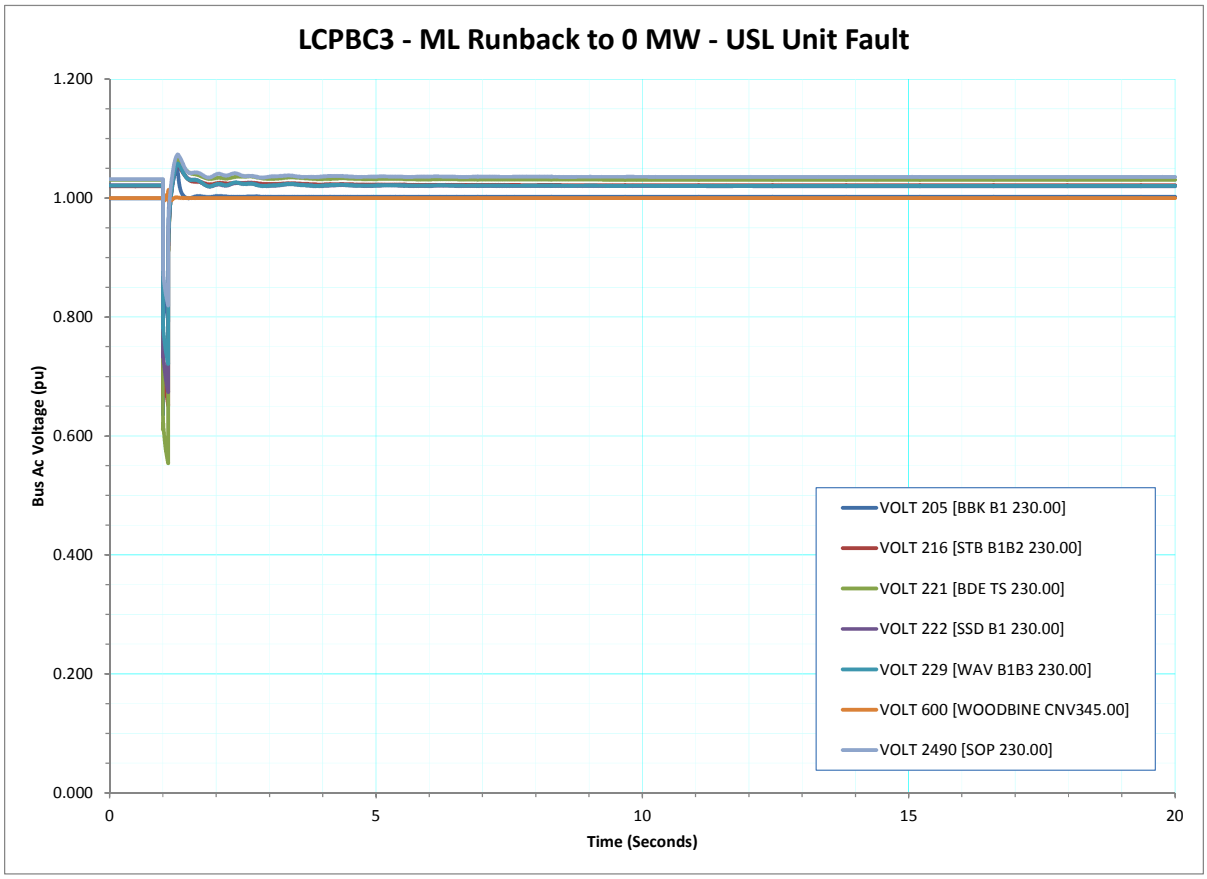

Figure 392 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - Bus Ac Voltage (pu)

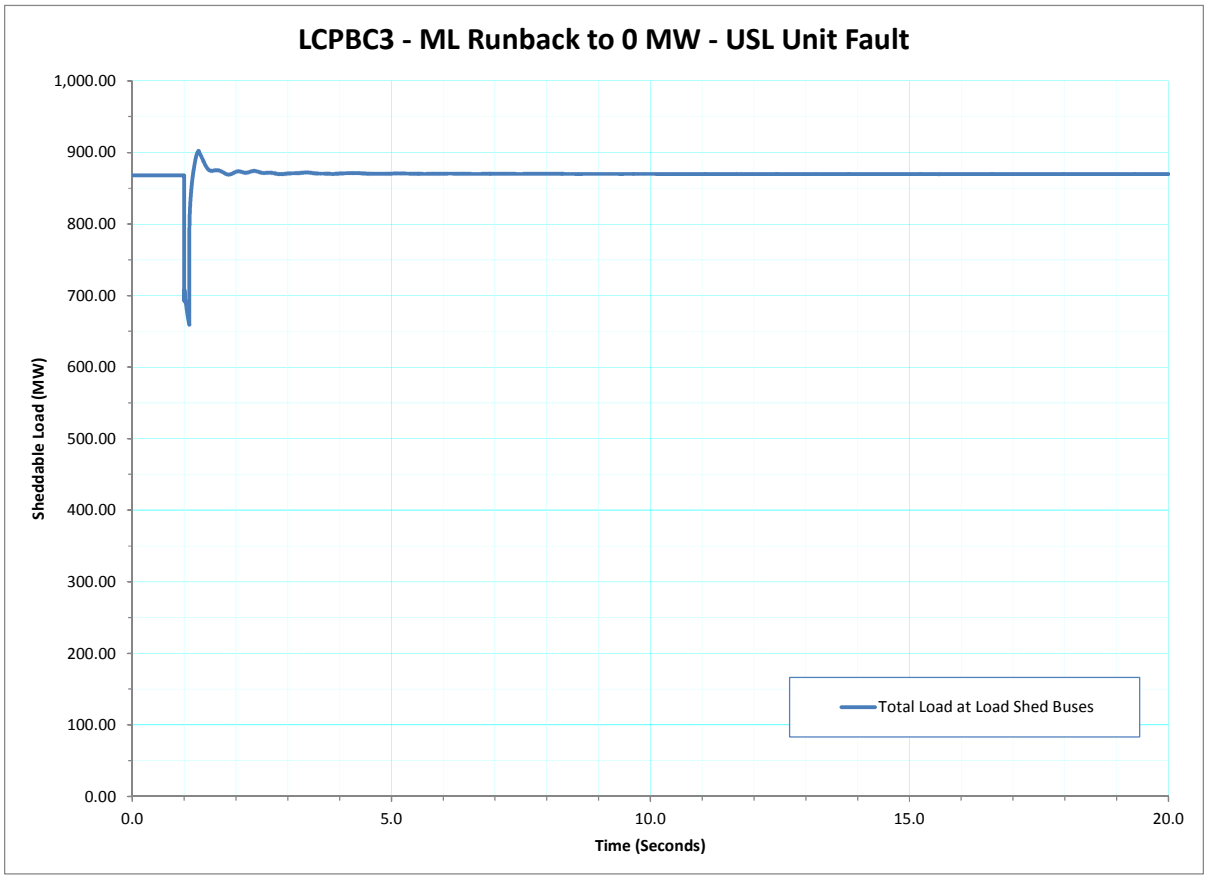

Figure 393 - LCPBC3 - ML Runback to 0 MW - USL Unit Fault - Sheddable Load (MW)

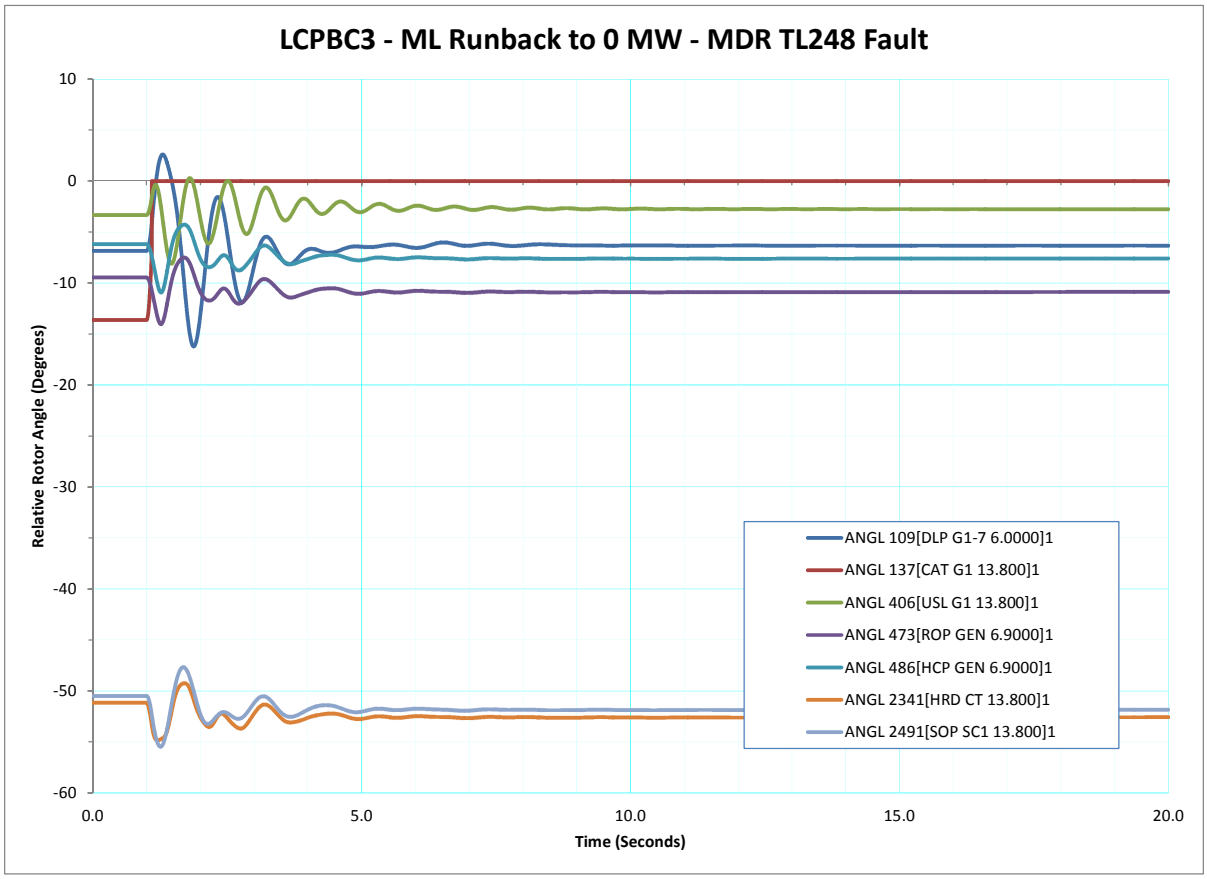

Figure 394 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

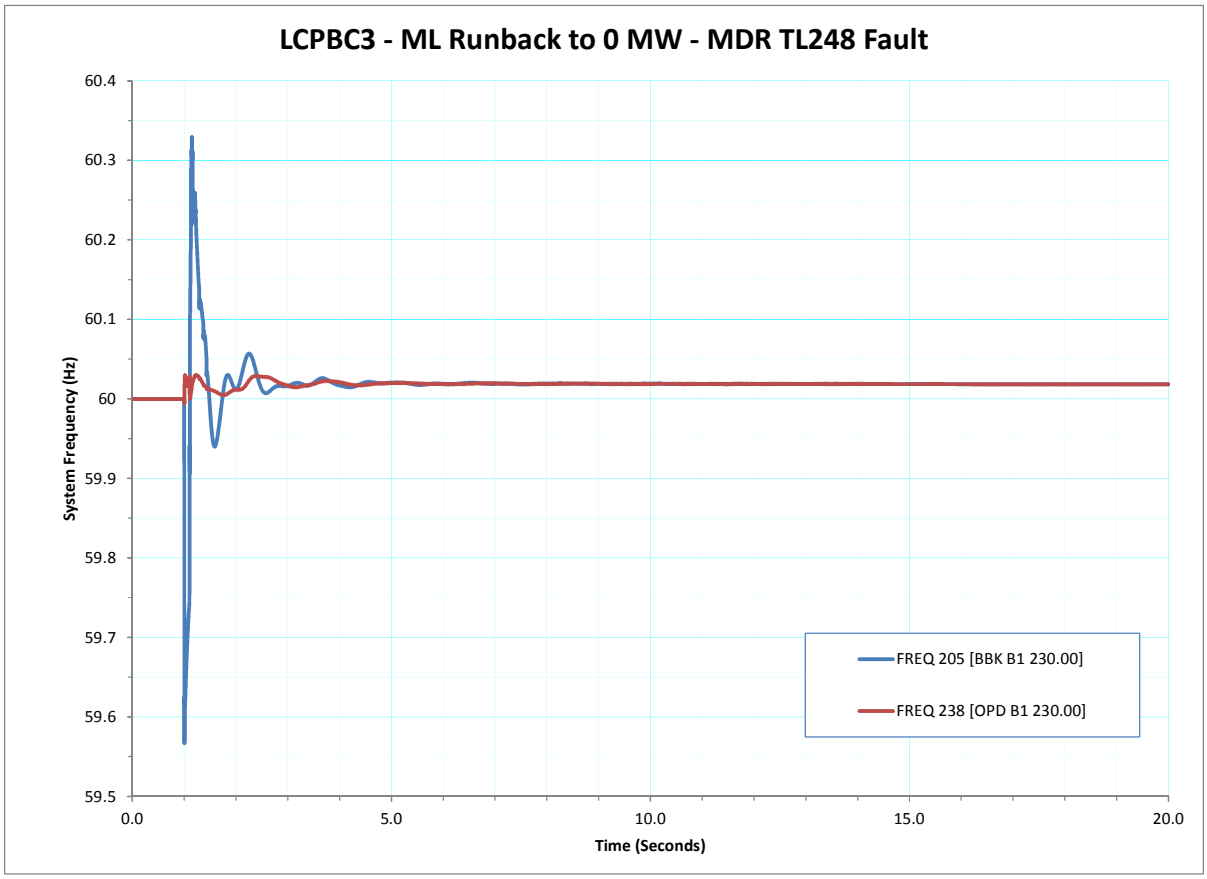

Figure 395 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - System Frequency (Hz)

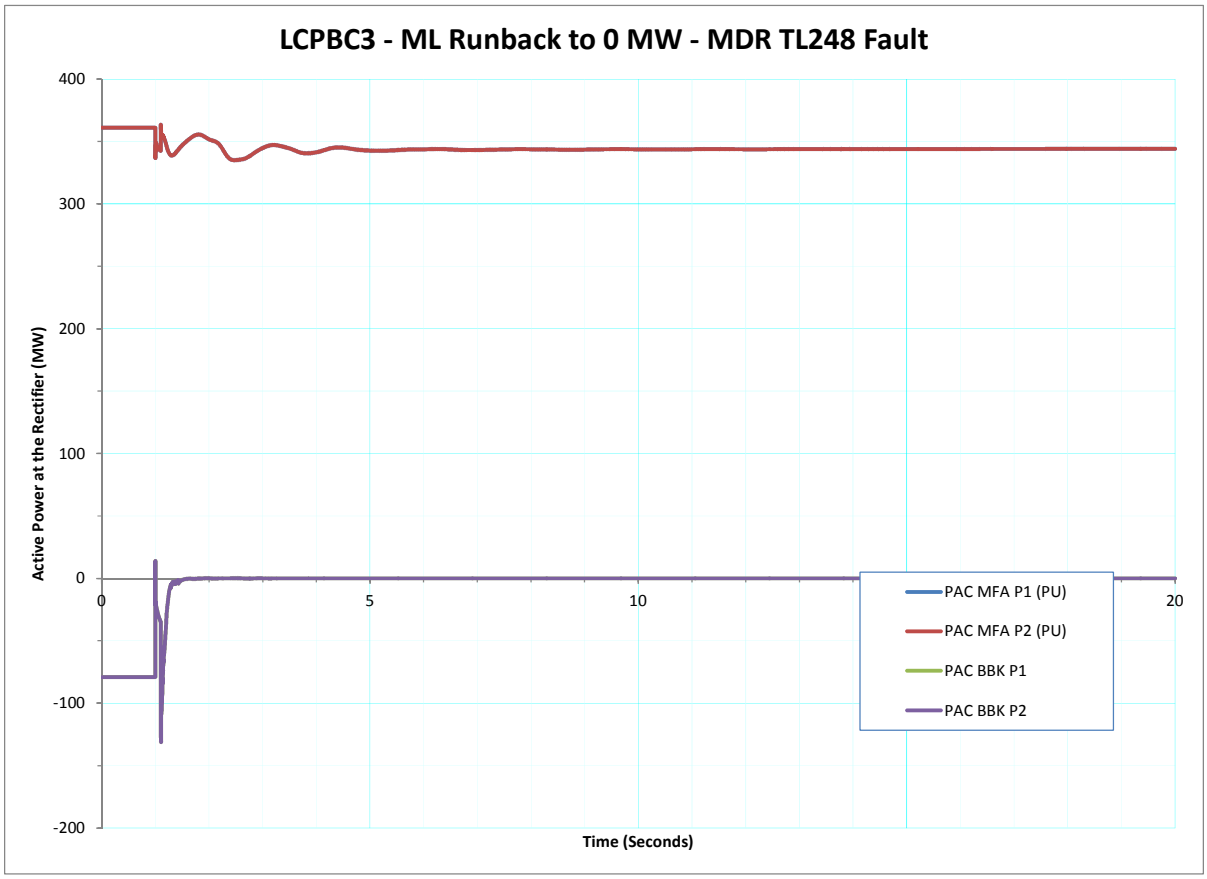

Figure 396 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

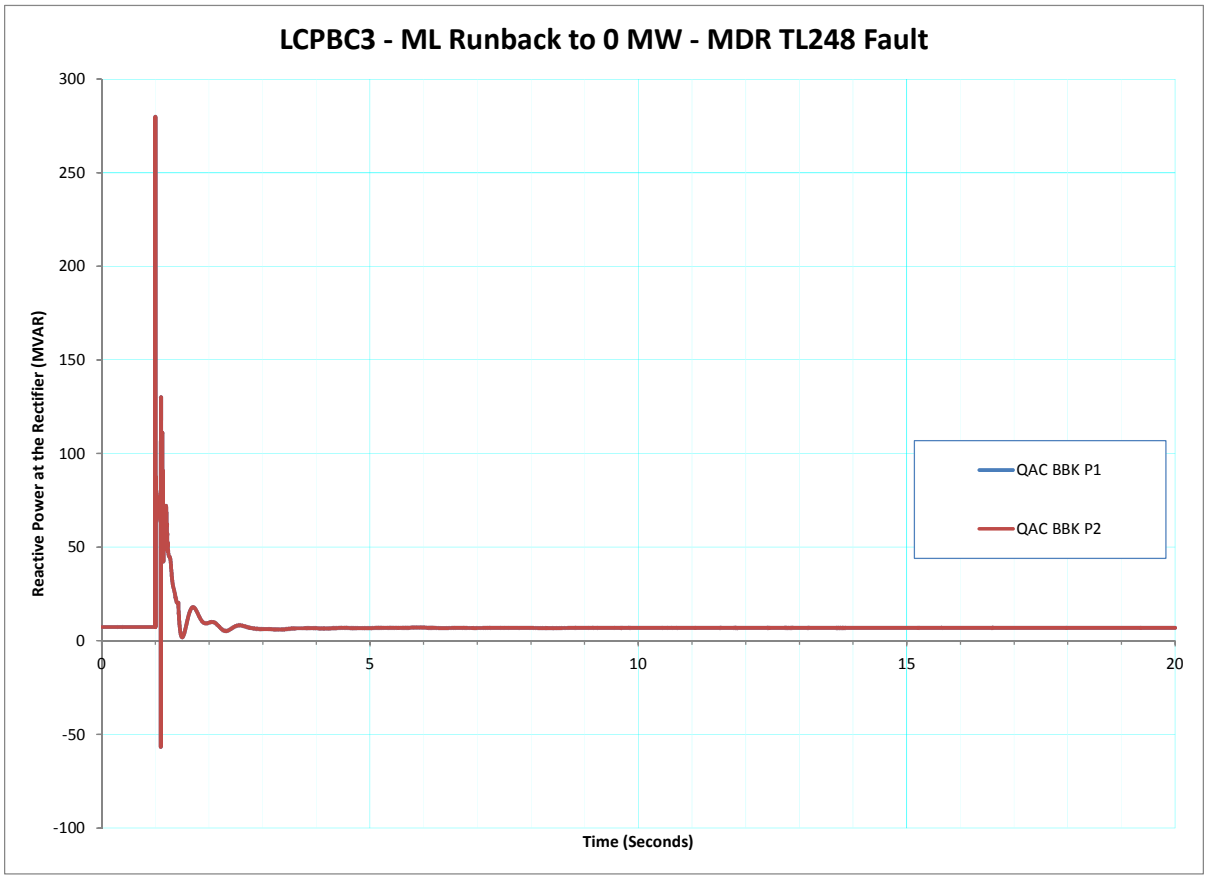

Figure 397 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

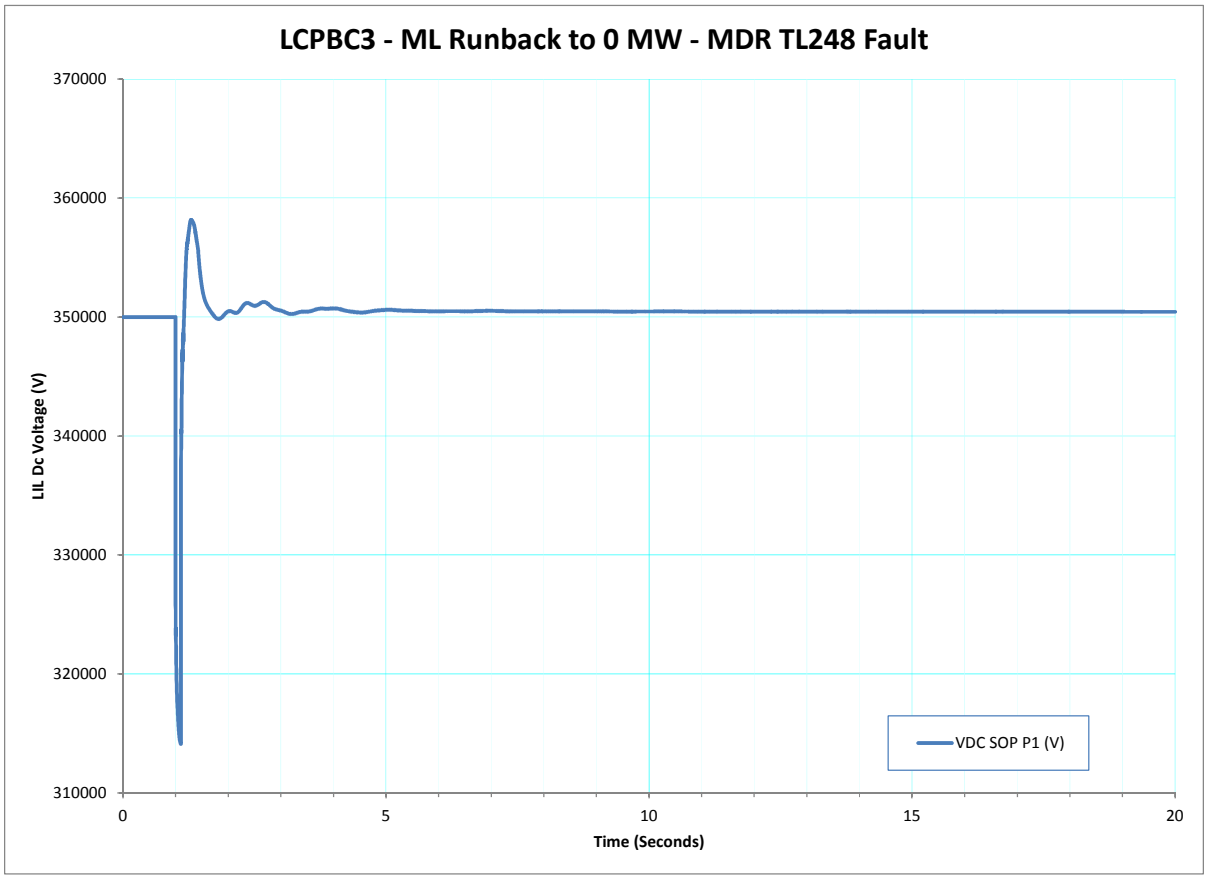

Figure 398 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - LIL Dc Voltage (V)

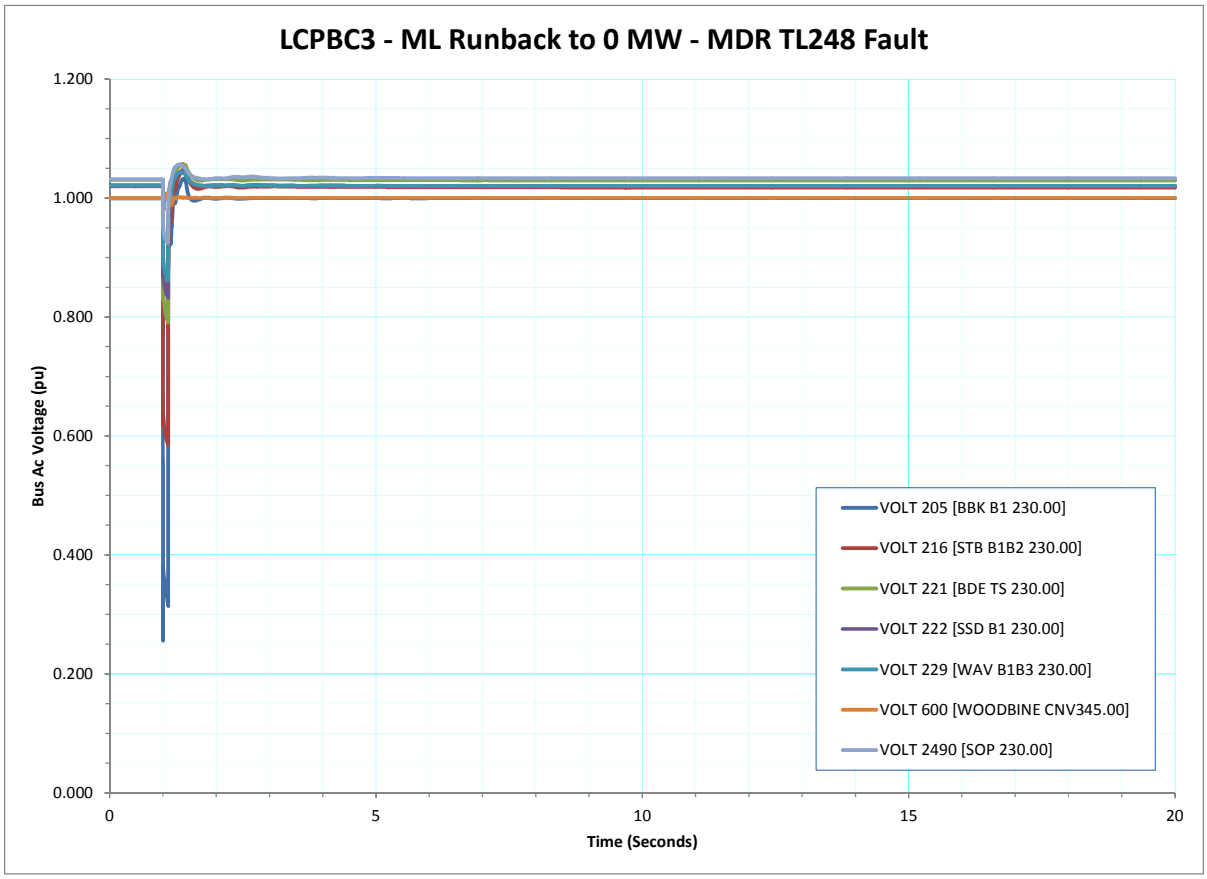

Figure 399 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

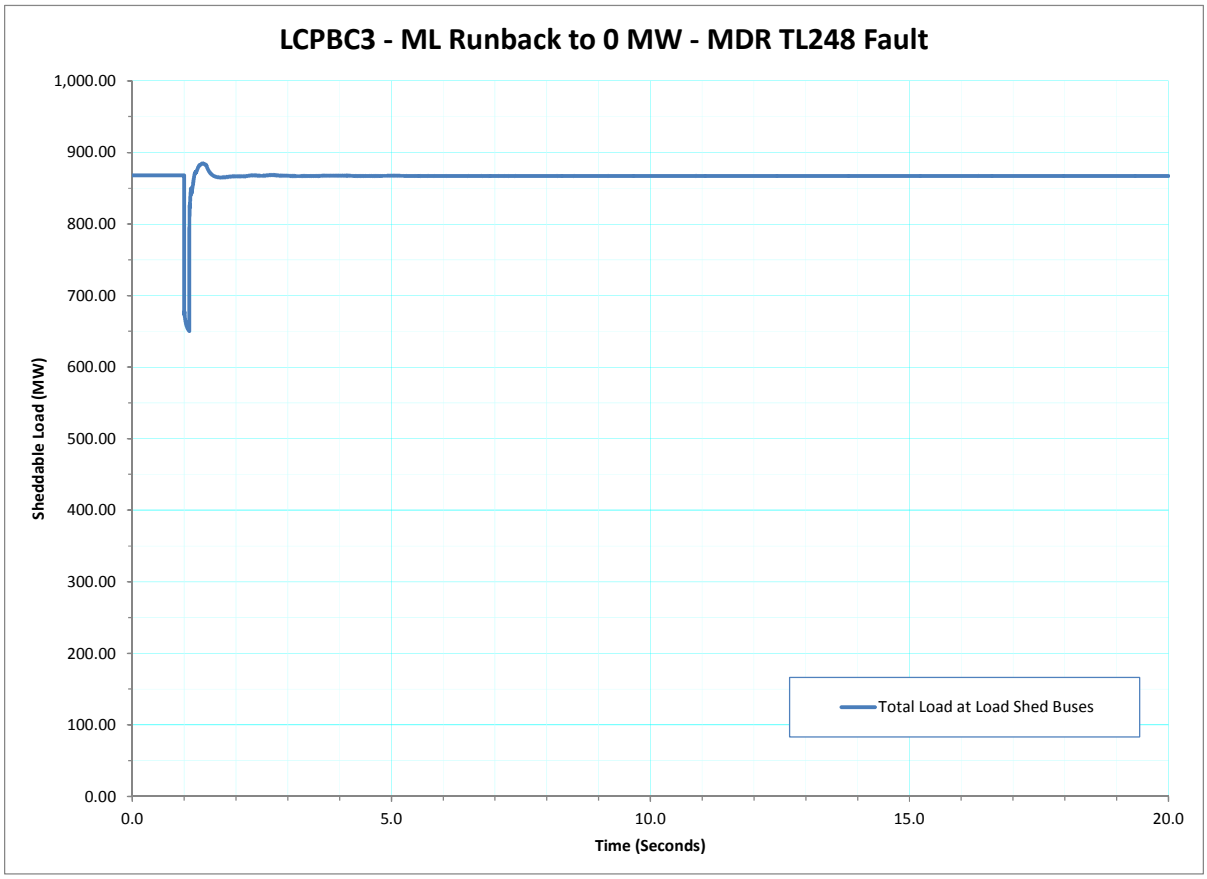

Figure 400 - LCPBC3 - ML Runback to 0 MW - MDR TL248 Fault - Sheddable Load (MW)

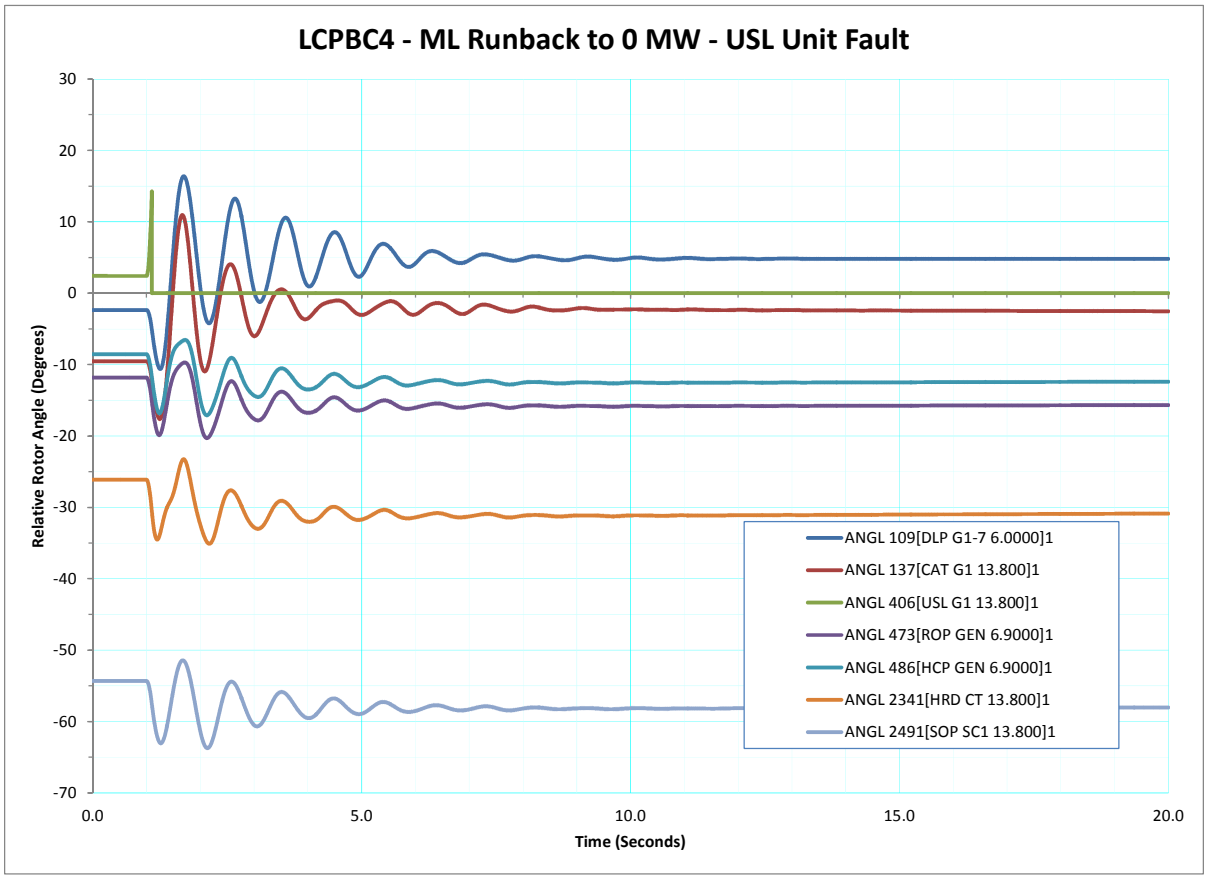

Figure 401 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

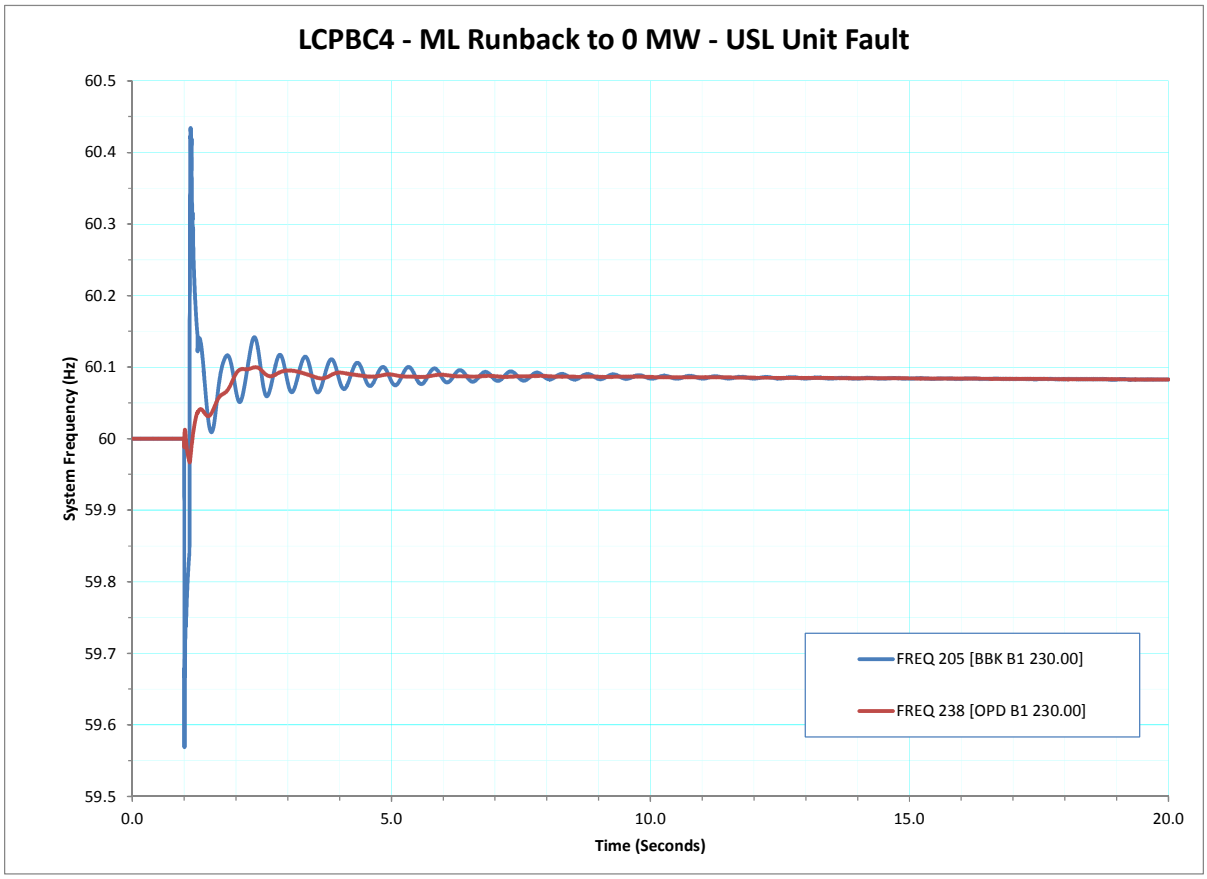

Figure 402 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - System Frequency (Hz)

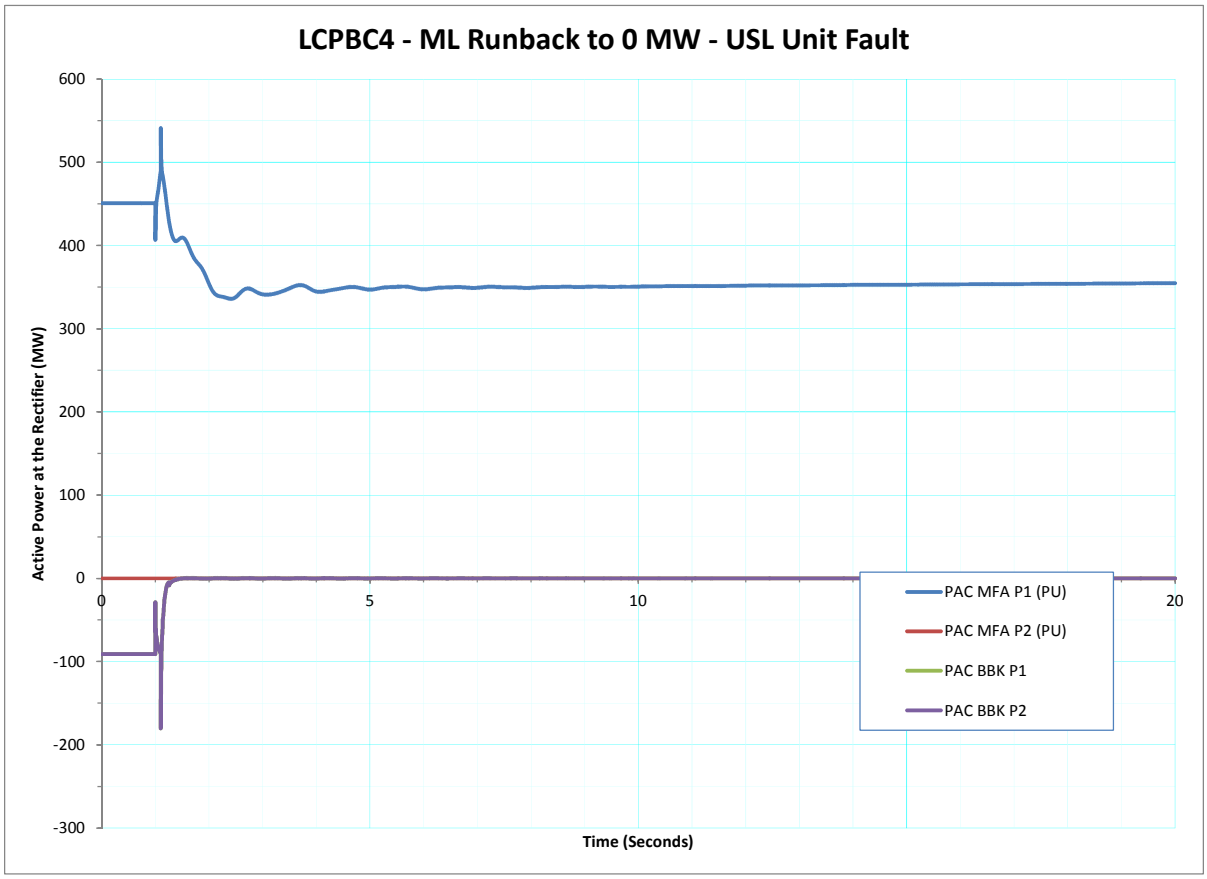

Figure 403 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - Active Power at the Rectifier (MW)

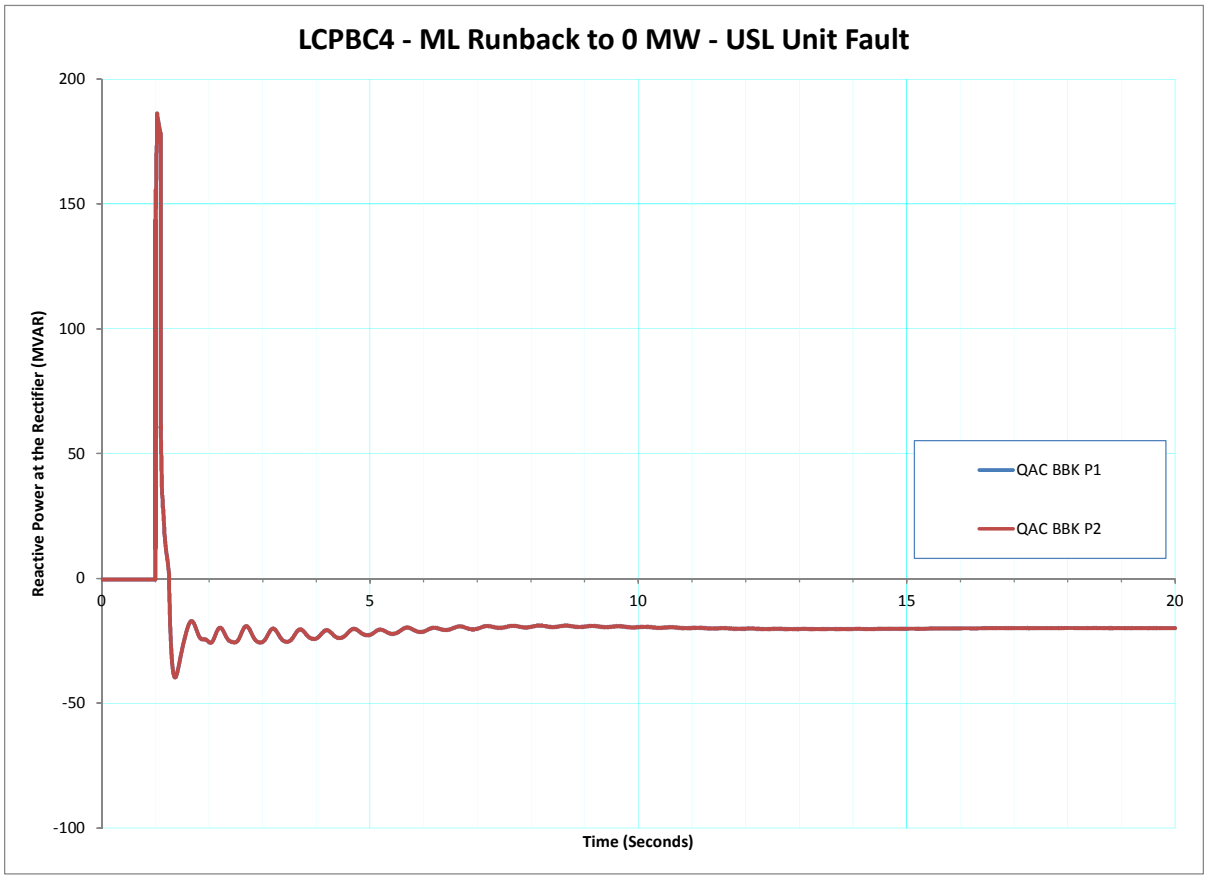

Figure 404 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

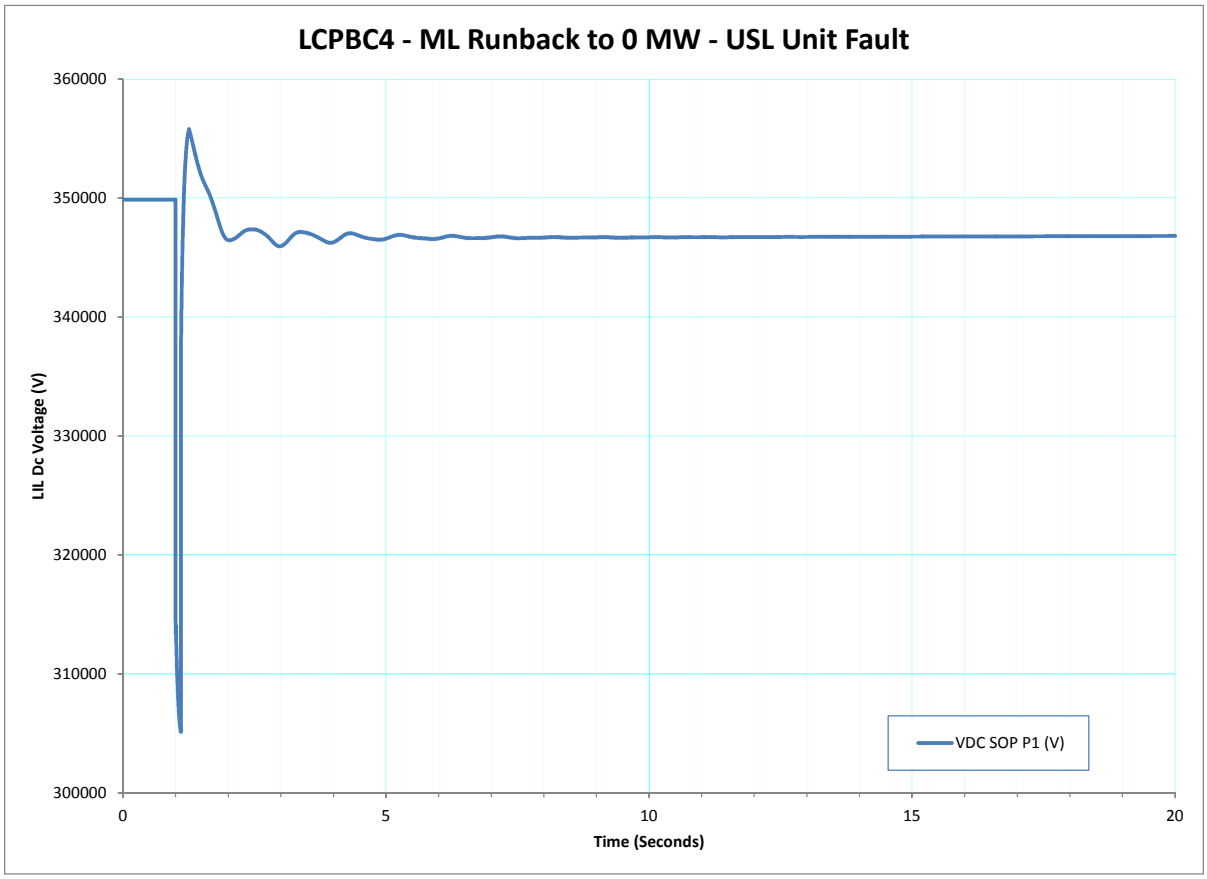

Figure 405 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - LIL Dc Voltage (V)

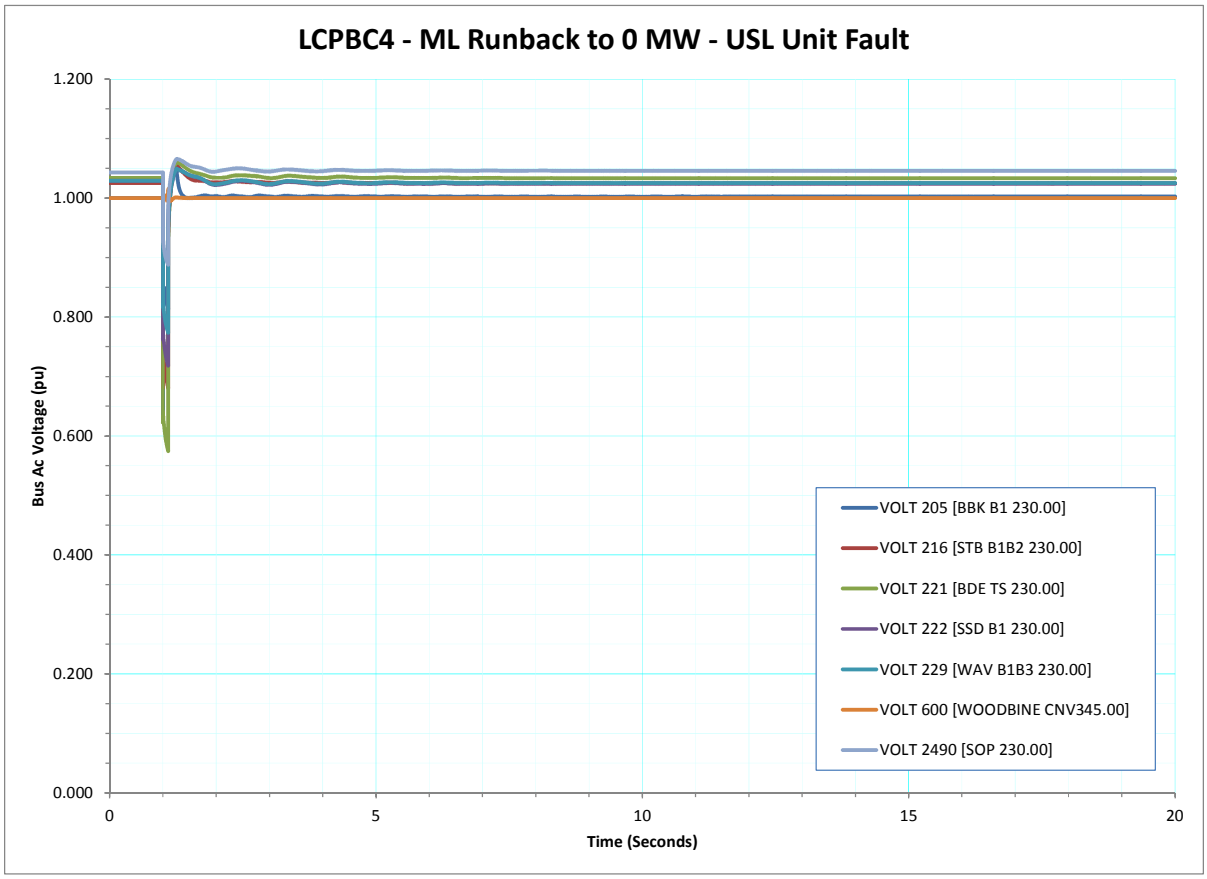

Figure 406 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - Bus Ac Voltage (pu)

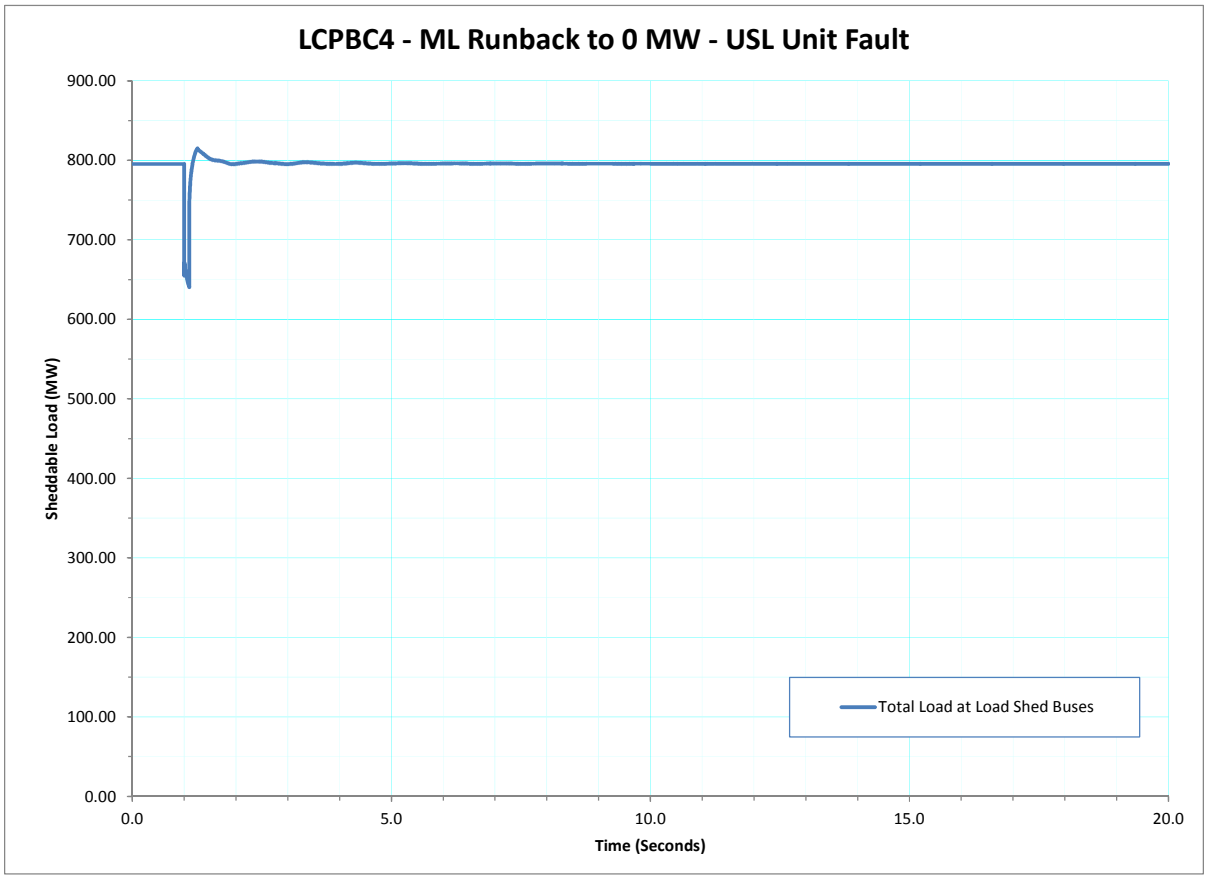

Figure 407 - LCPBC4 - ML Runback to 0 MW - USL Unit Fault - Sheddable Load (MW)

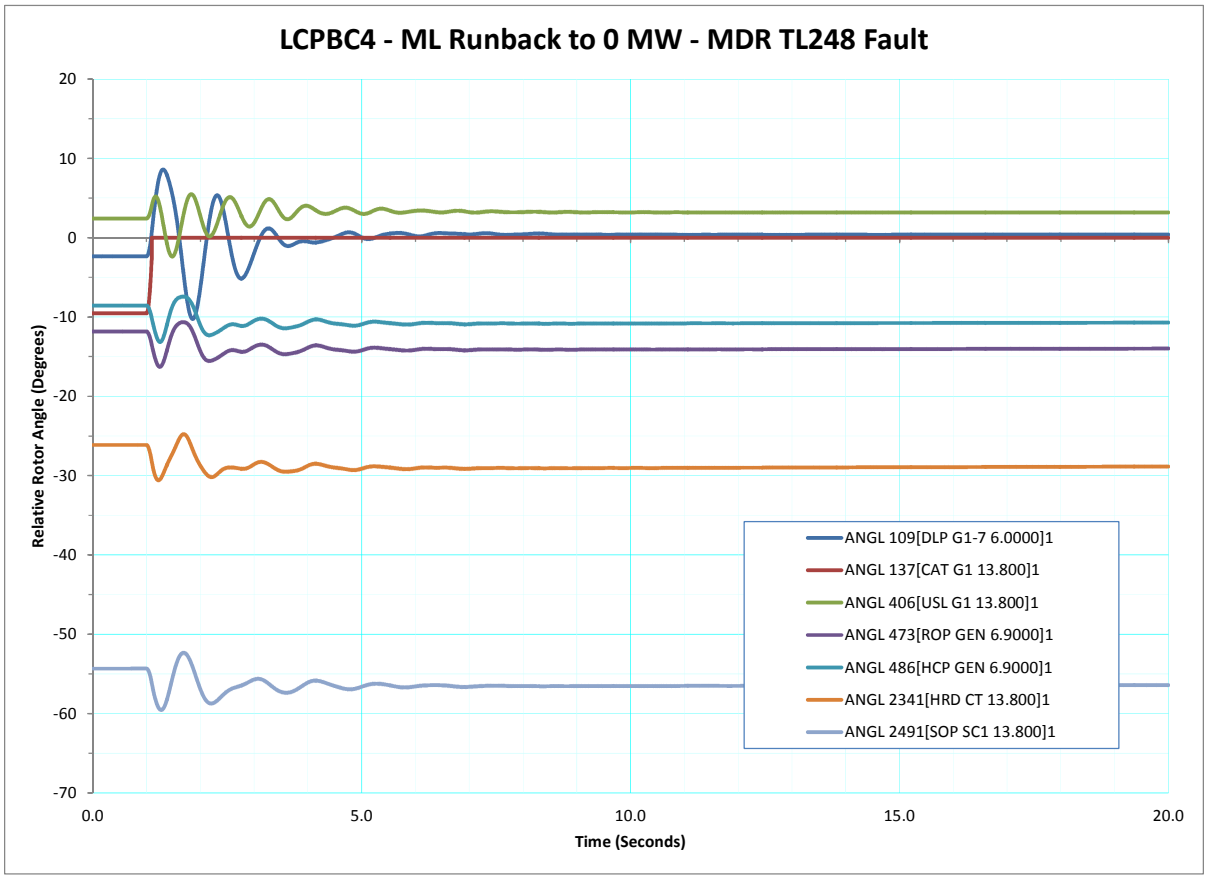

Figure 408 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

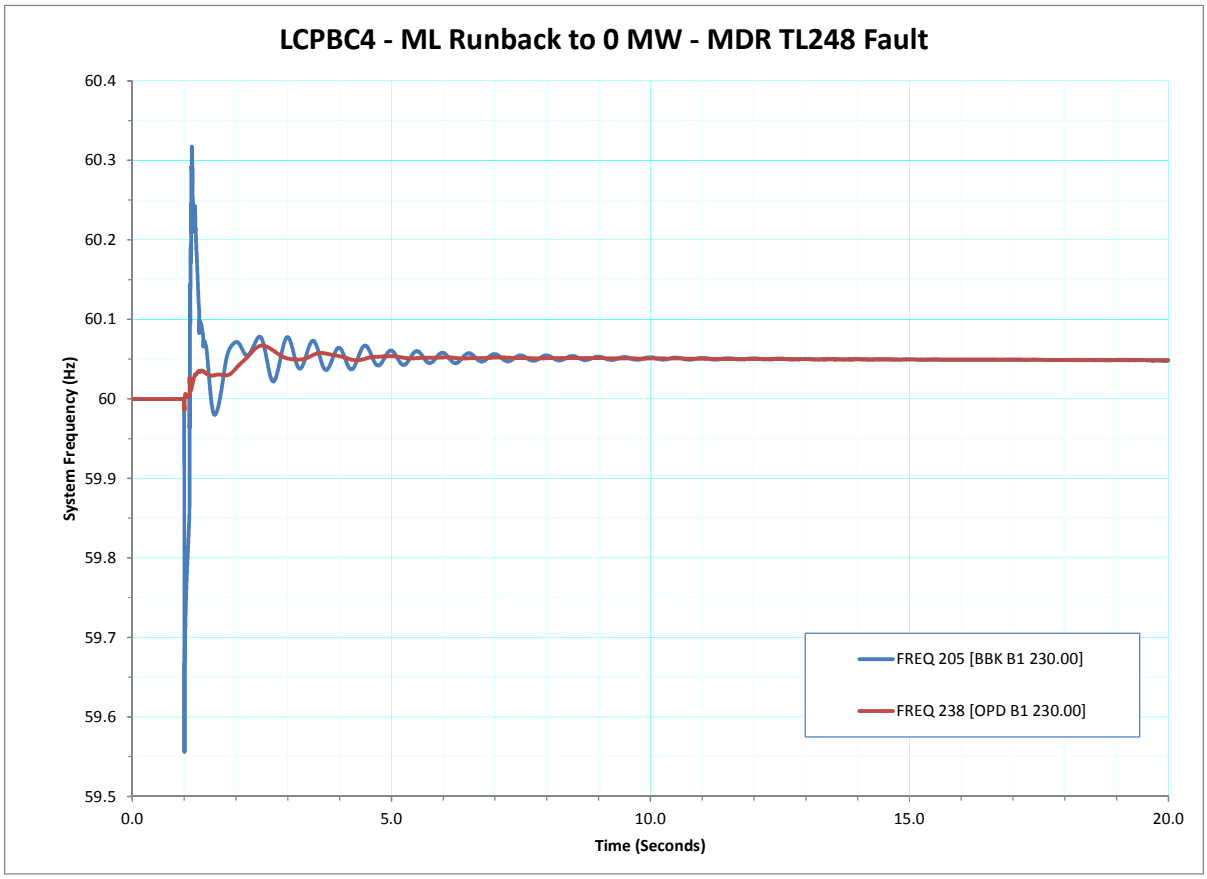

Figure 409 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - System Frequency (Hz)

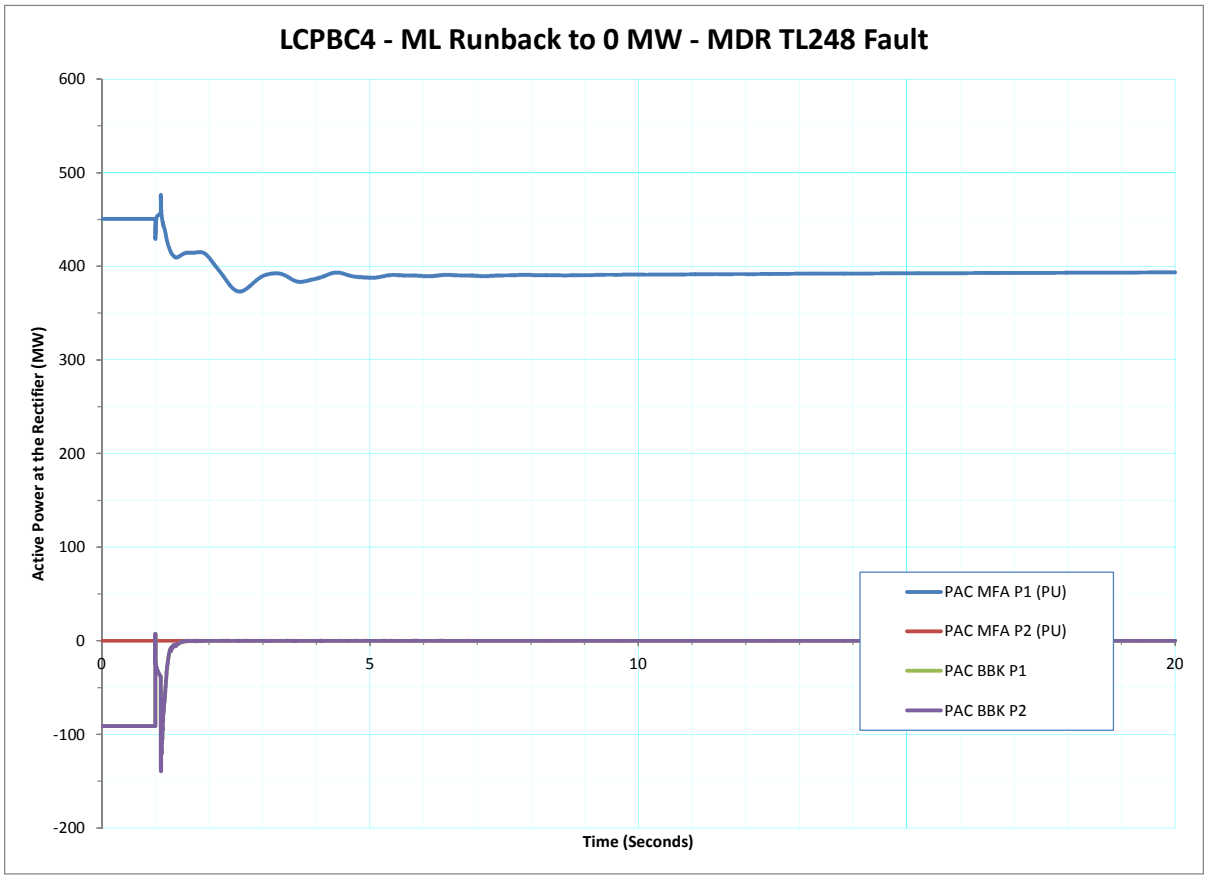

Figure 410 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

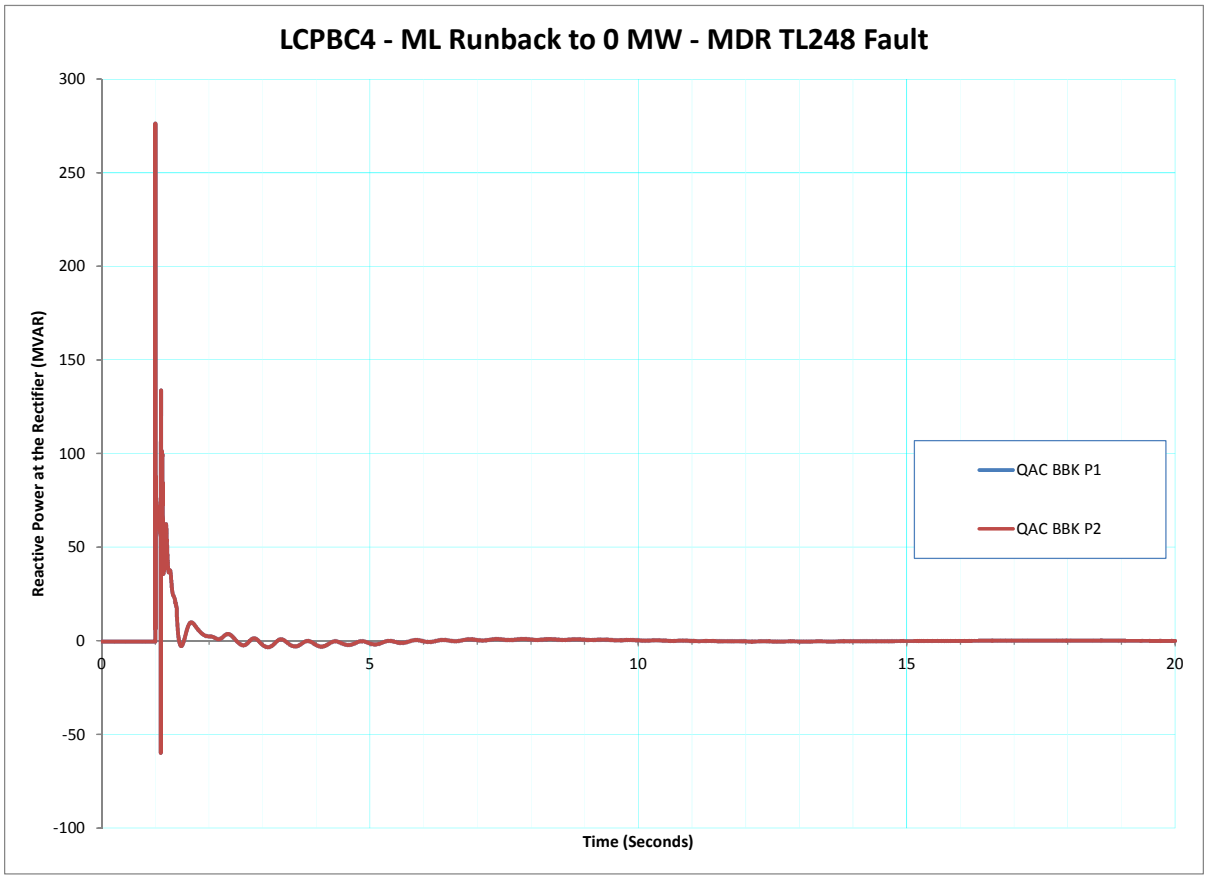

Figure 411 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

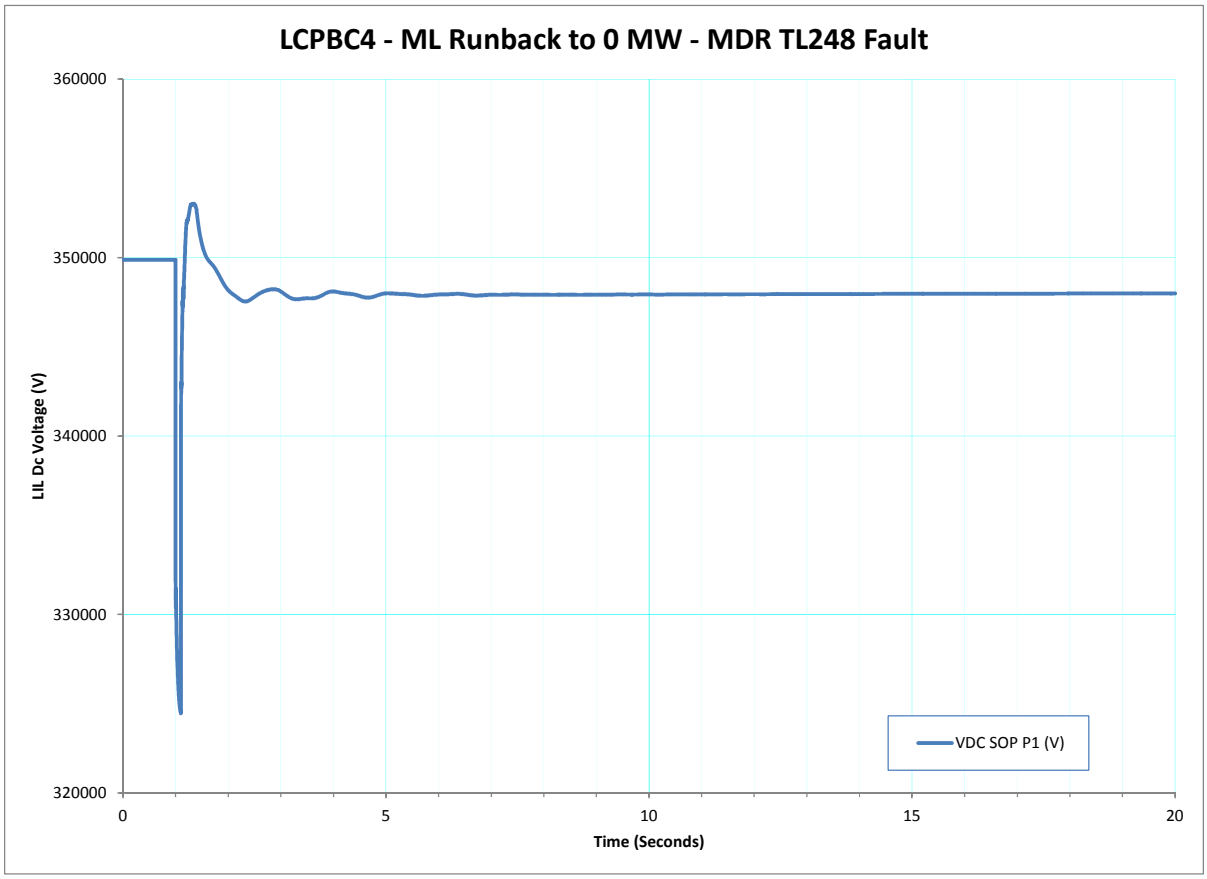

Figure 412 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - LIL Dc Voltage (V)

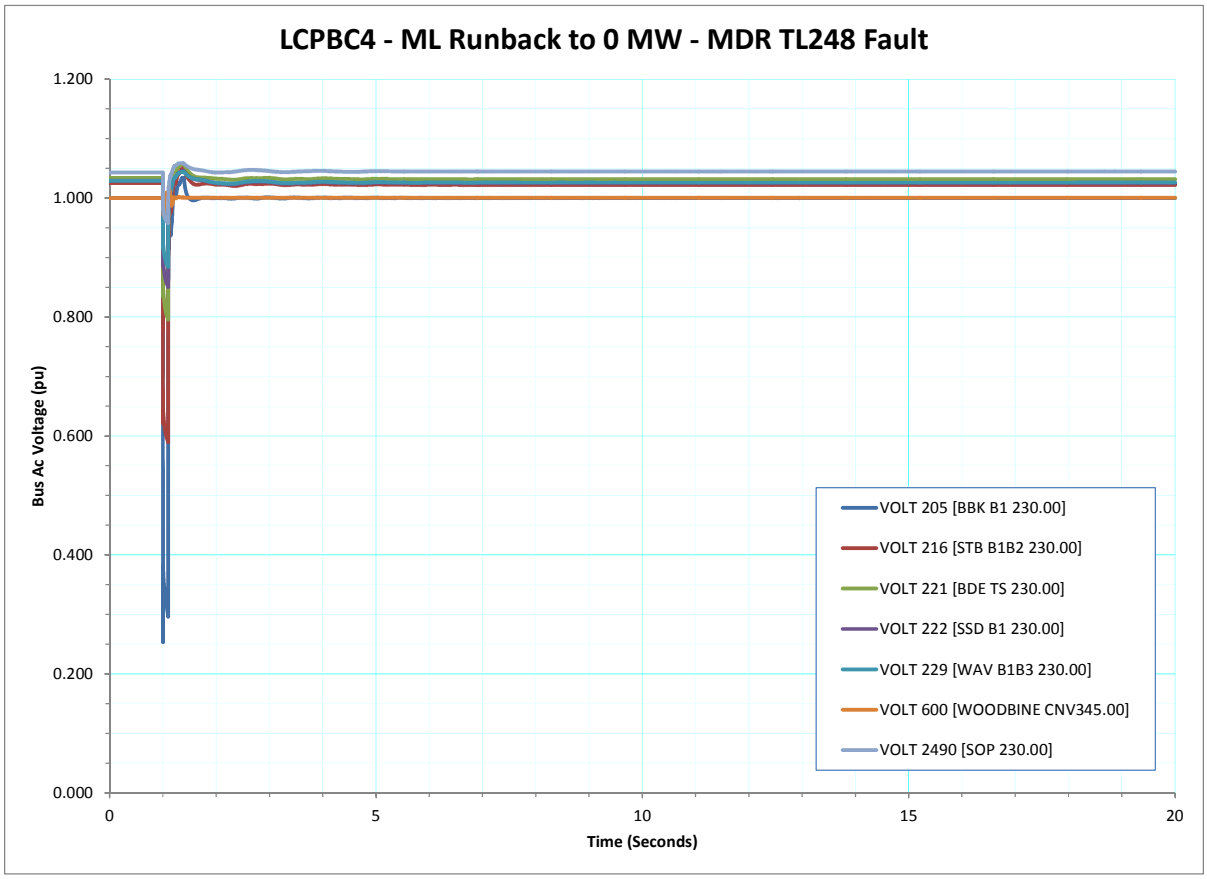

Figure 413 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

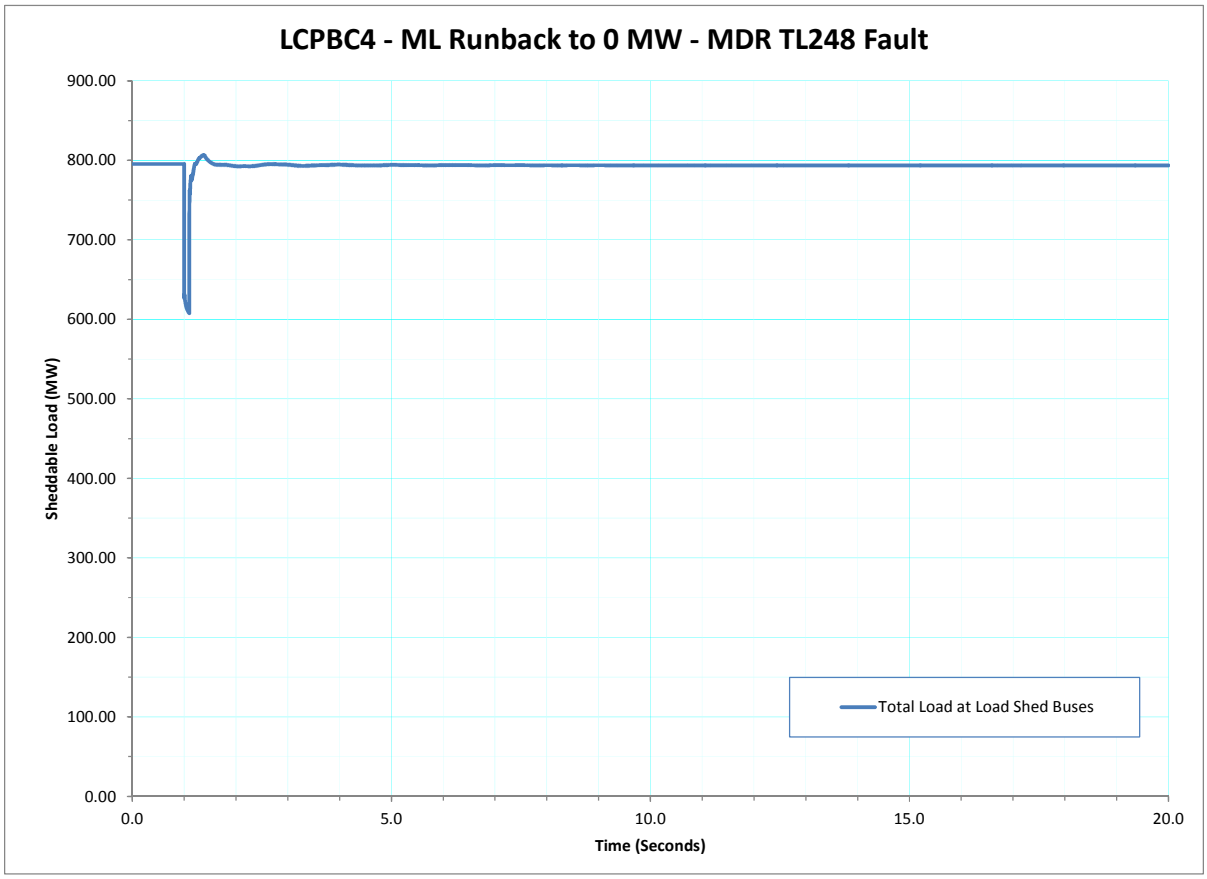

Figure 414 - LCPBC4 - ML Runback to 0 MW - MDR TL248 Fault - Sheddable Load (MW)

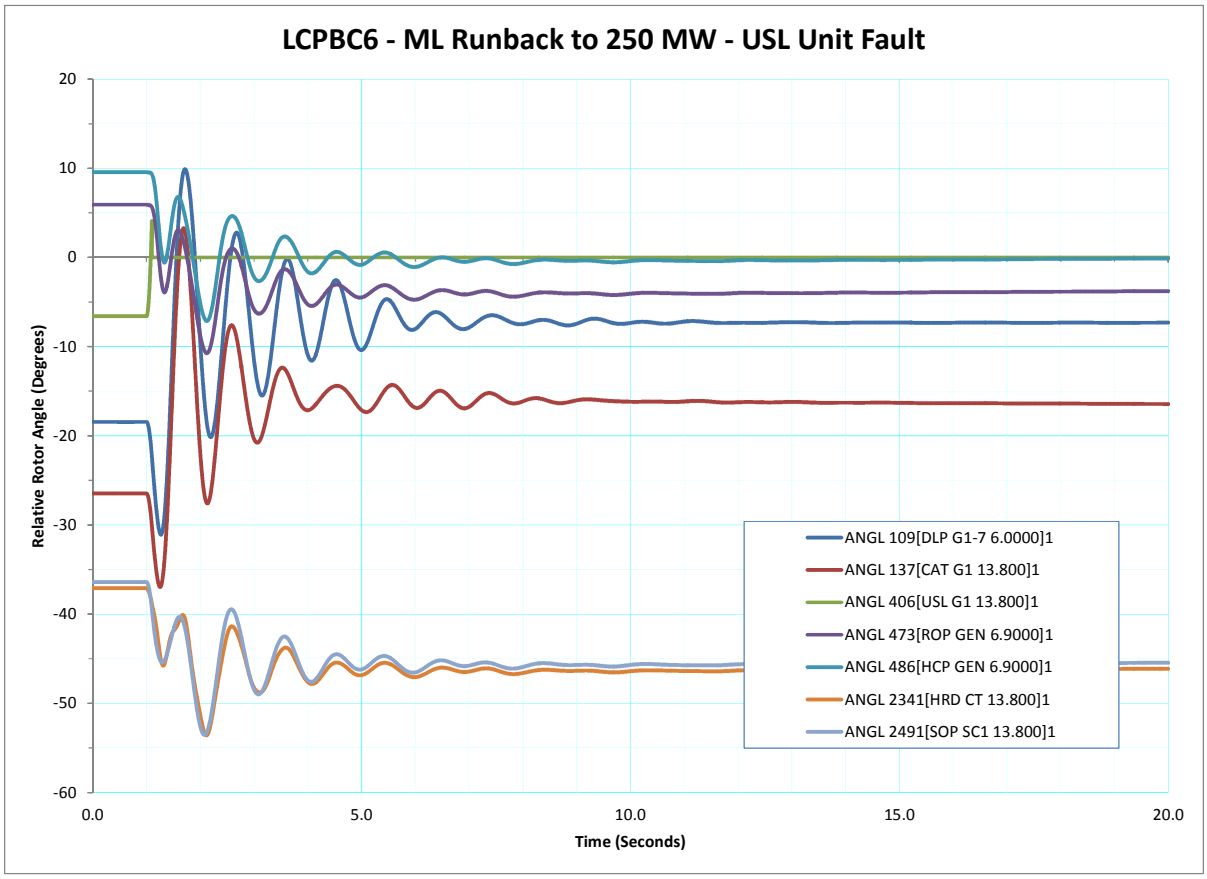

Figure 415 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

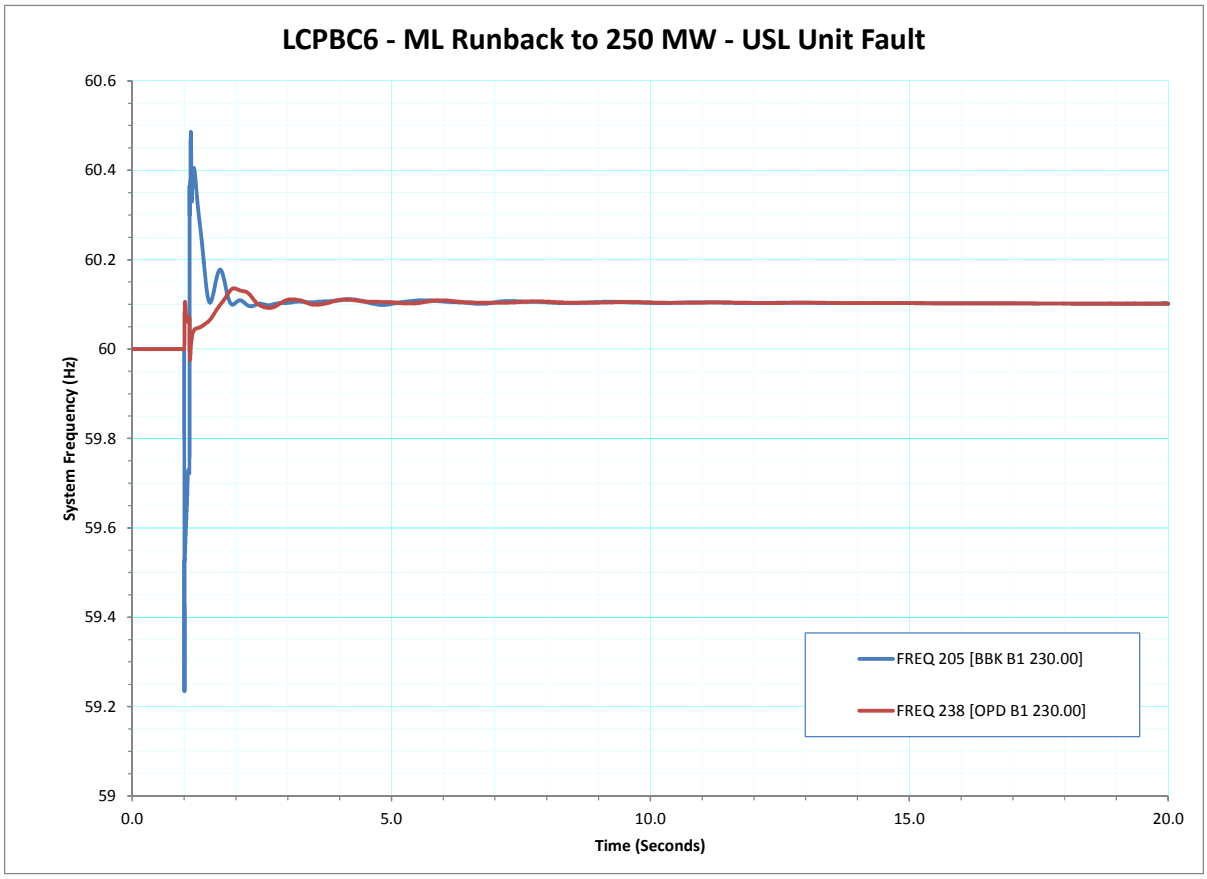

Figure 416 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - System Frequency (Hz)

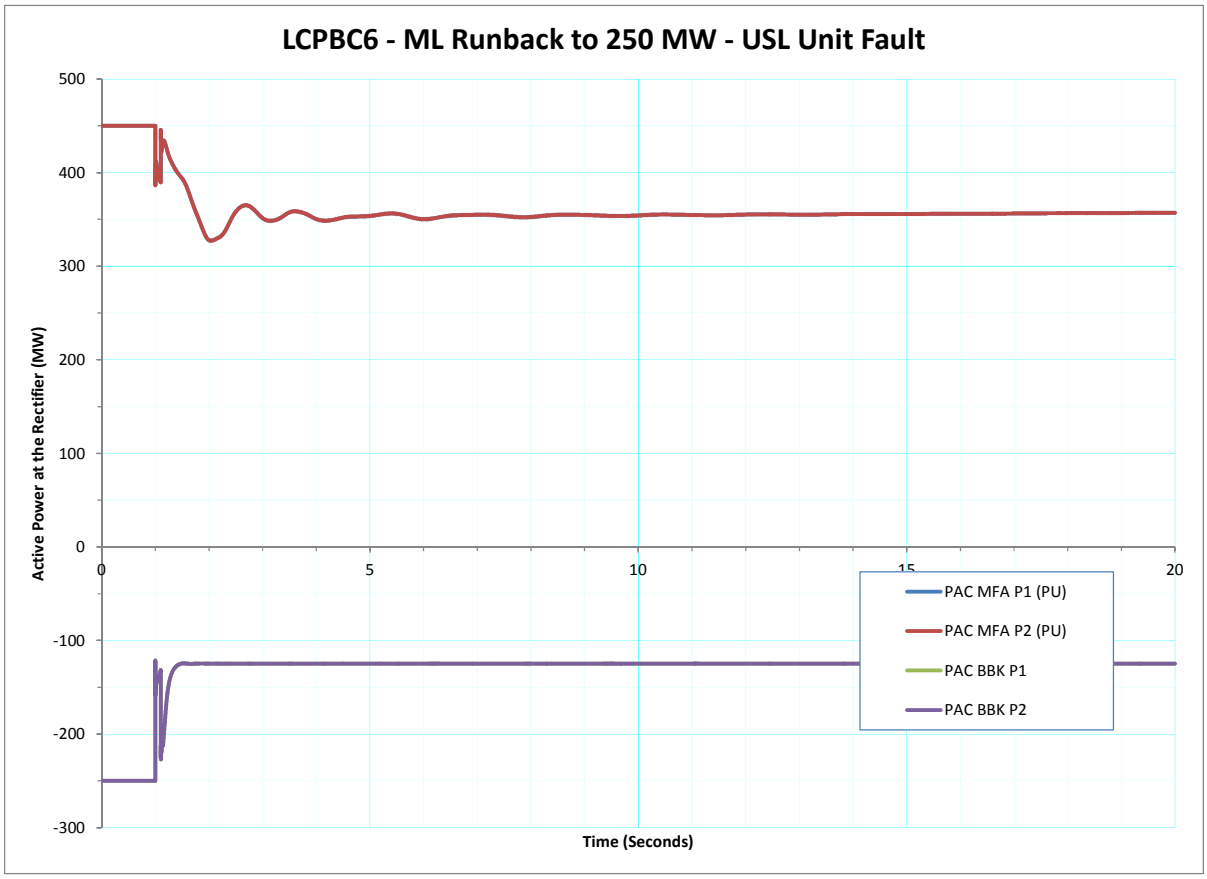

Figure 417 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - Active Power at the Rectifier (MW)

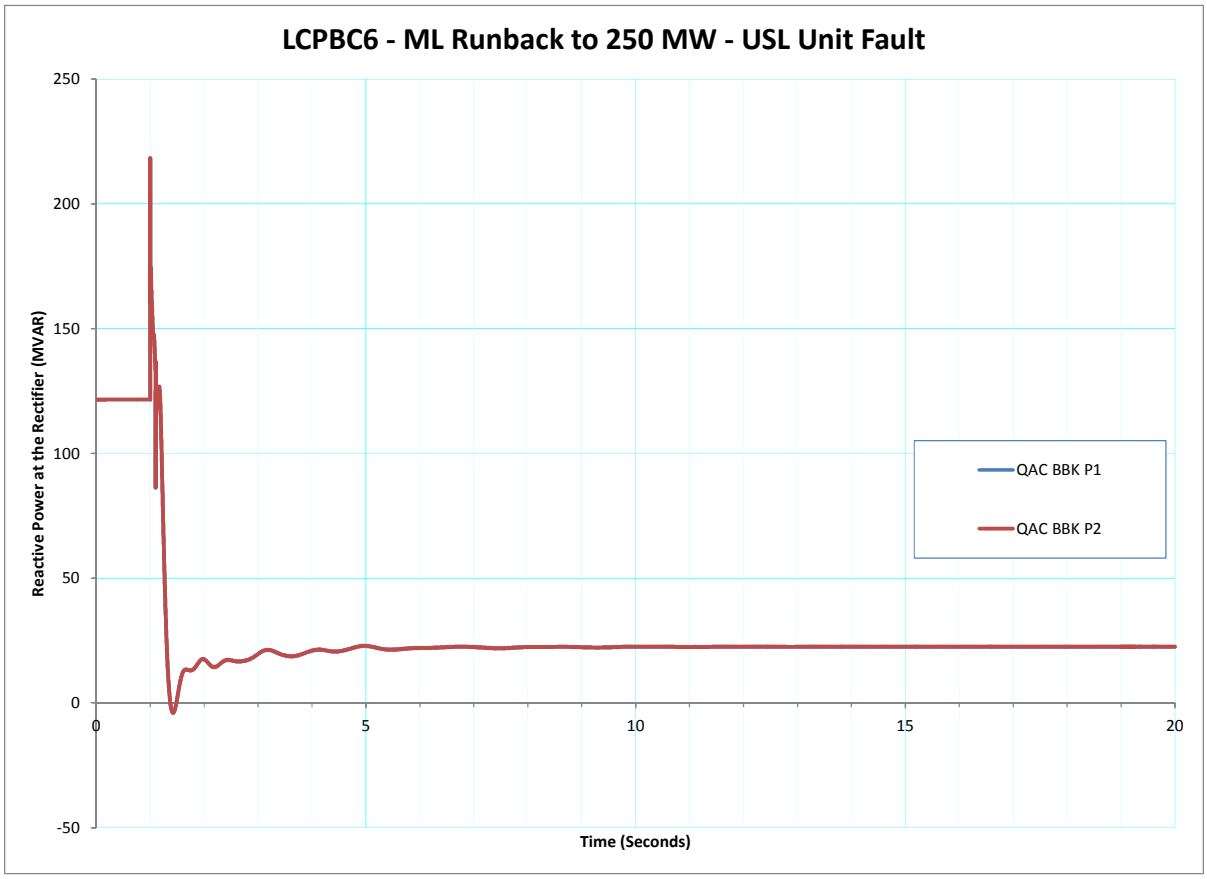

Figure 418 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

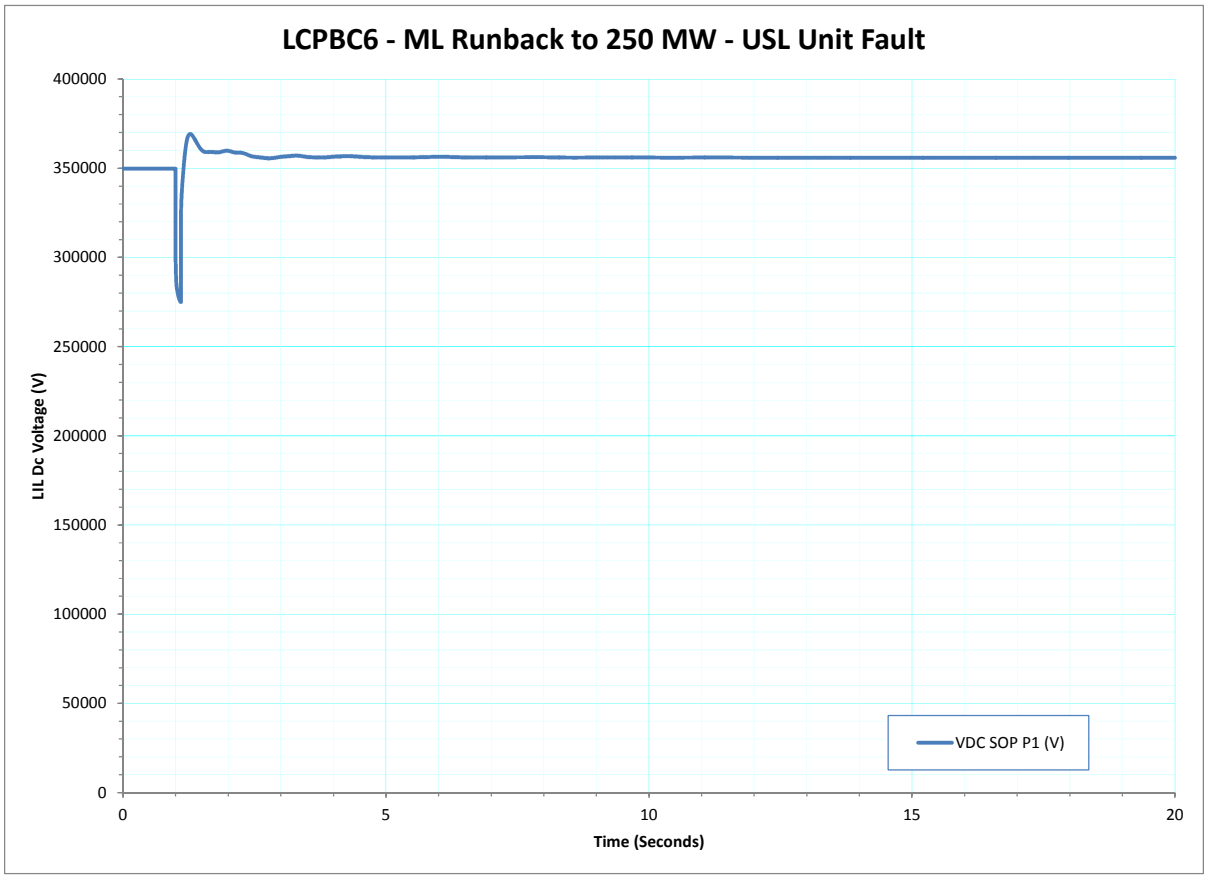

Figure 419 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - LIL Dc Voltage (V)

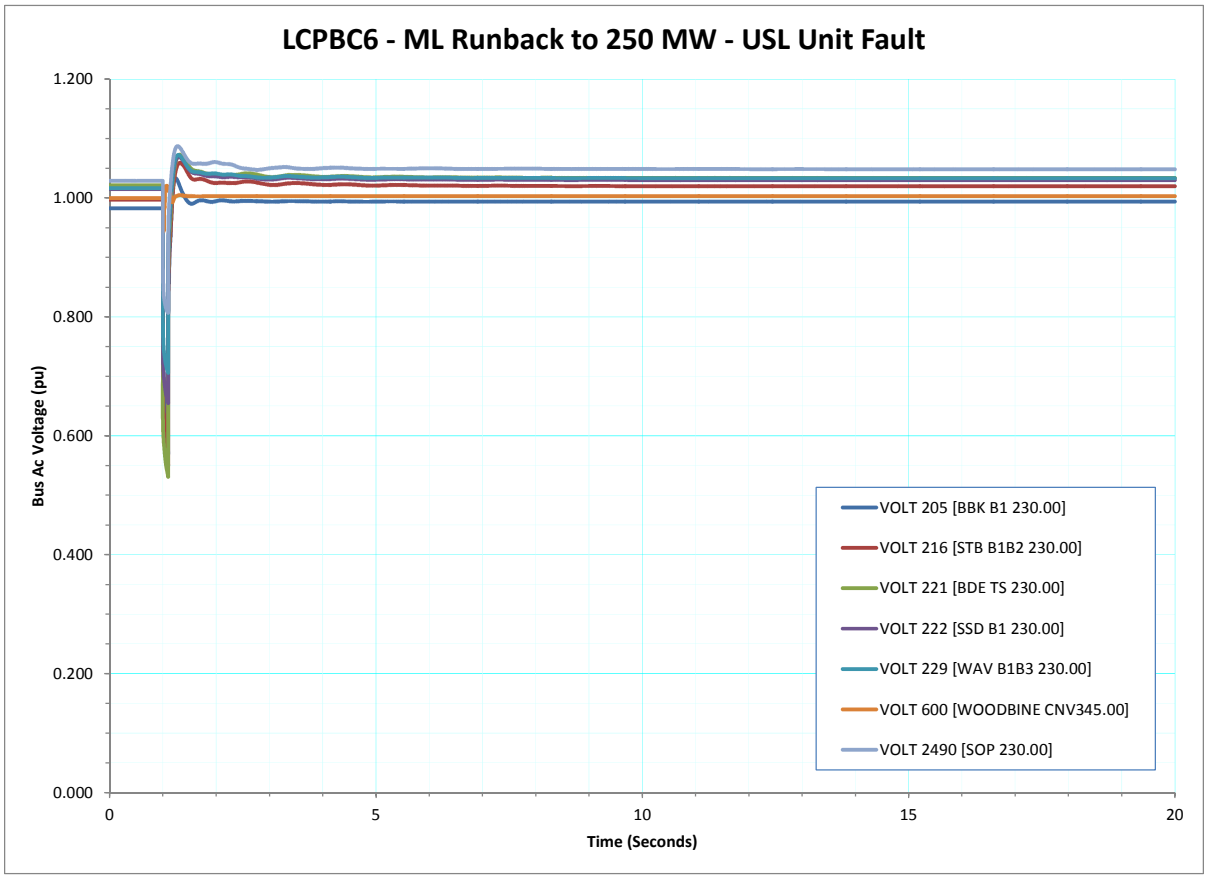

Figure 420 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - Bus Ac Voltage (pu)

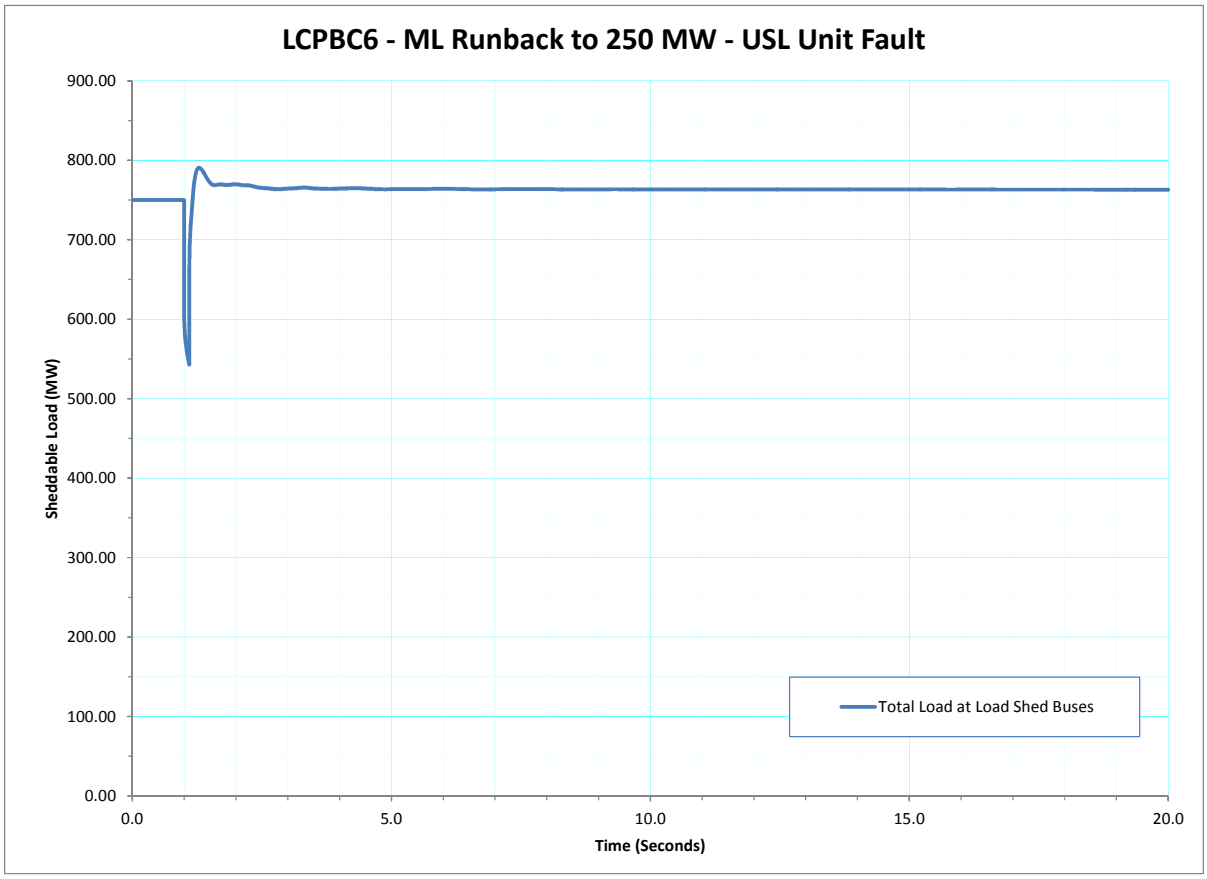

Figure 421 - LCPBC6 - ML Runback to 250 MW - USL Unit Fault - Sheddable Load (MW)

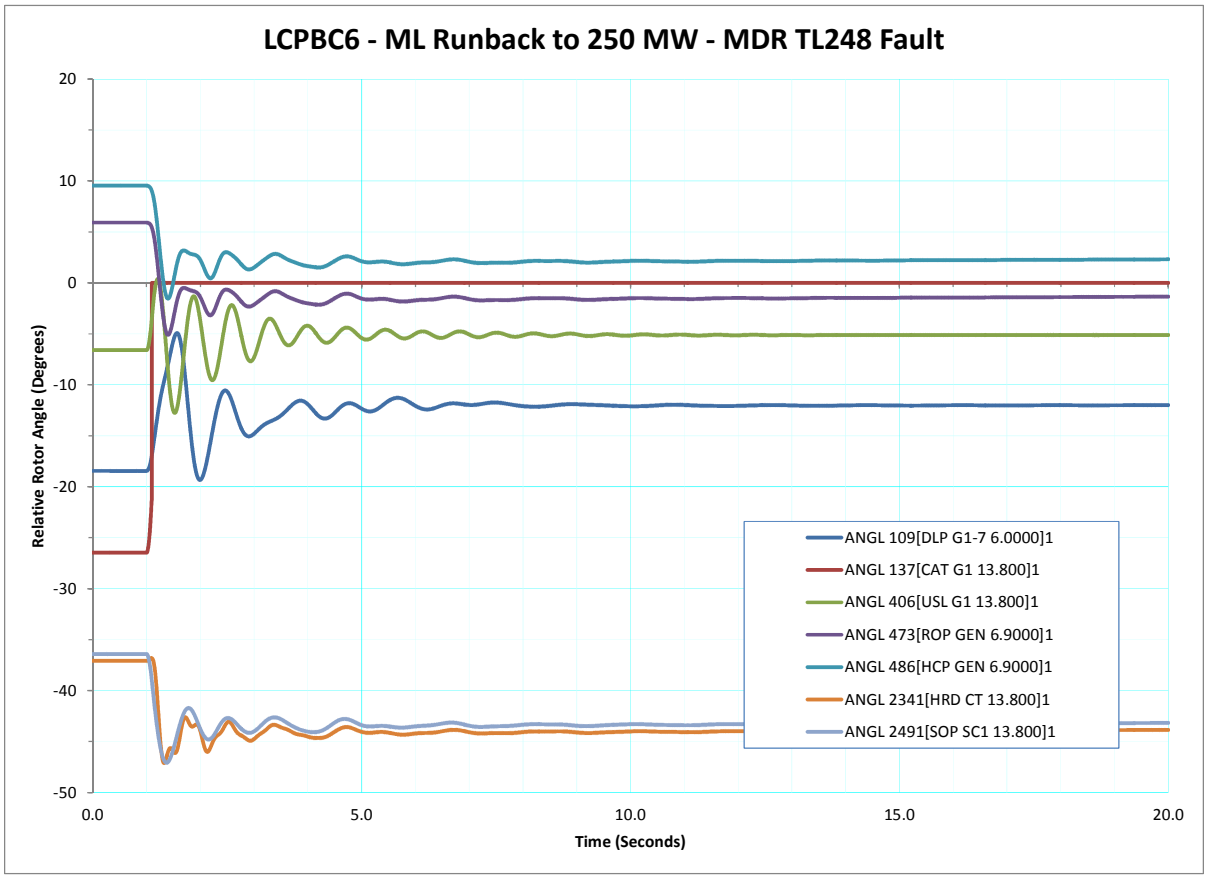

Figure 422 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

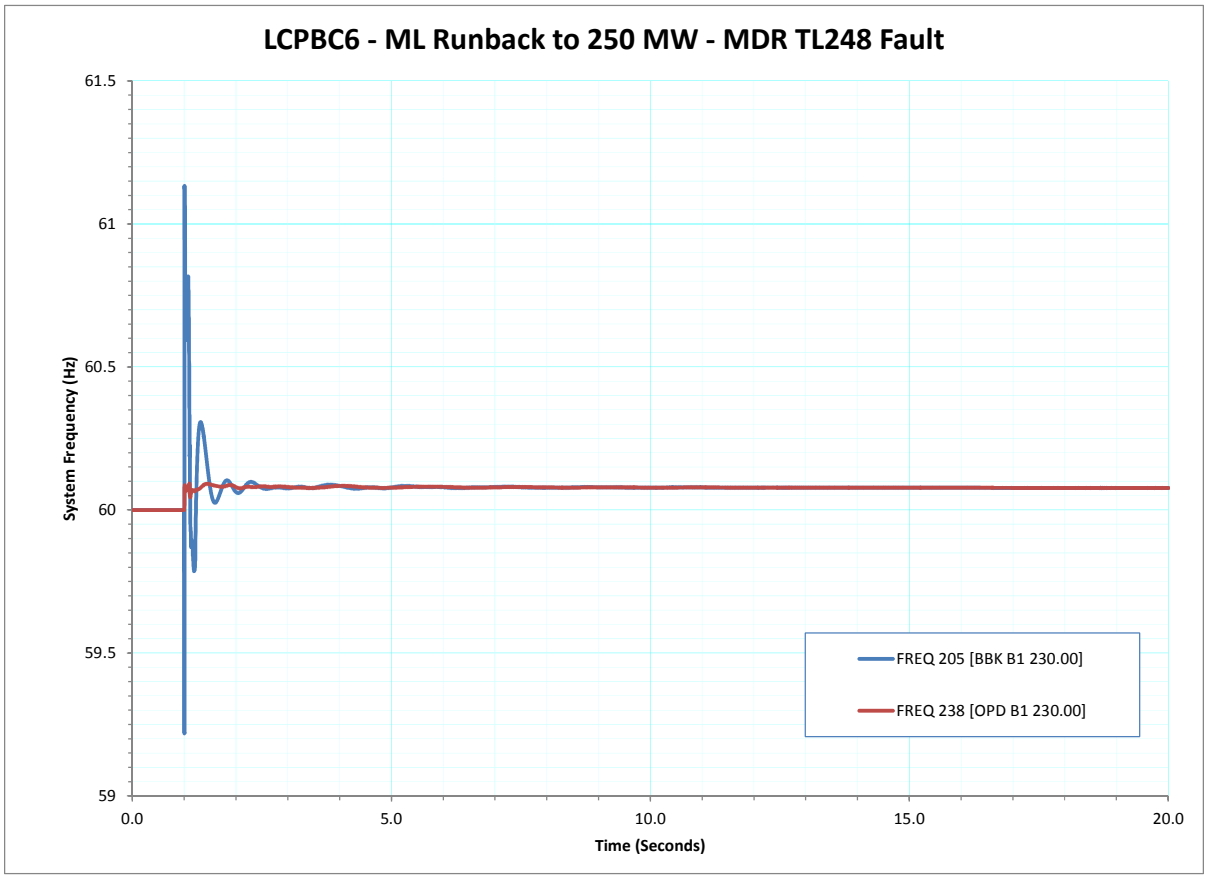

Figure 423 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - System Frequency (Hz)

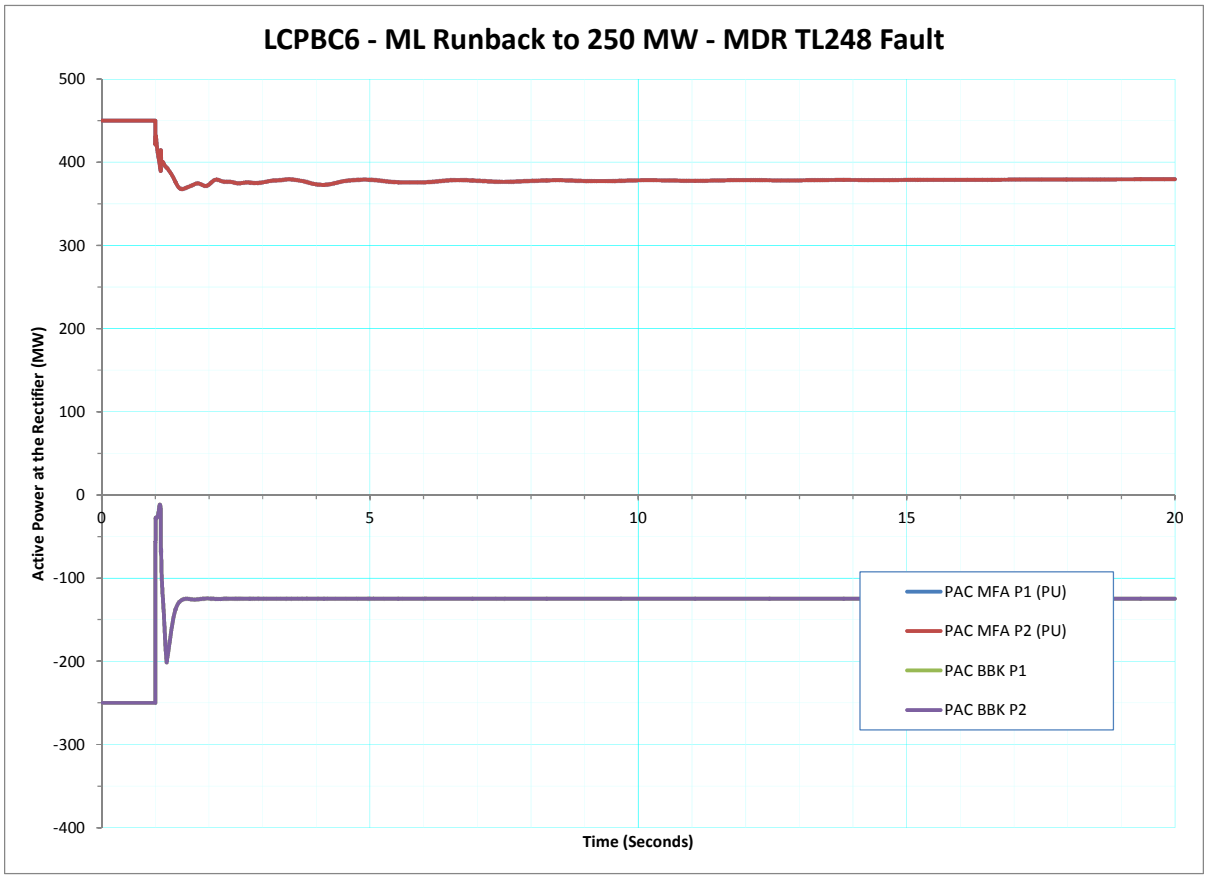

Figure 424 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

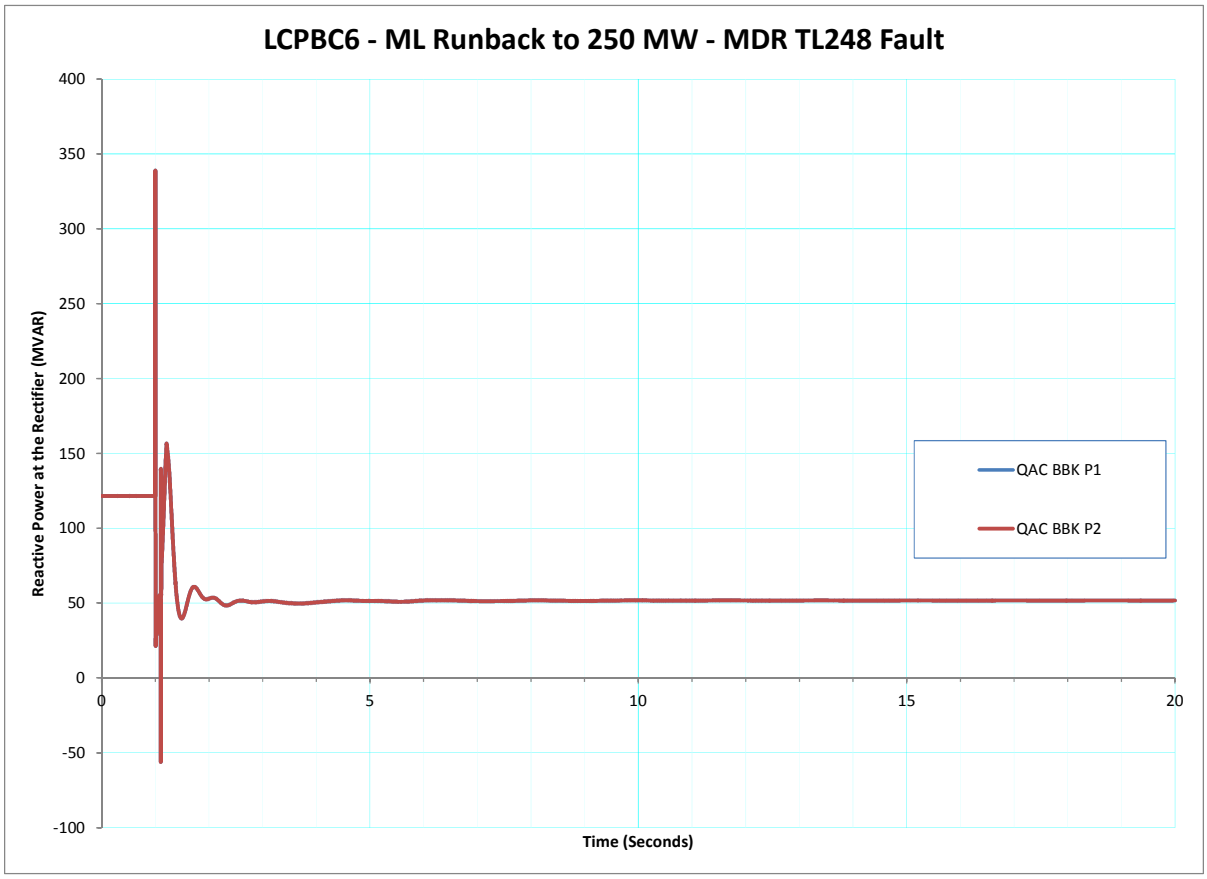

Figure 425 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

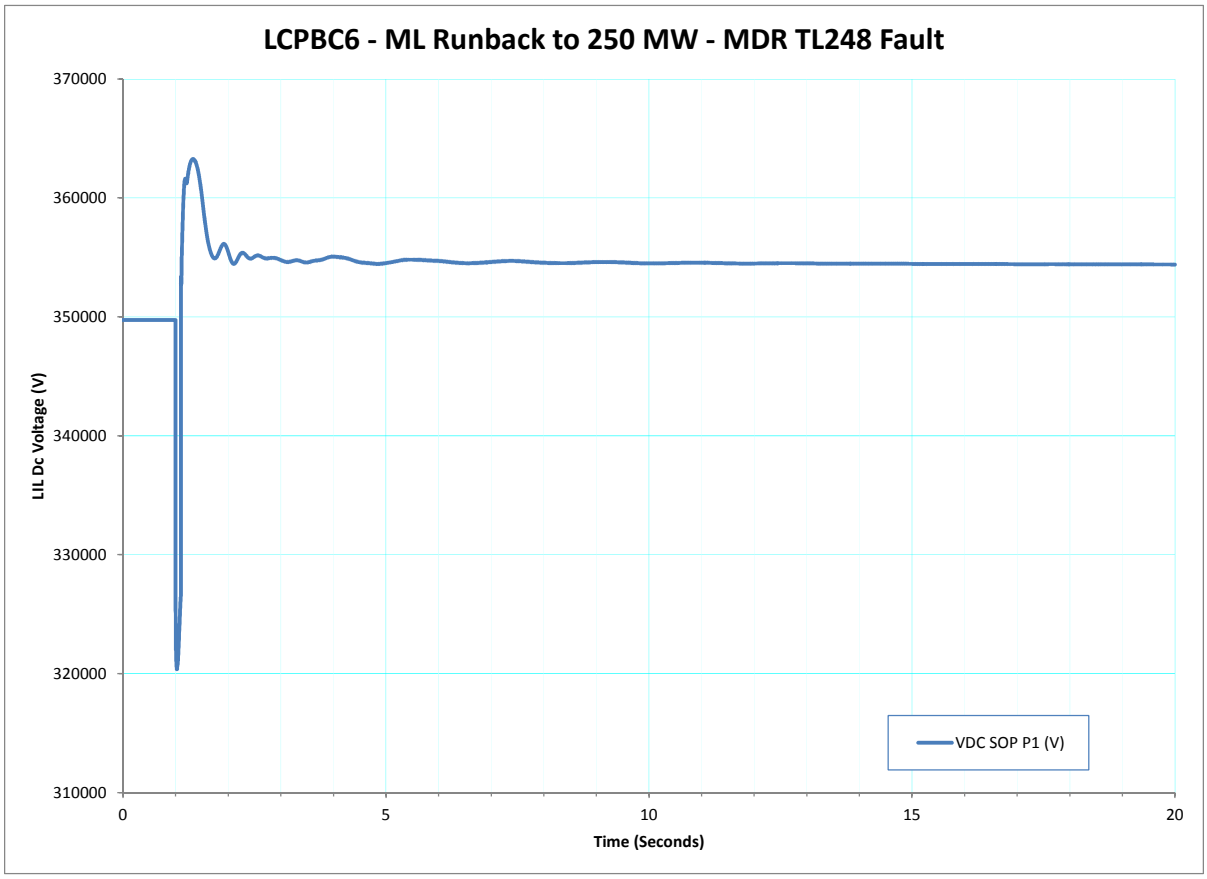

Figure 426 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - LIL Dc Voltage (V)

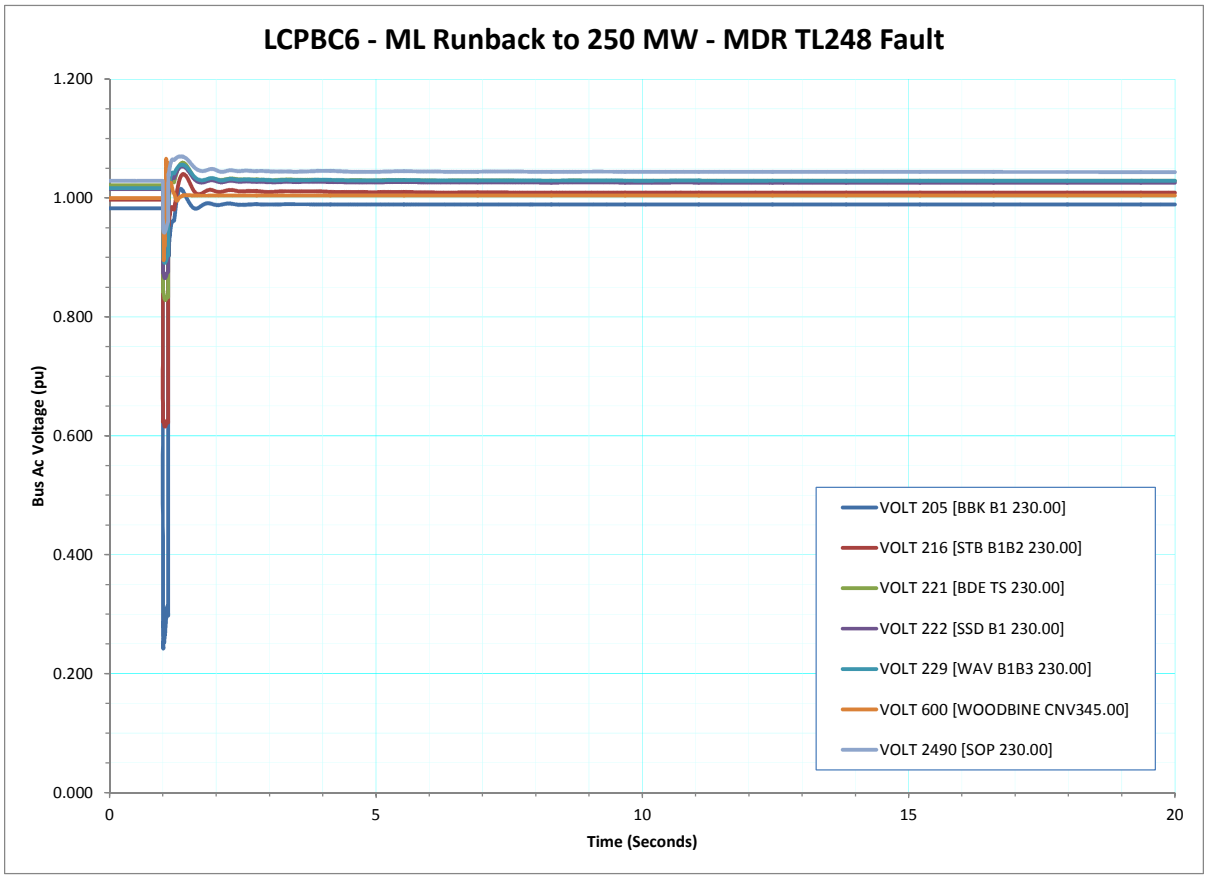

Figure 427 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

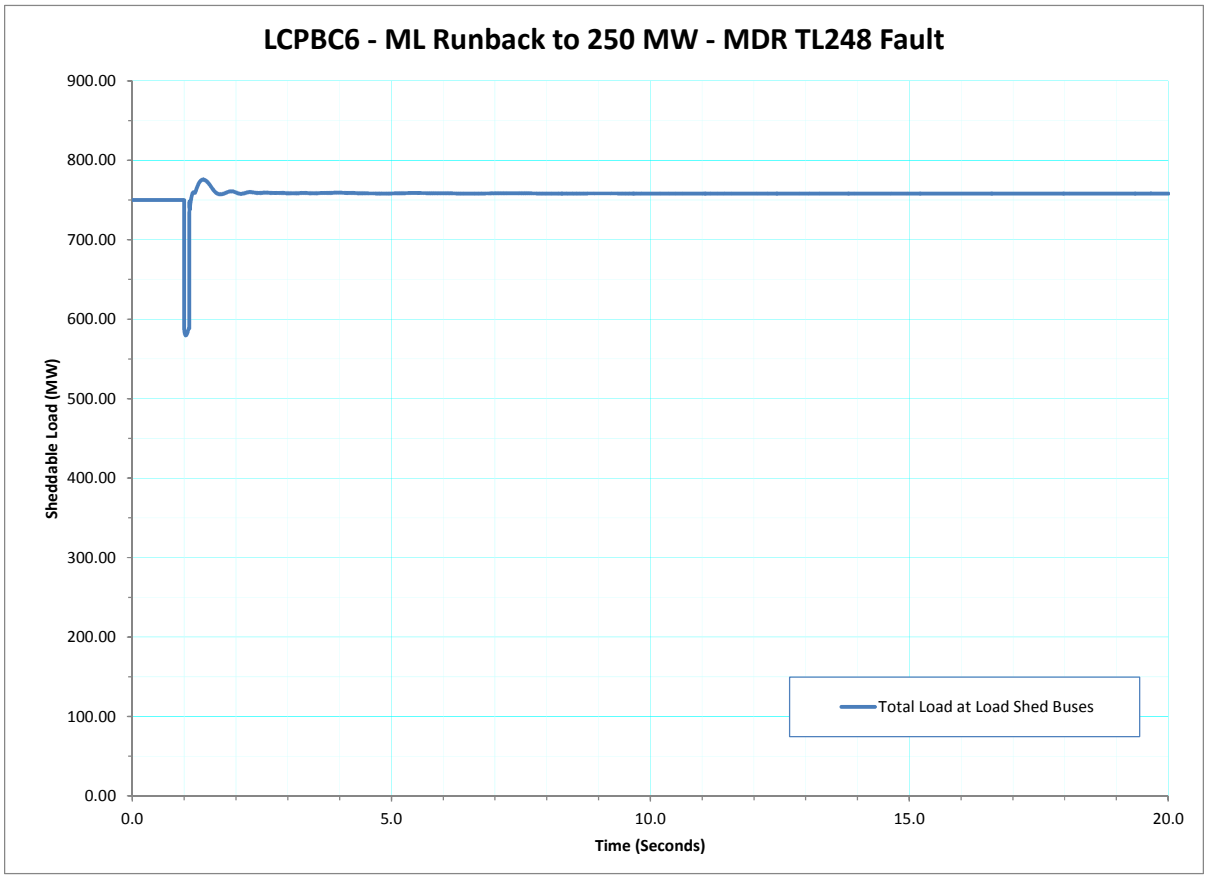

Figure 428 - LCPBC6 - ML Runback to 250 MW - MDR TL248 Fault - Sheddable Load (MW)

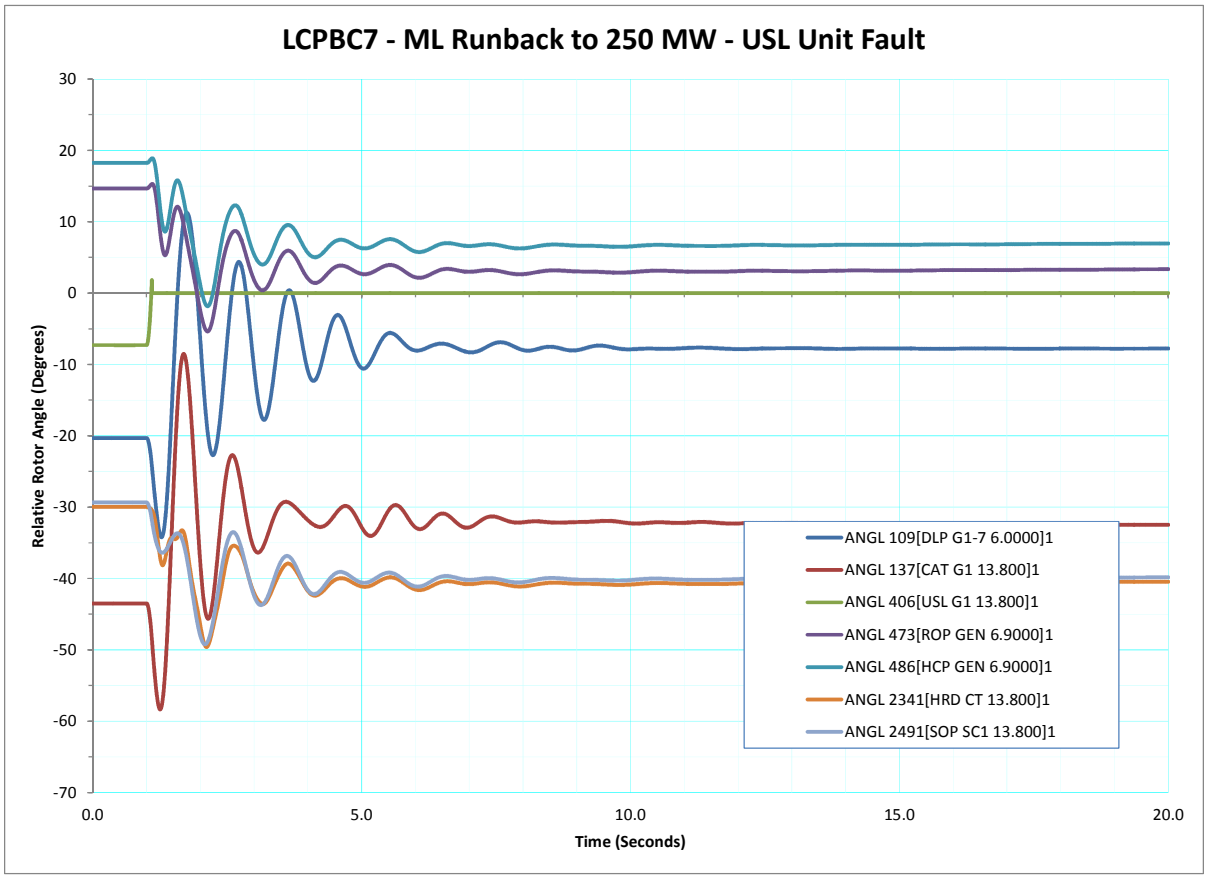

Figure 429 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

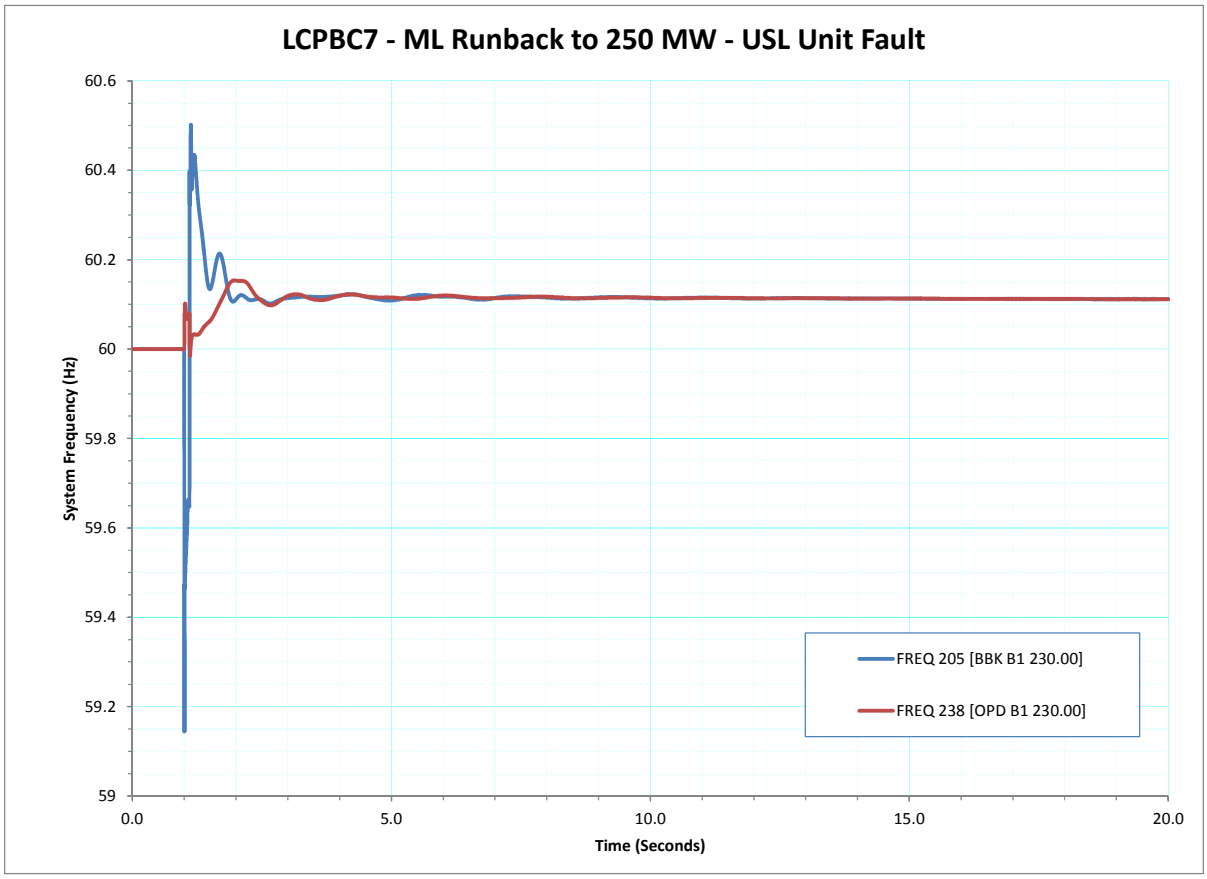

Figure 430 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - System Frequency (Hz)

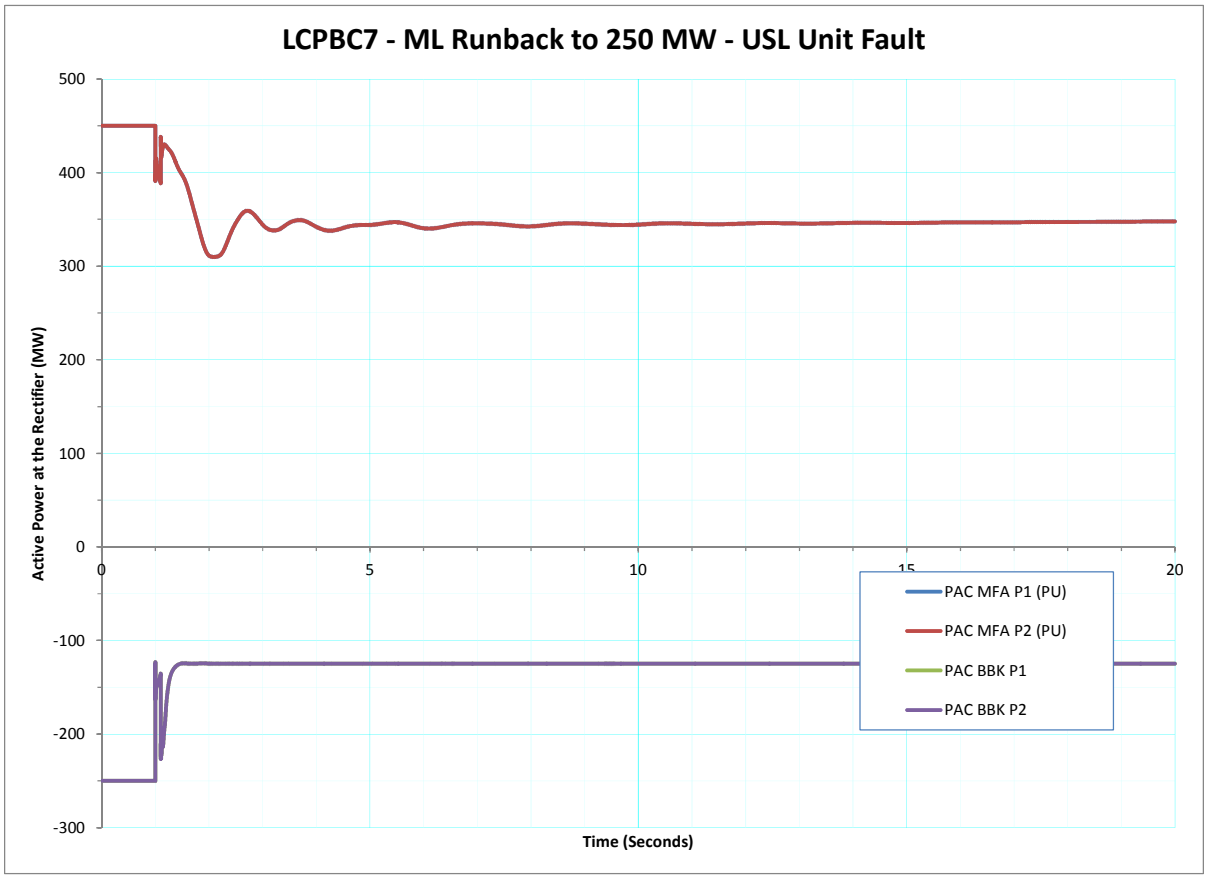

Figure 431 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - Active Power at the Rectifier (MW)

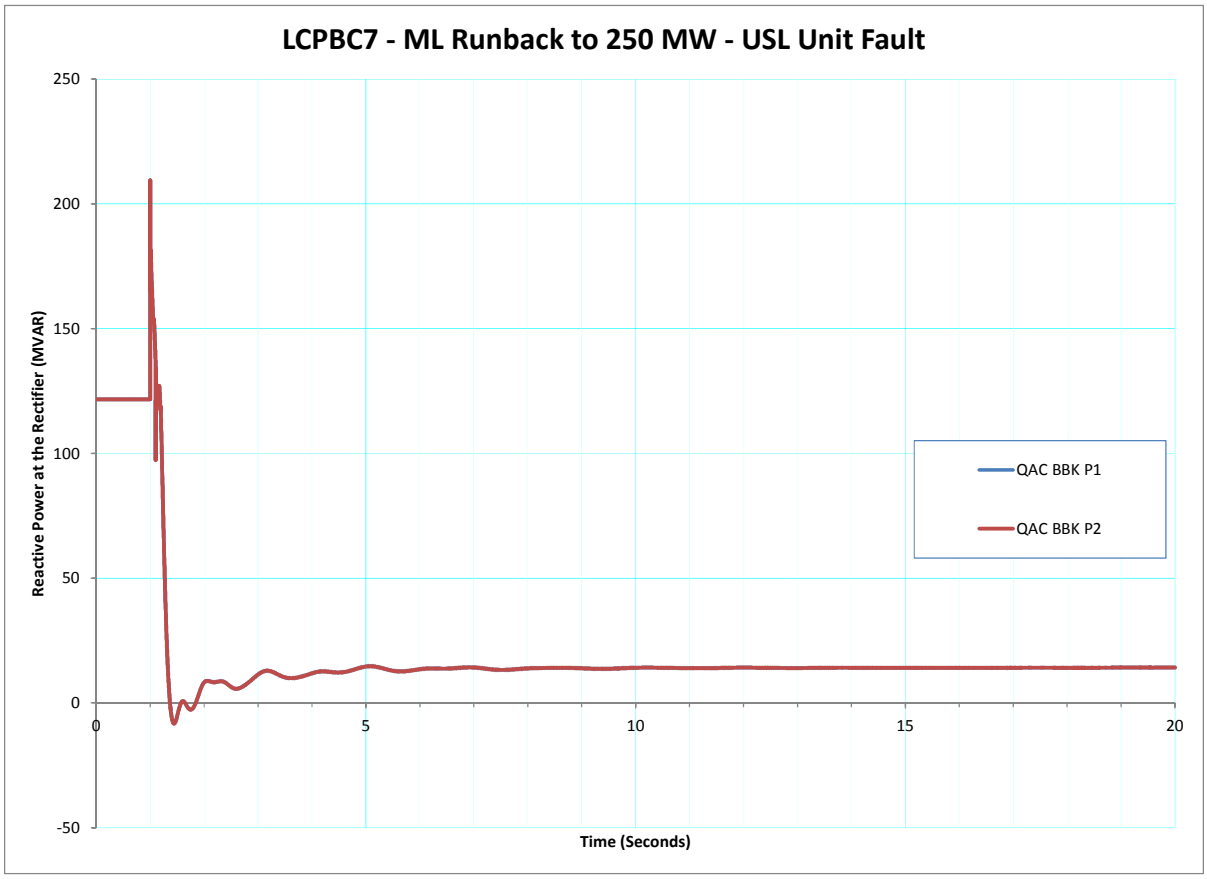

Figure 432 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

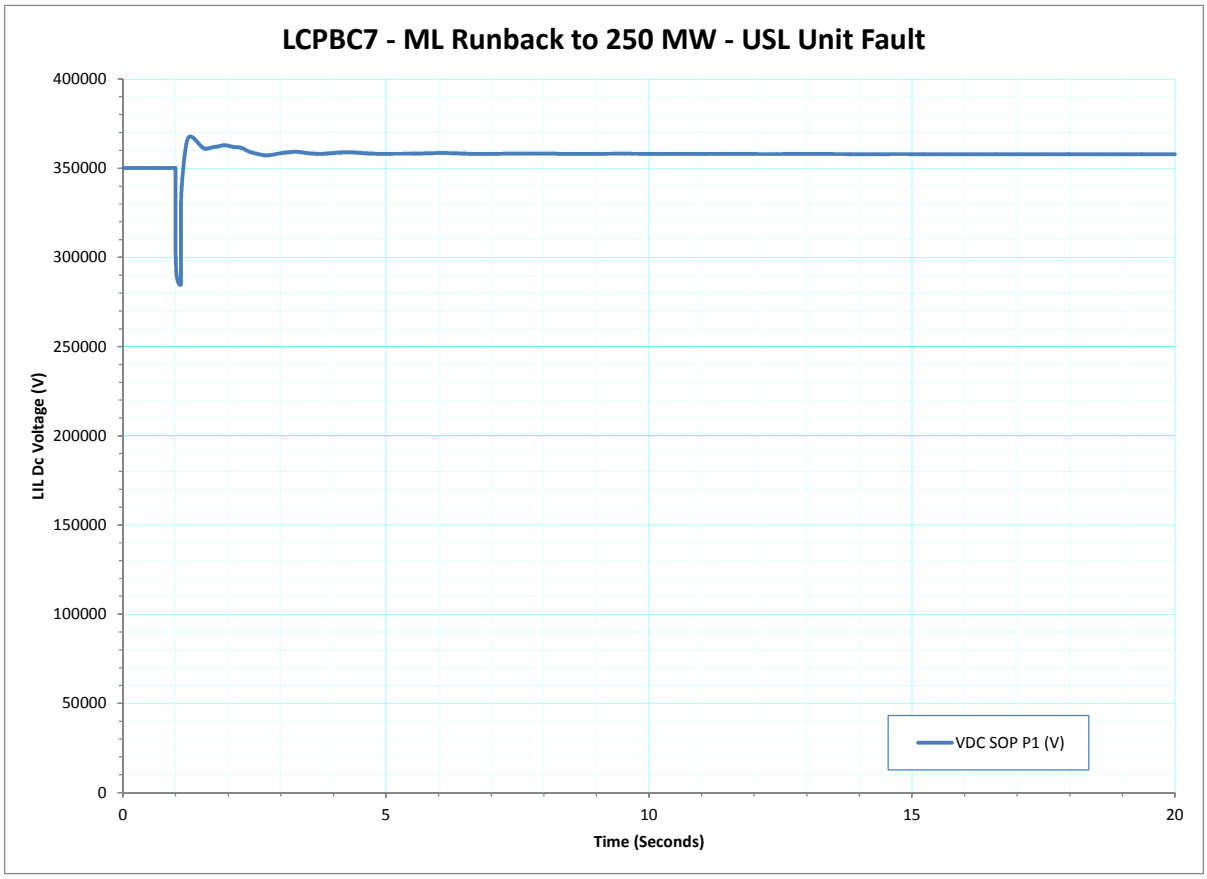

Figure 433 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - LIL Dc Voltage (V)

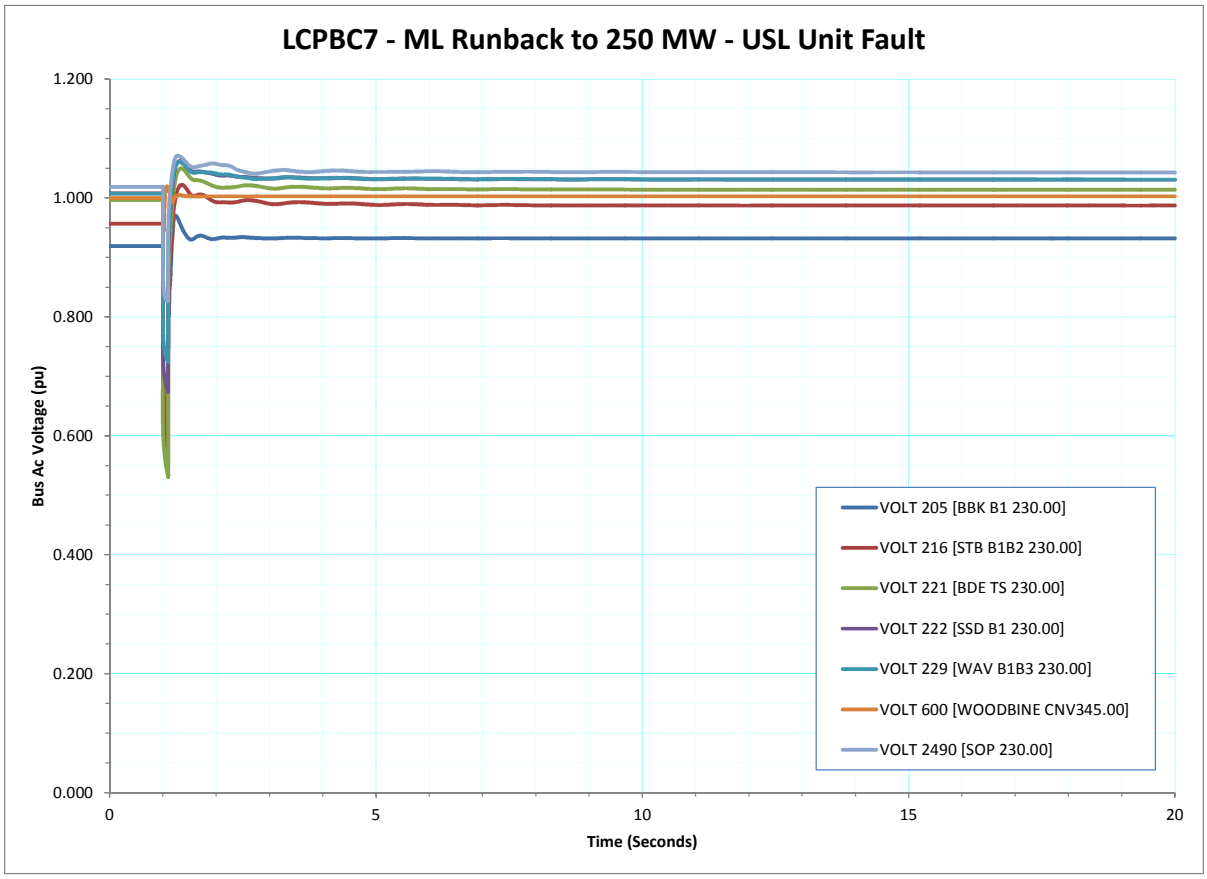

Figure 434 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - Bus Ac Voltage (pu)

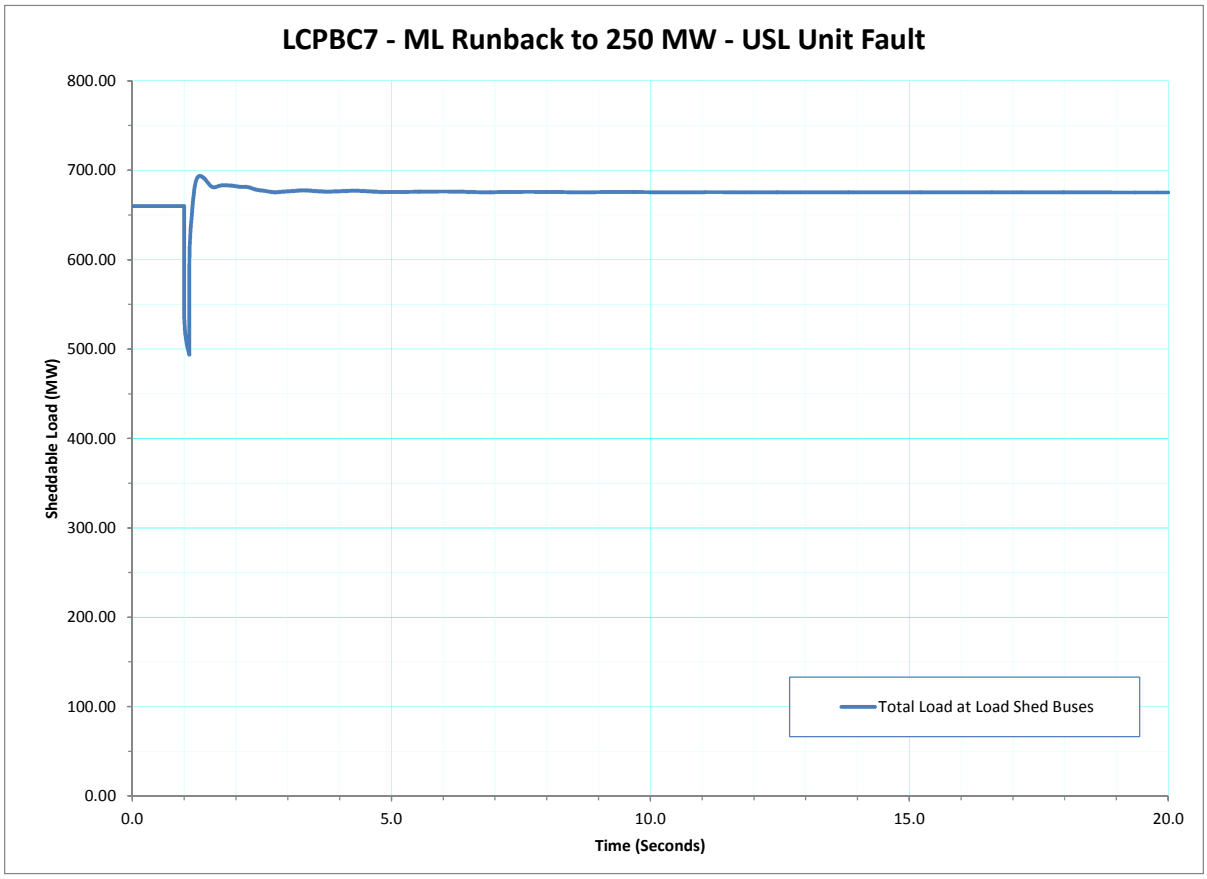

Figure 435 - LCPBC7 - ML Runback to 250 MW - USL Unit Fault - Sheddable Load (MW)

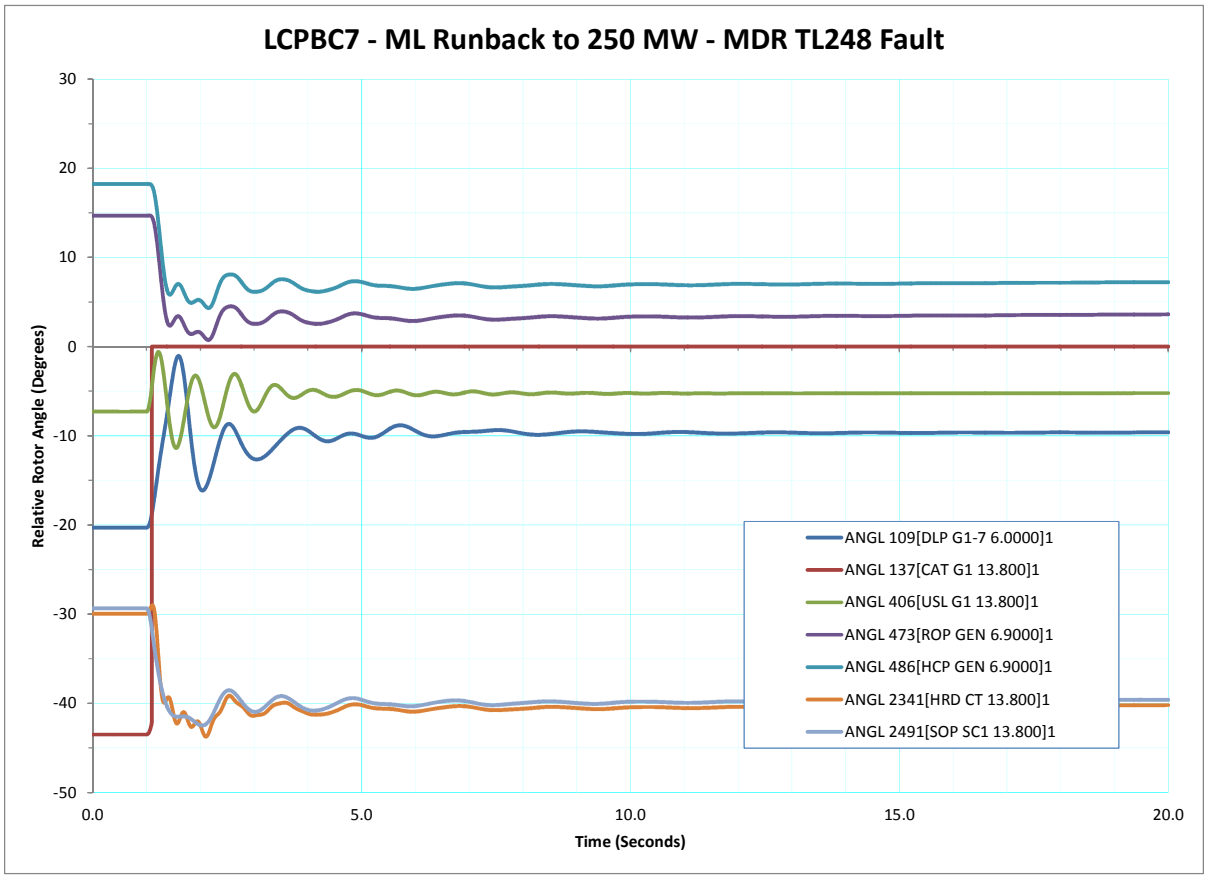

Figure 436 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

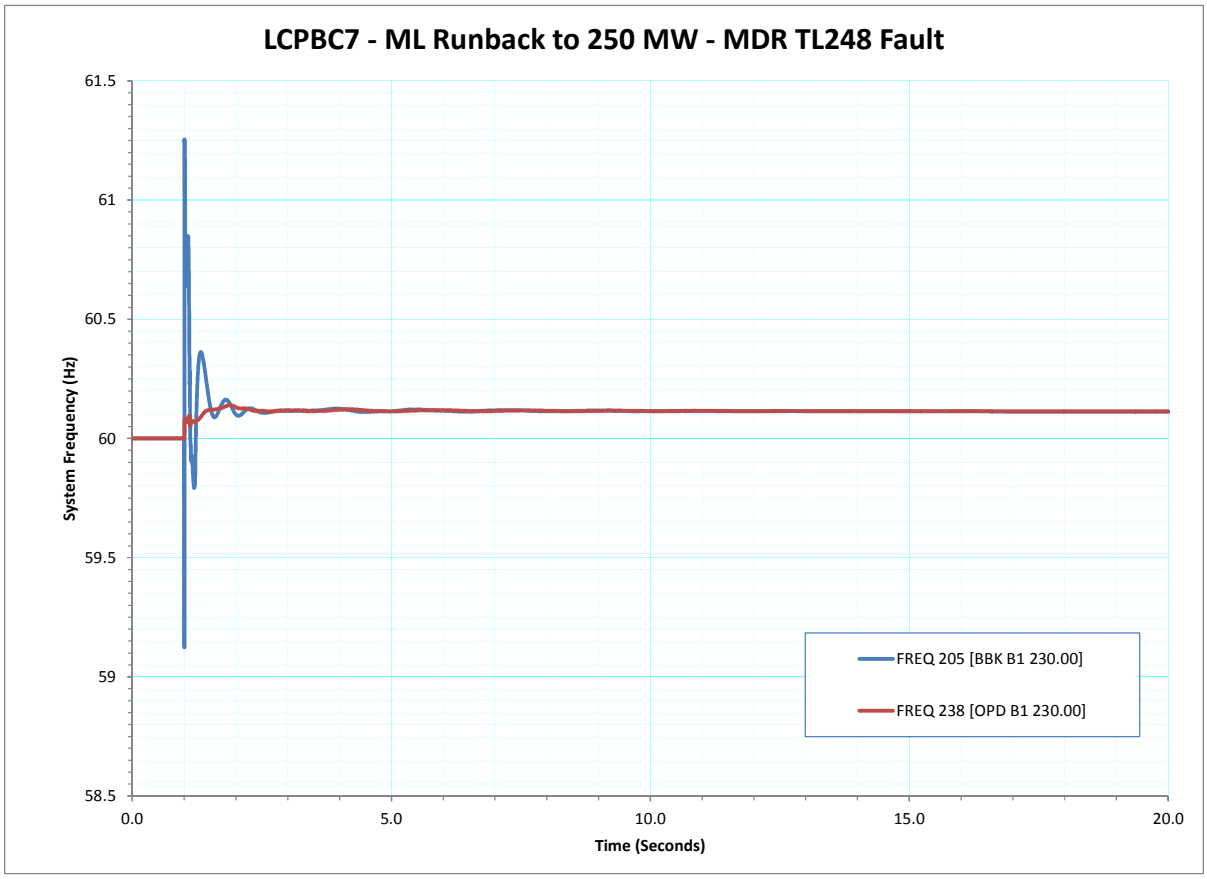

Figure 437 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - System Frequency (Hz)

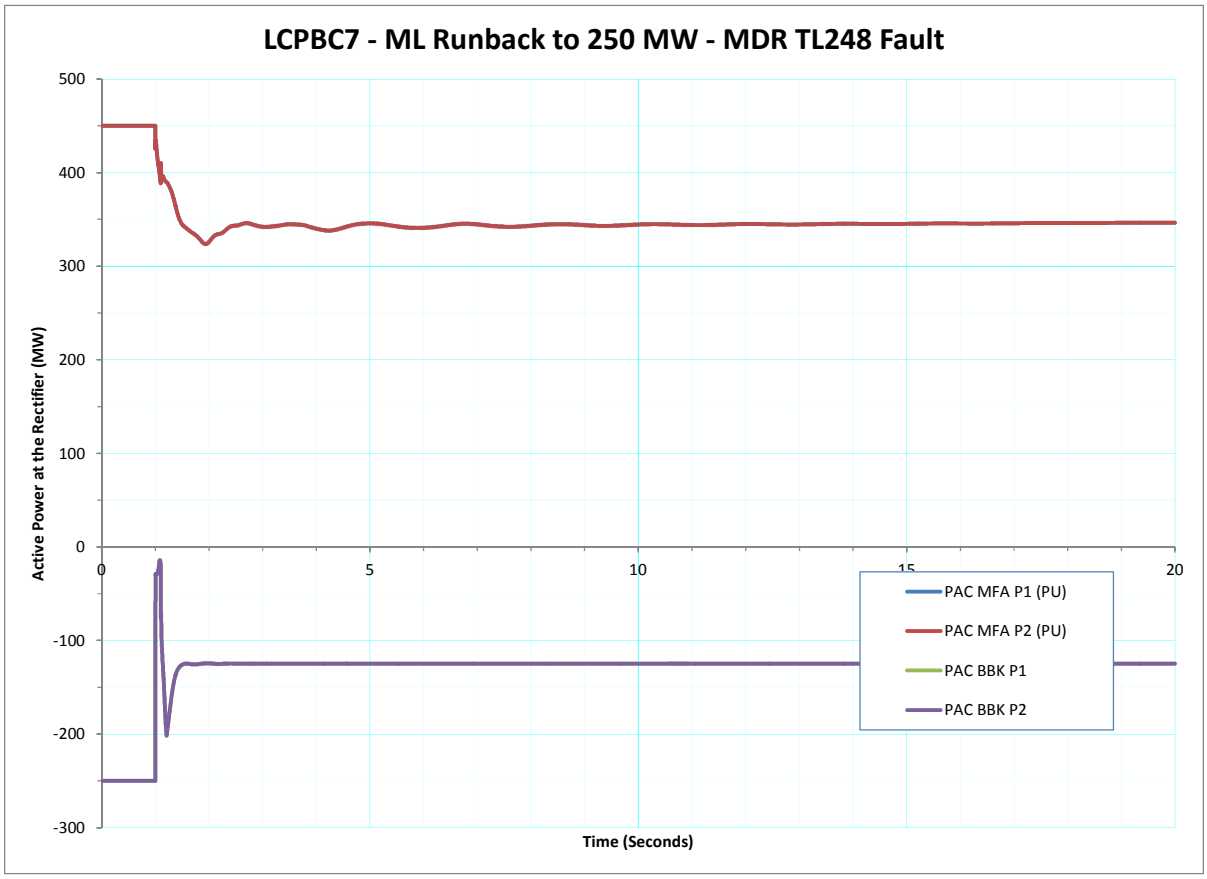

Figure 438 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

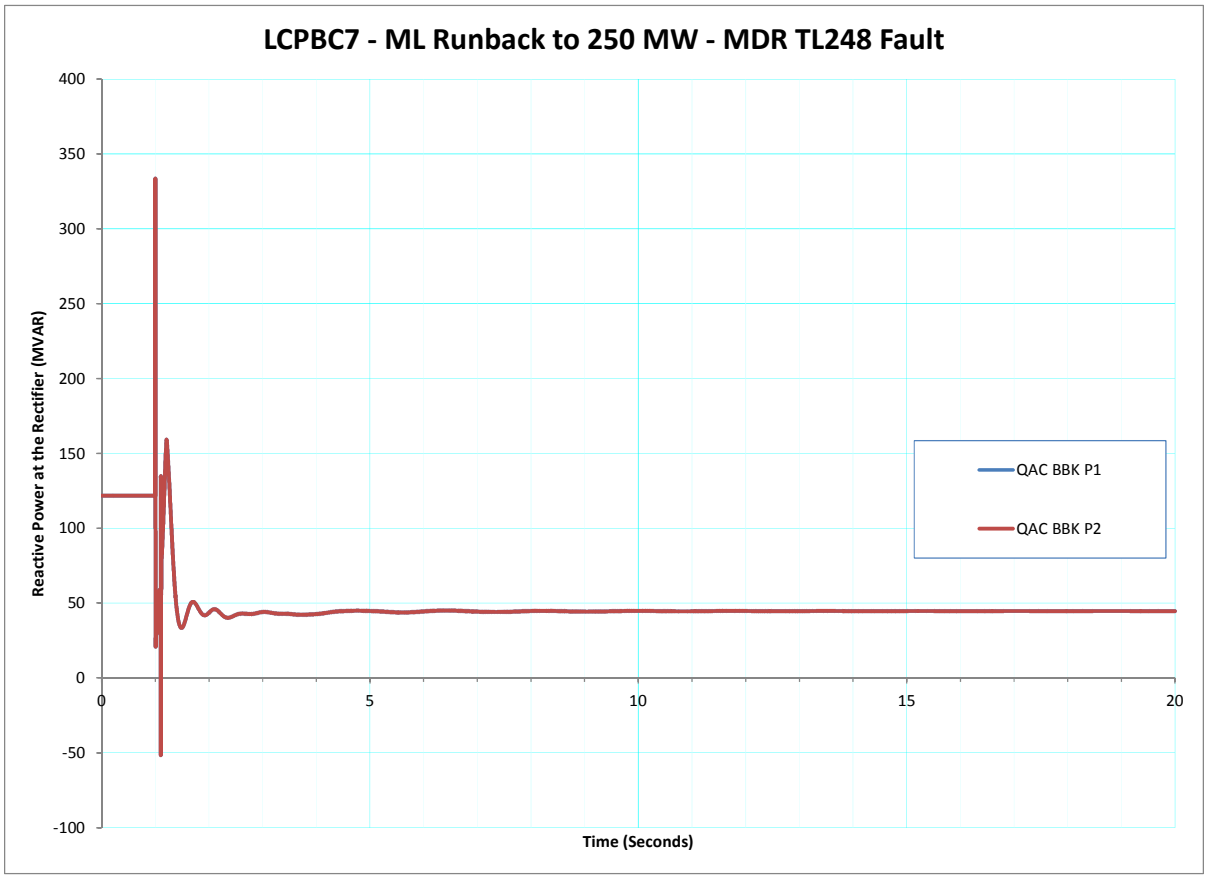

Figure 439 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

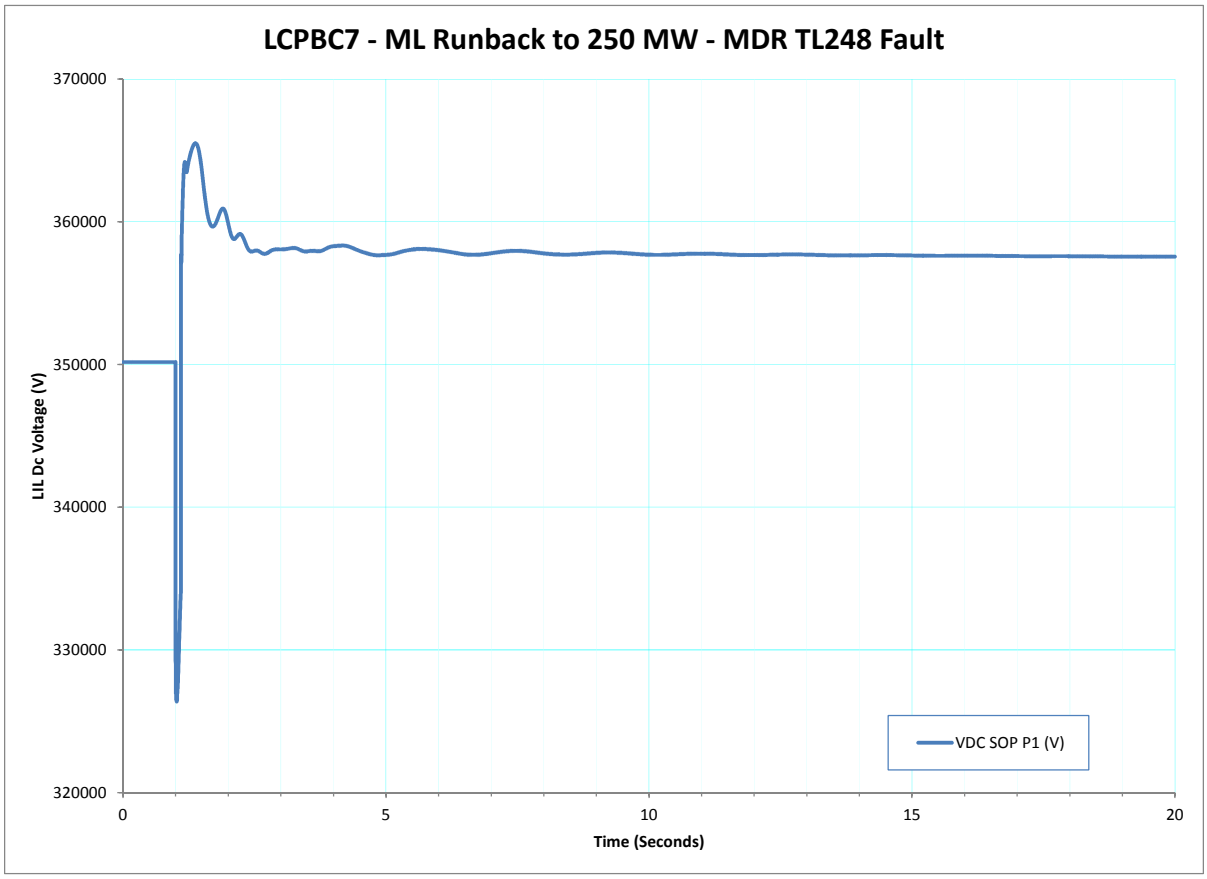

Figure 440 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - LIL Dc Voltage (V)

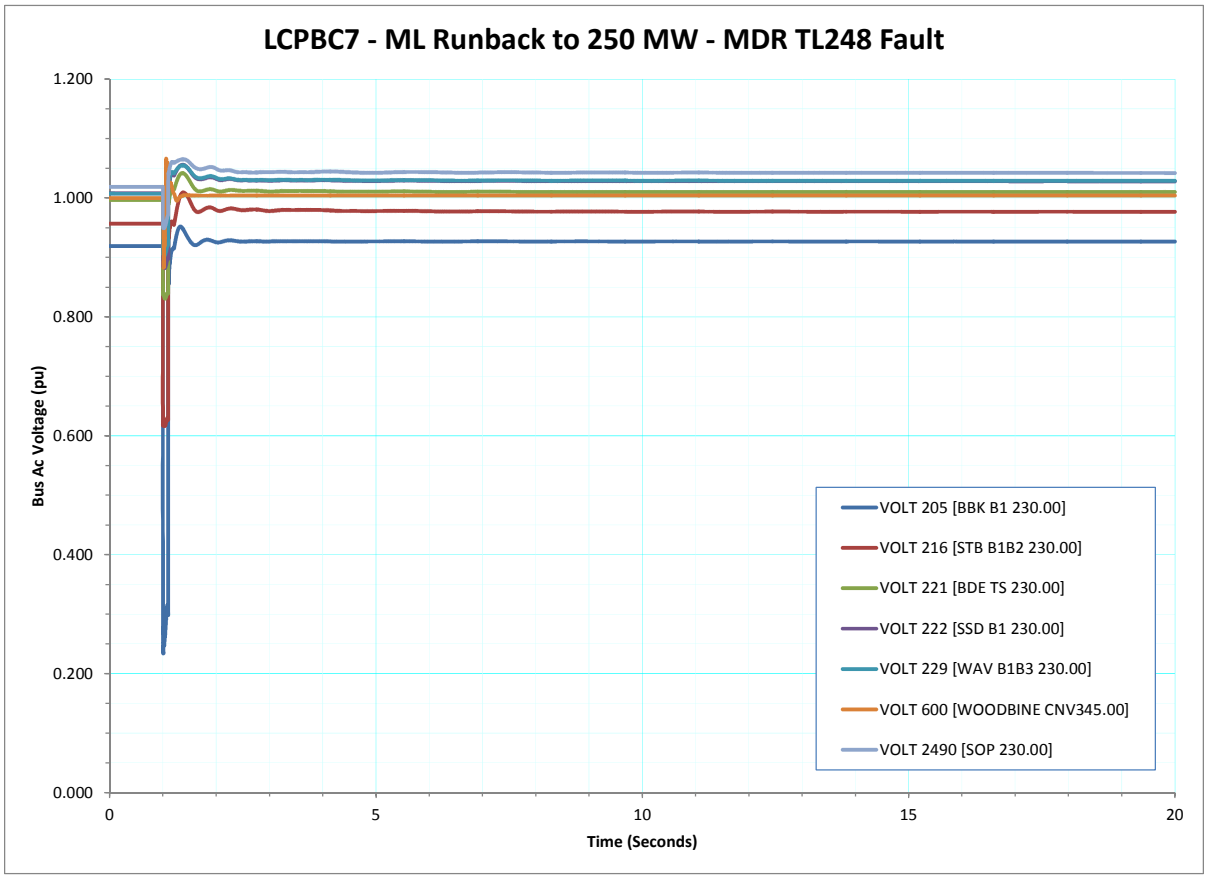

Figure 441 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

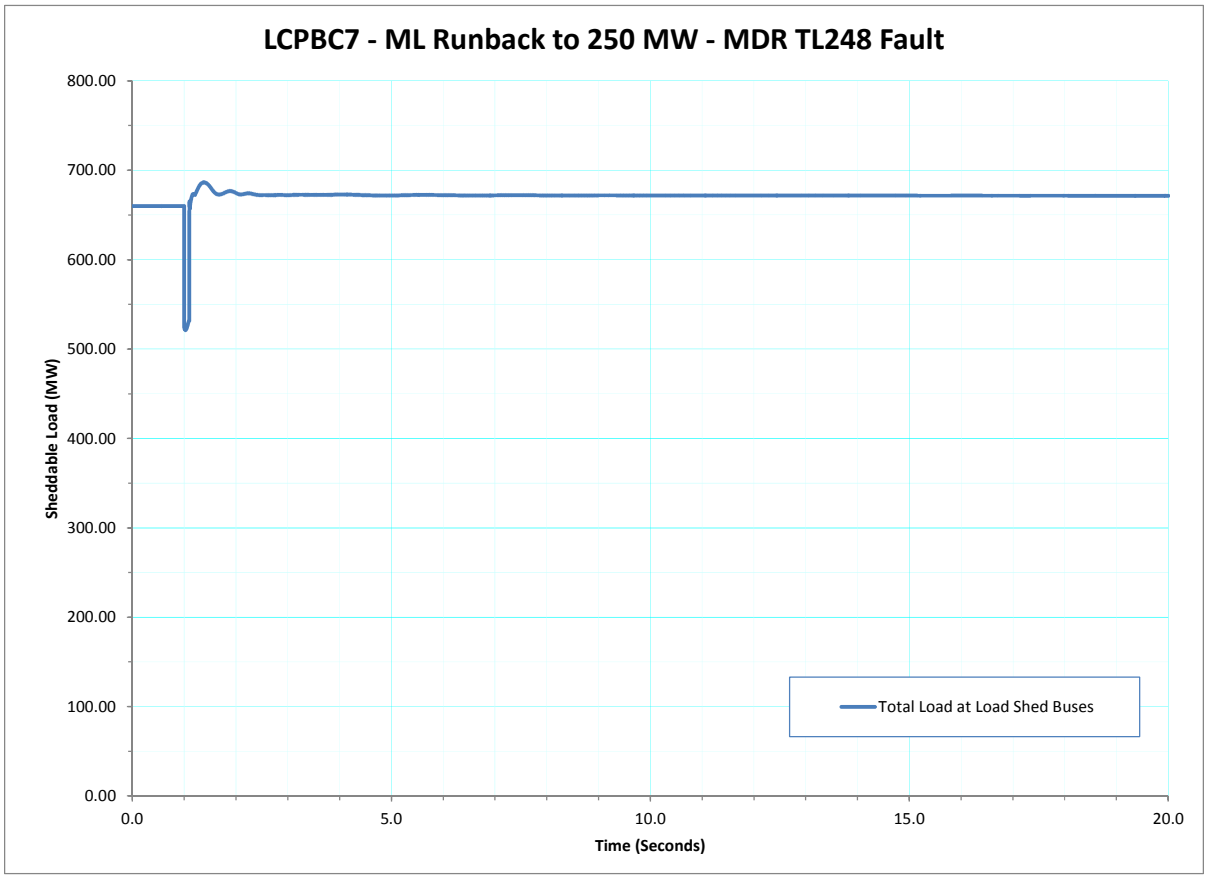

Figure 442 - LCPBC7 - ML Runback to 250 MW - MDR TL248 Fault - Sheddable Load (MW)

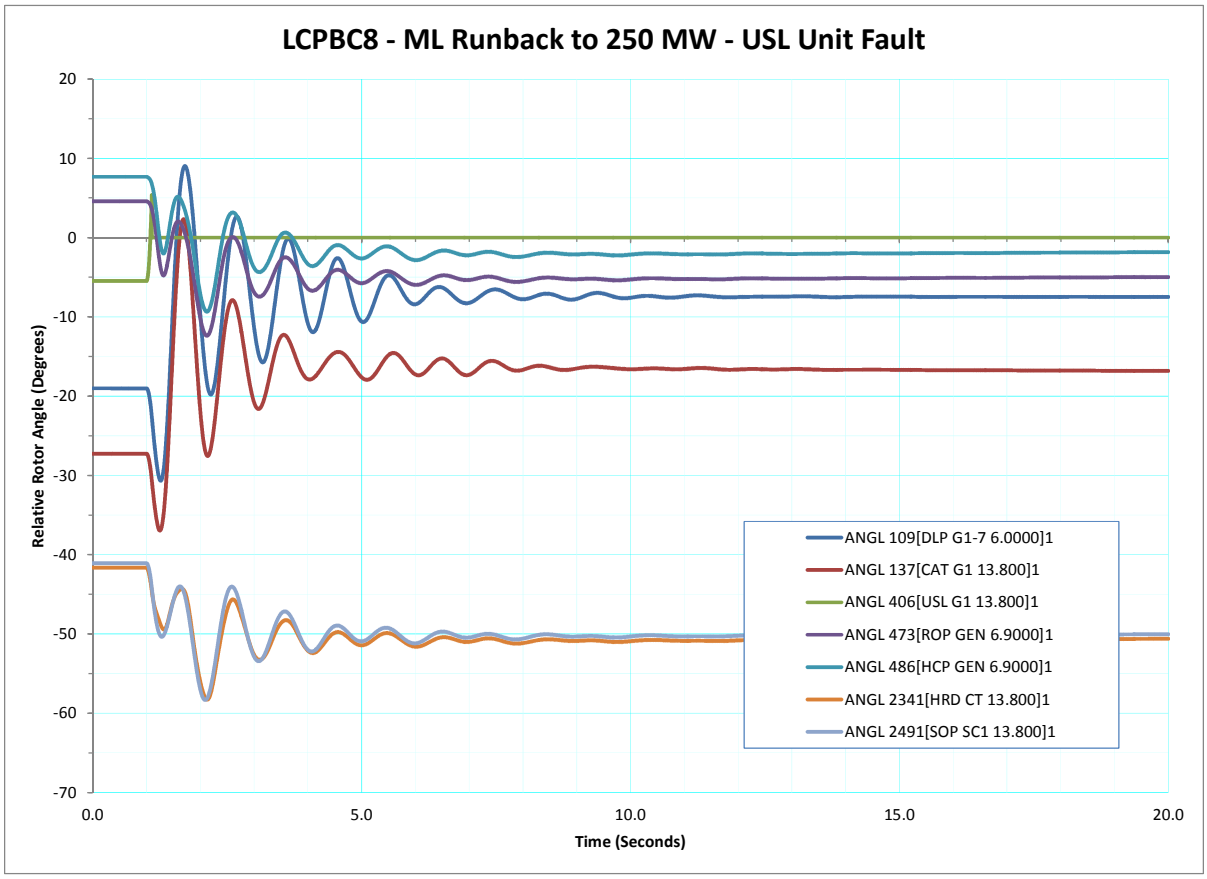

Figure 443 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

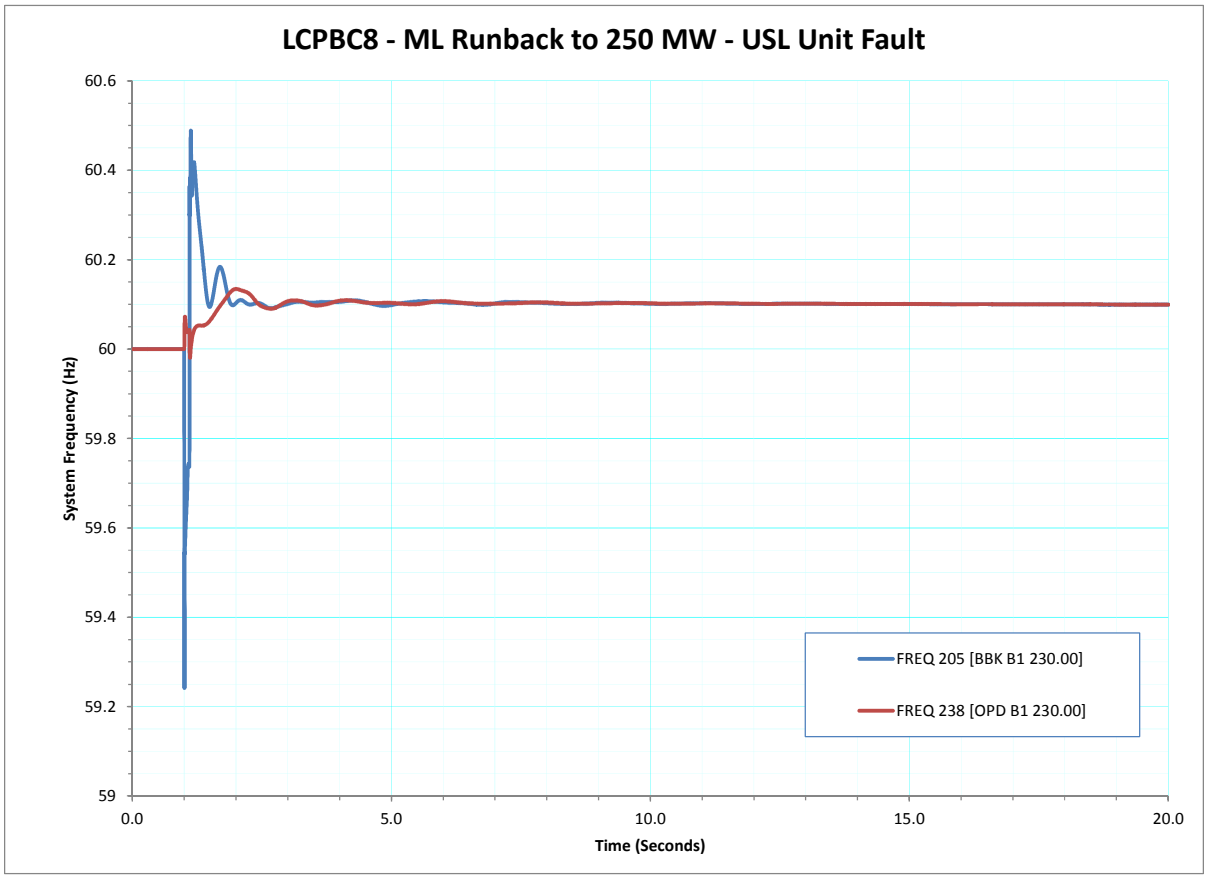

Figure 444 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - System Frequency (Hz)

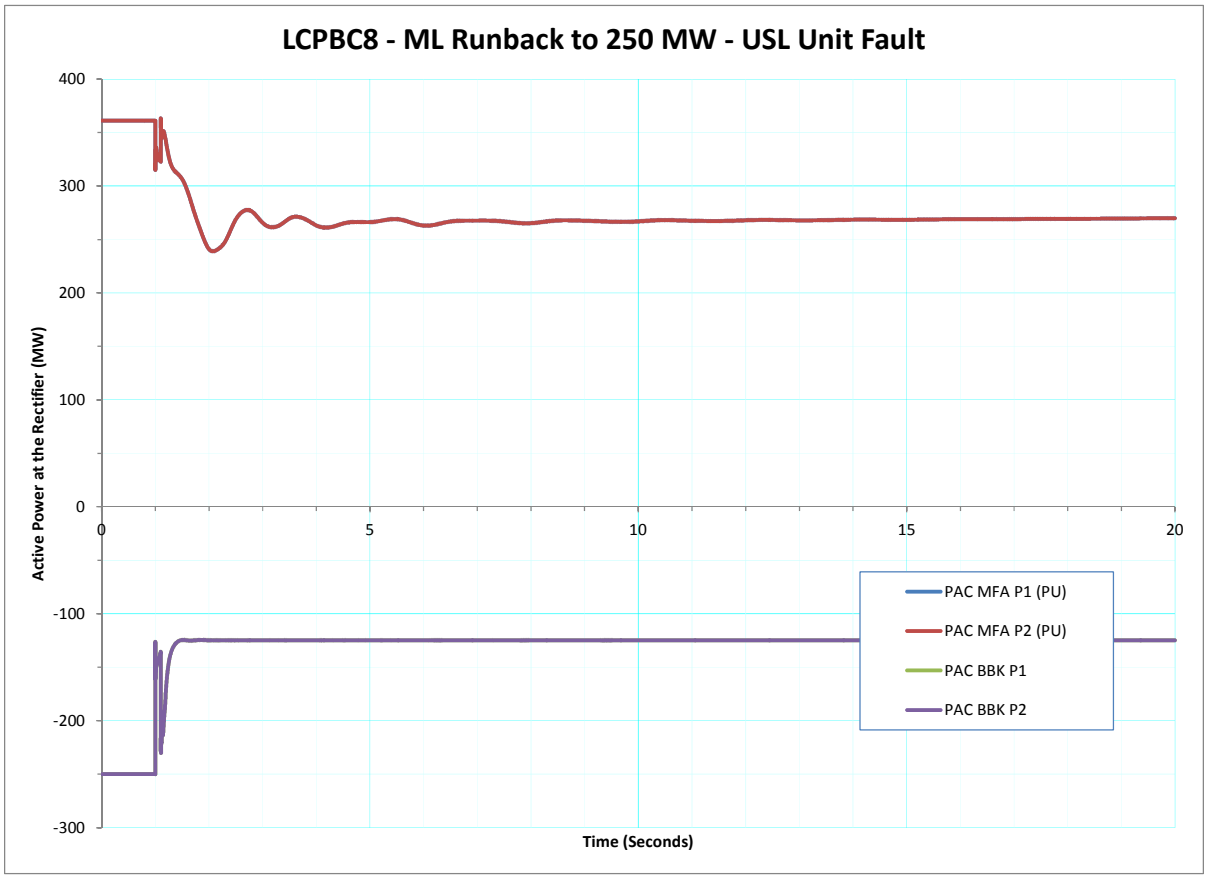

Figure 445 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - Active Power at the Rectifier (MW)

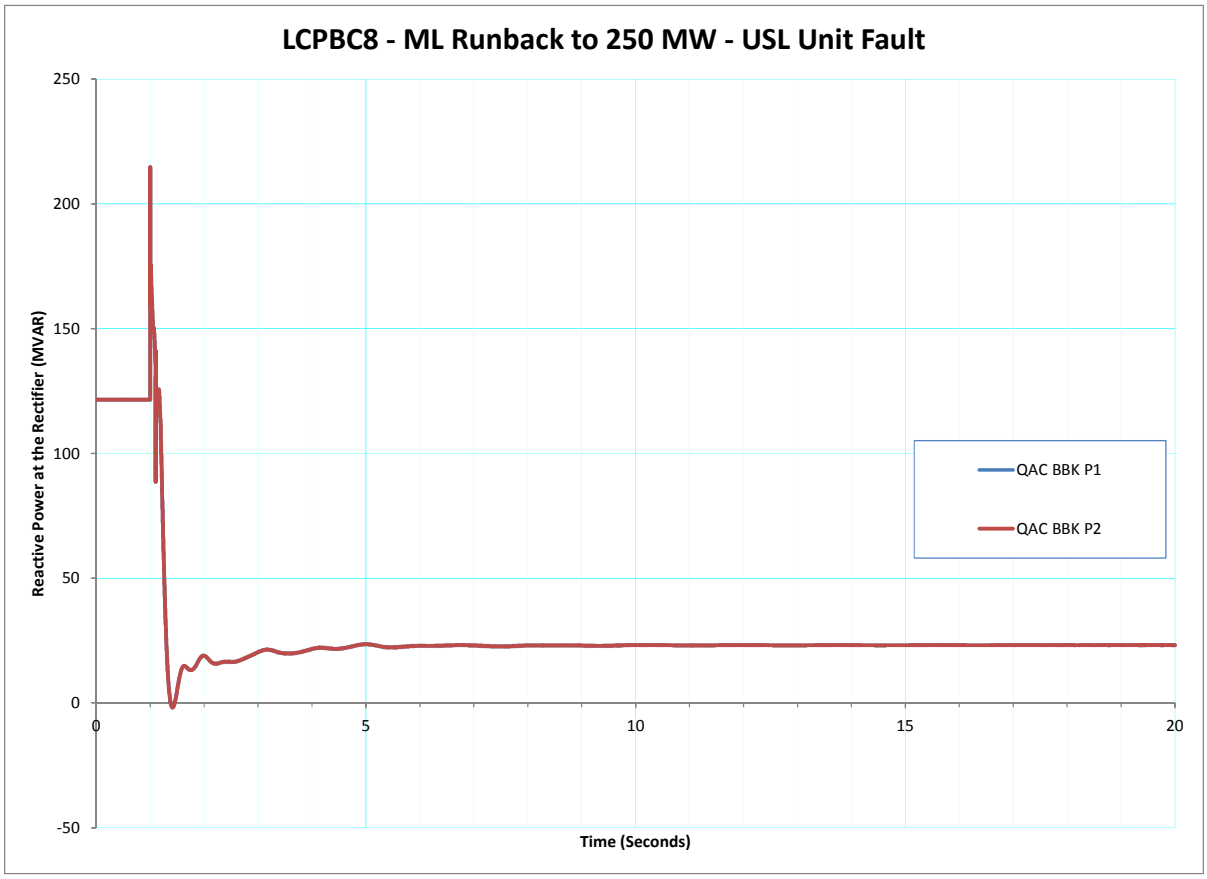

Figure 446 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

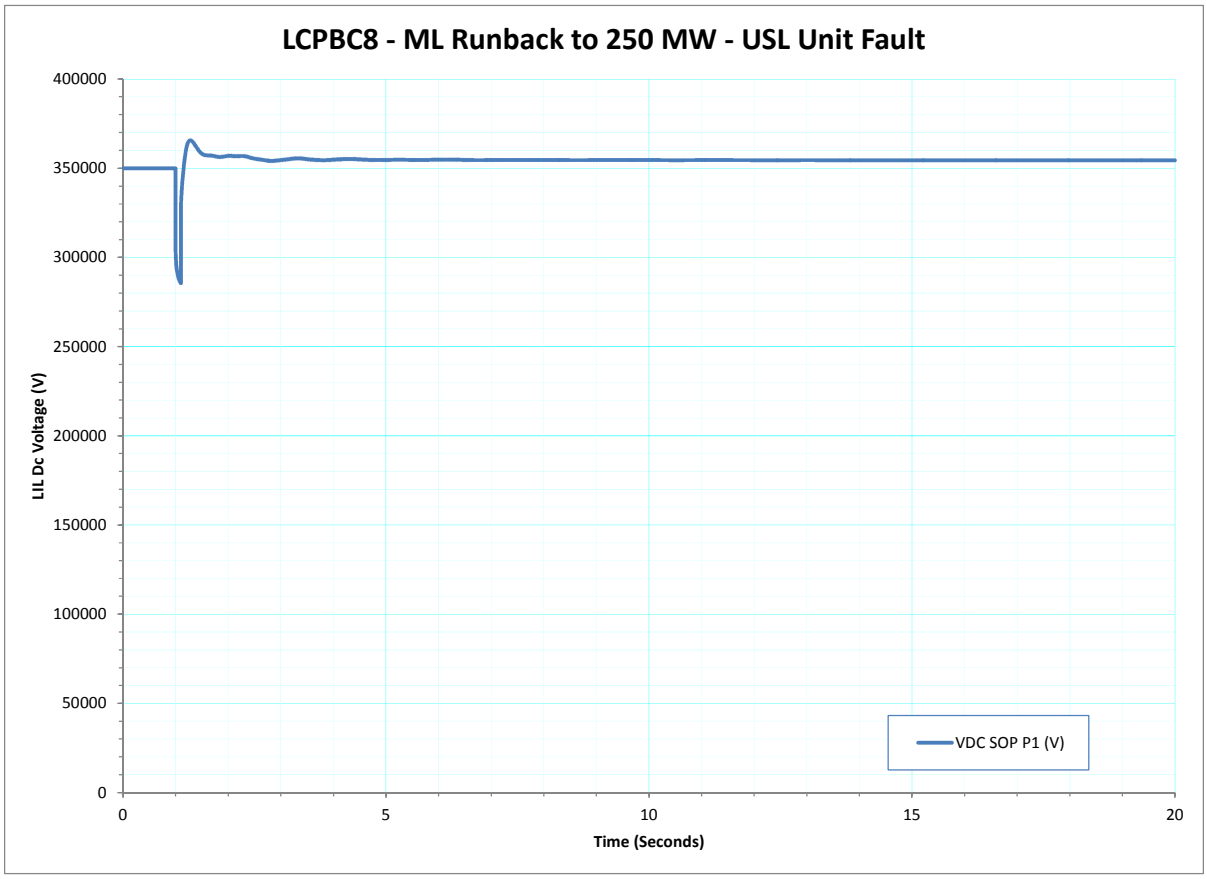

Figure 447 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - LIL Dc Voltage (V)

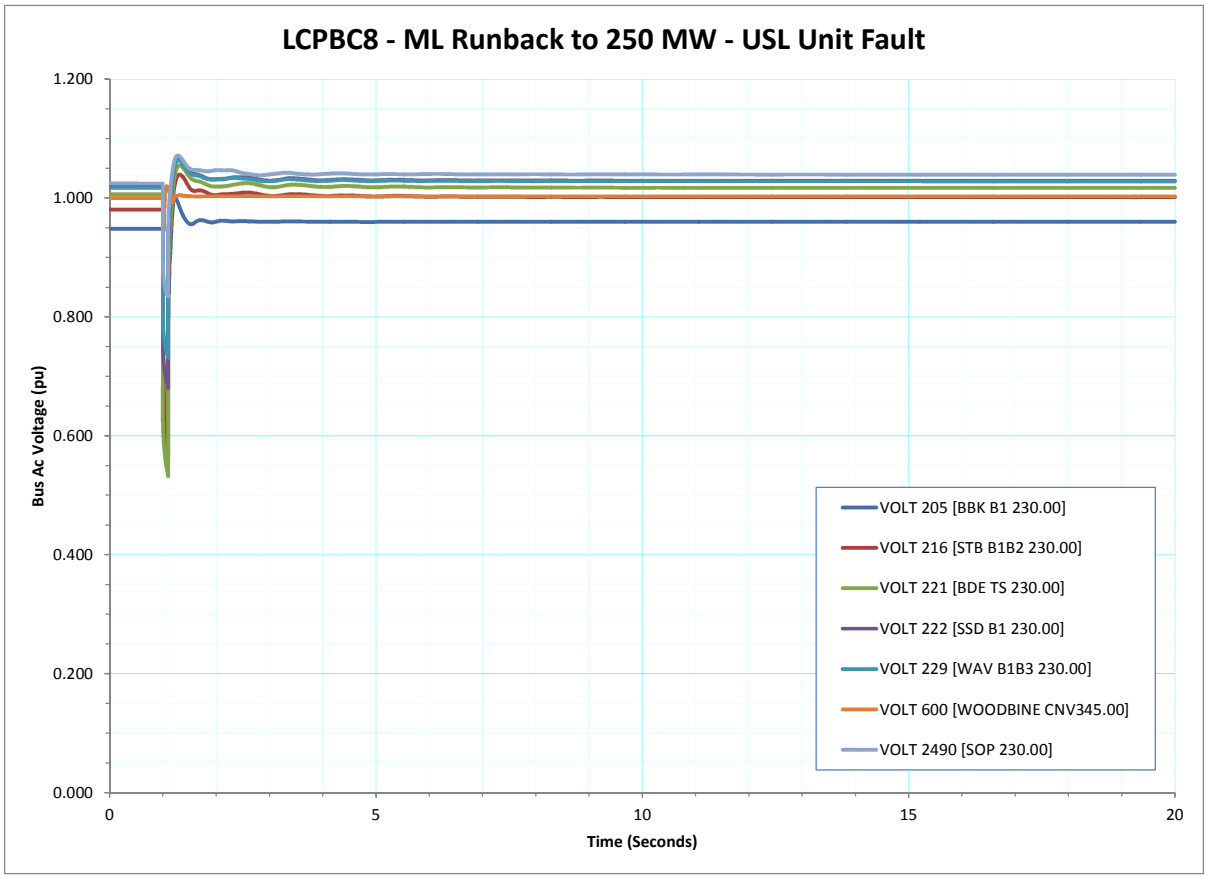

Figure 448 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - Bus Ac Voltage (pu)

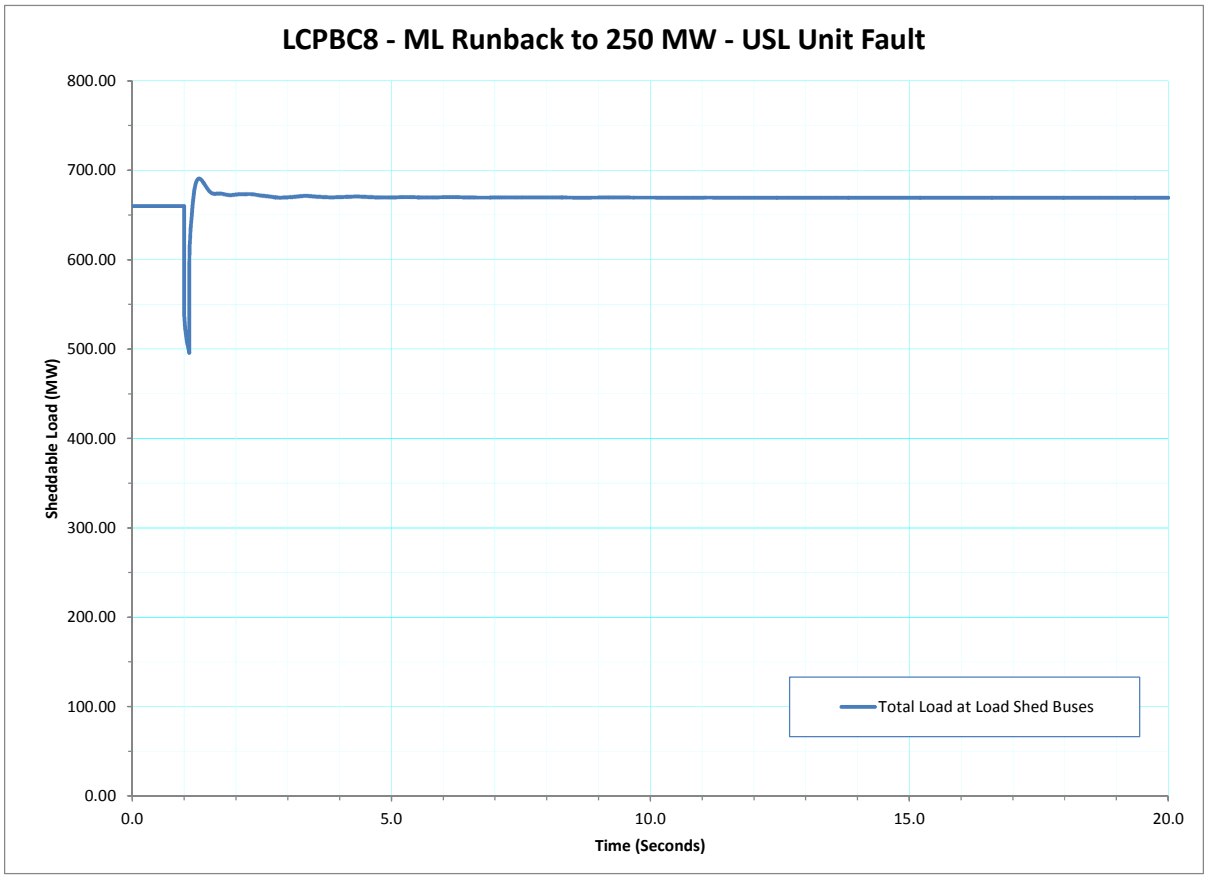

Figure 449 - LCPBC8 - ML Runback to 250 MW - USL Unit Fault - Sheddable Load (MW)

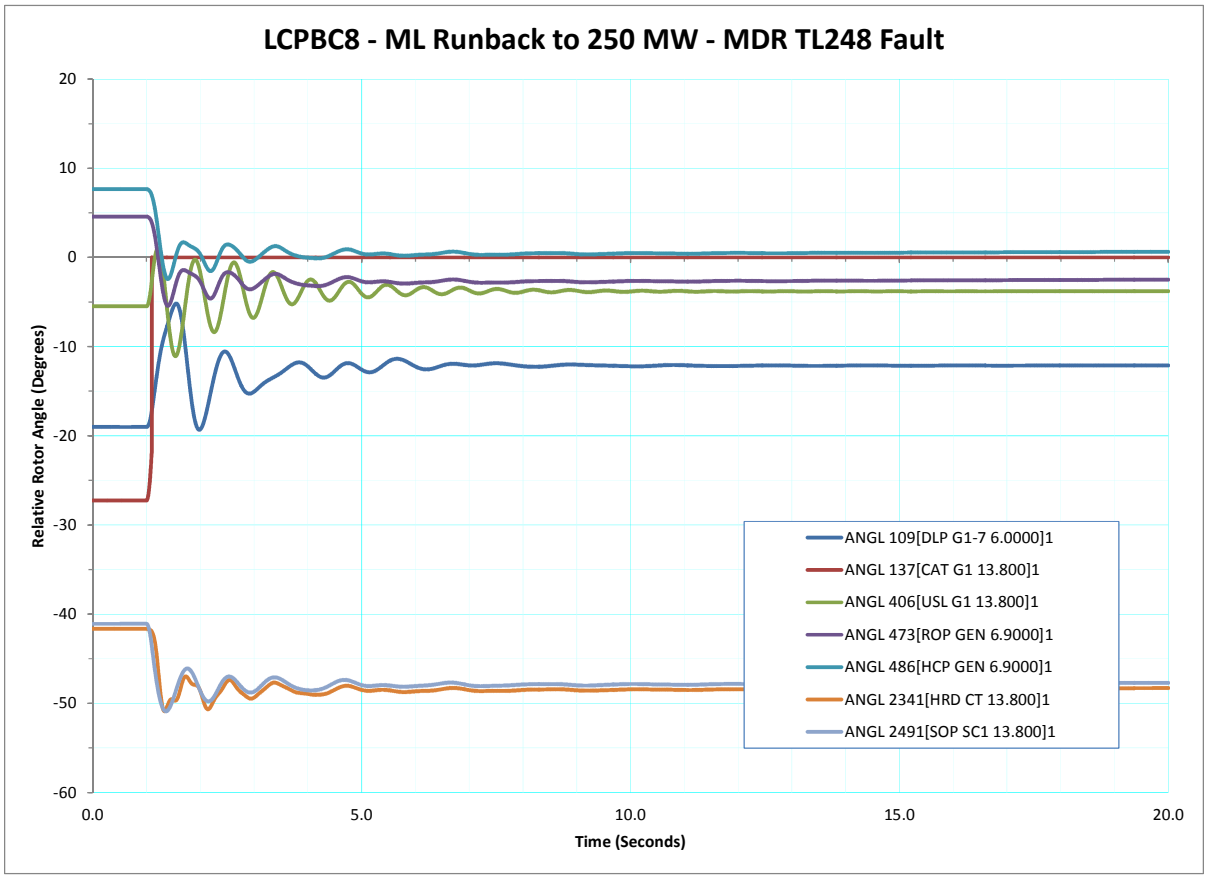

Figure 450 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

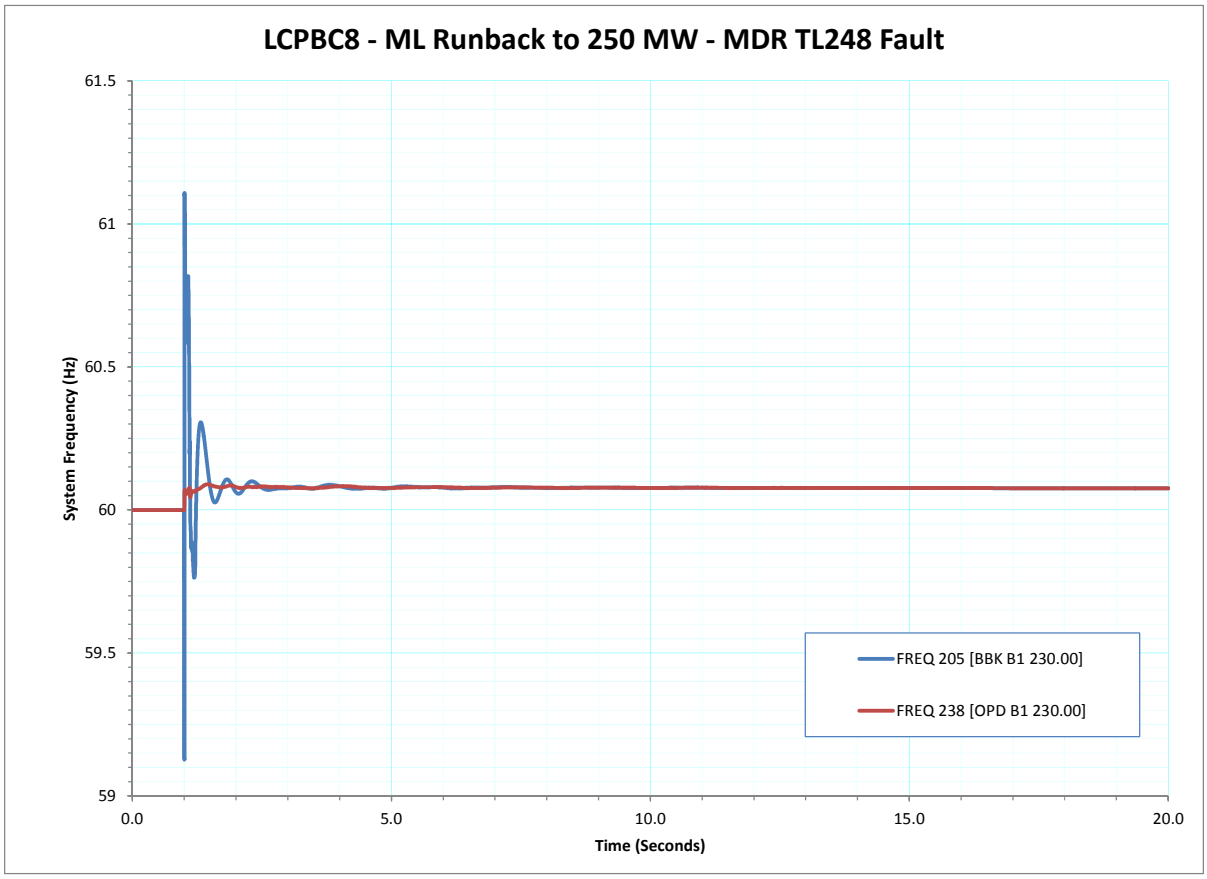

Figure 451 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - System Frequency (Hz)

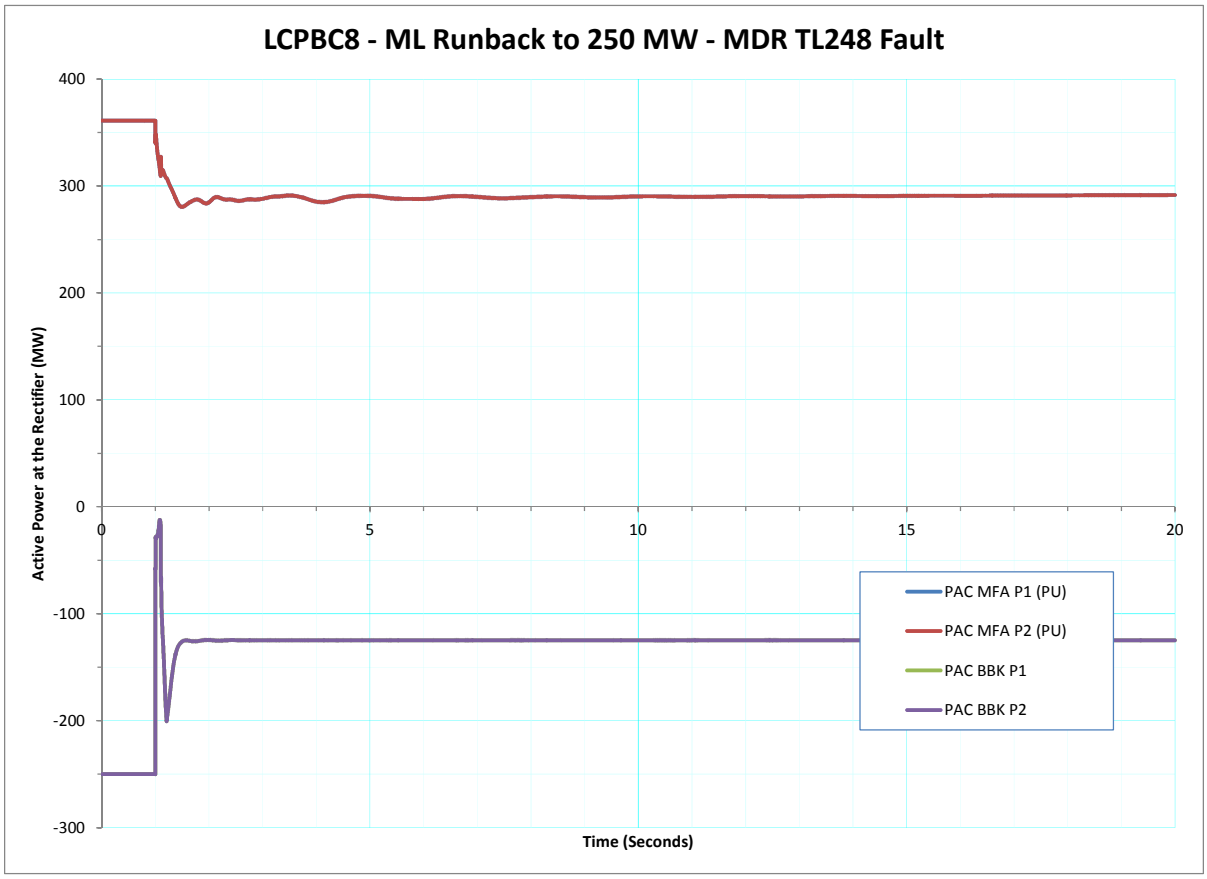

Figure 452 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

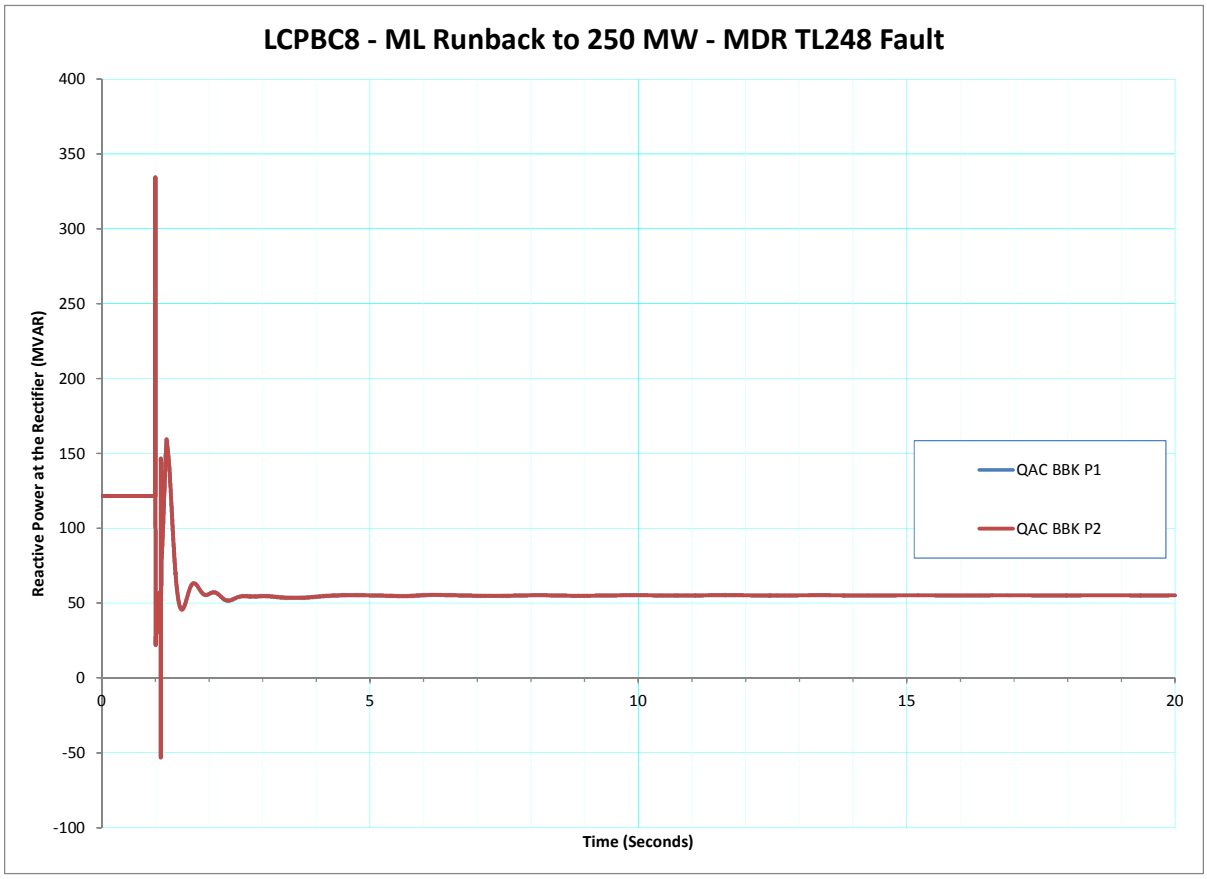

Figure 453 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

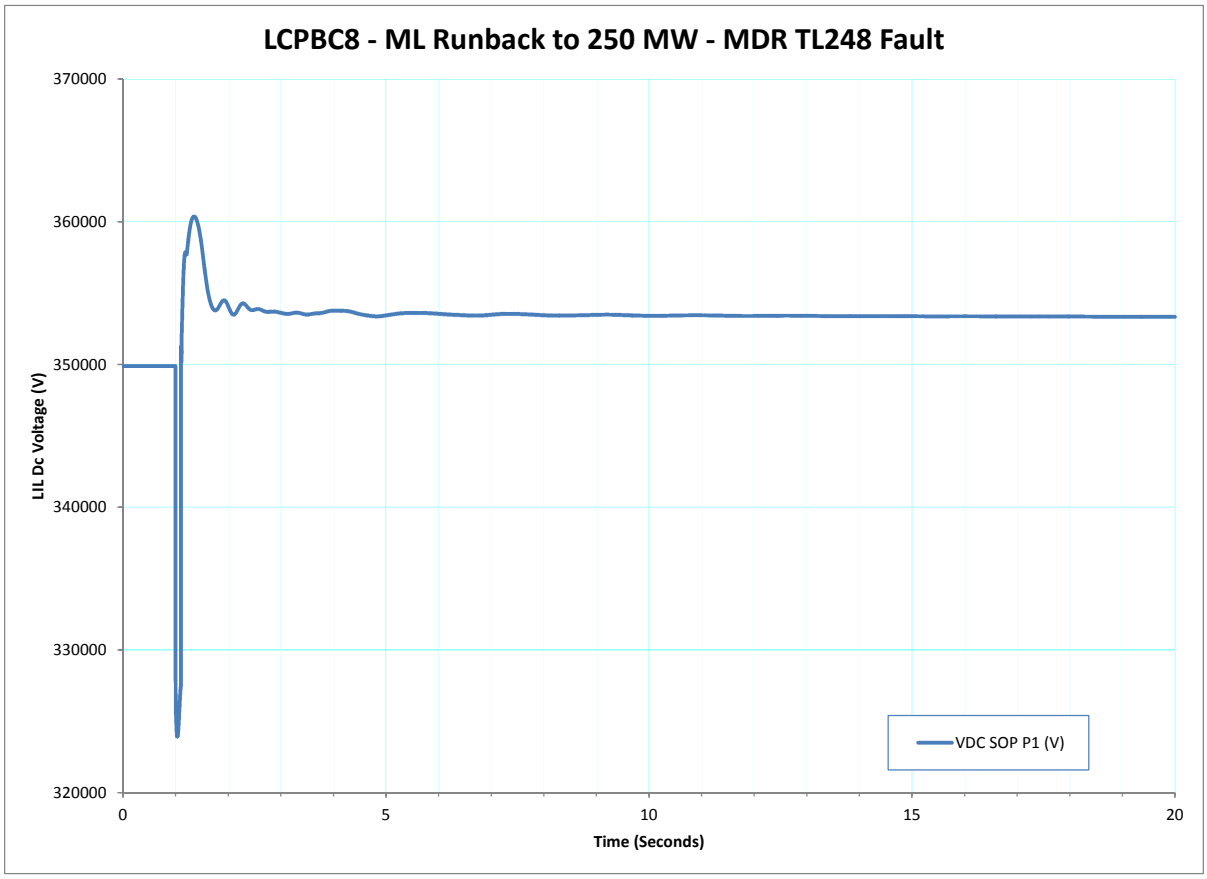

Figure 454 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - LIL Dc Voltage (V)

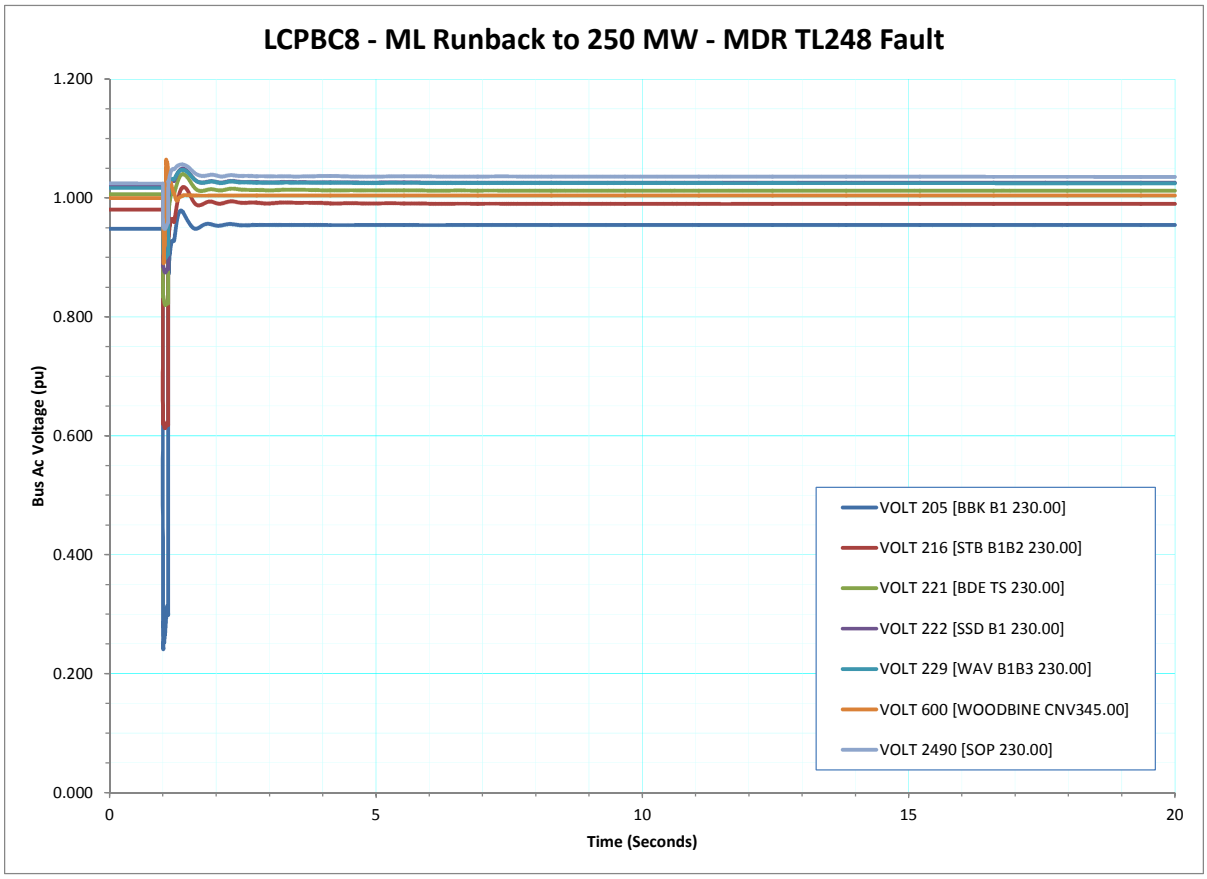

Figure 455 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

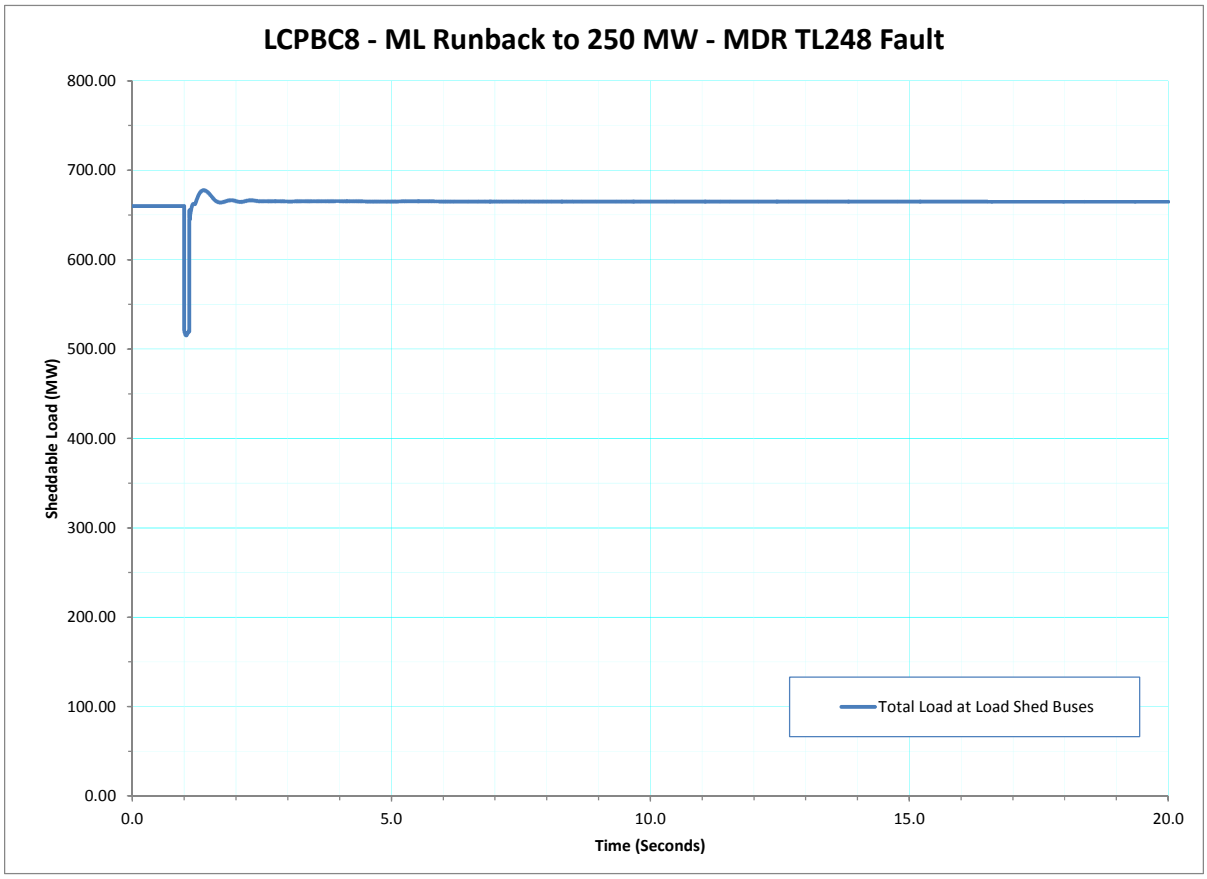

Figure 456 - LCPBC8 - ML Runback to 250 MW - MDR TL248 Fault - Sheddable Load (MW)

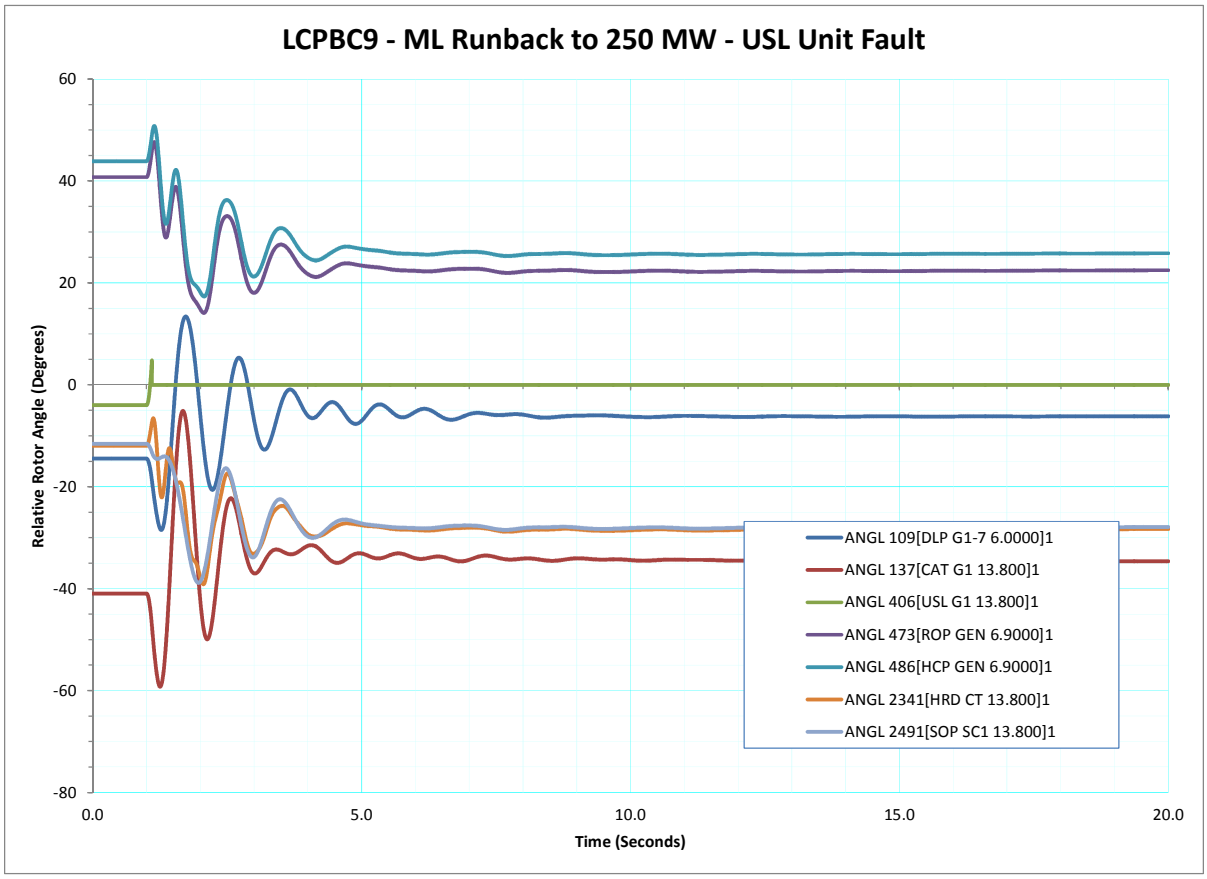

Figure 457 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

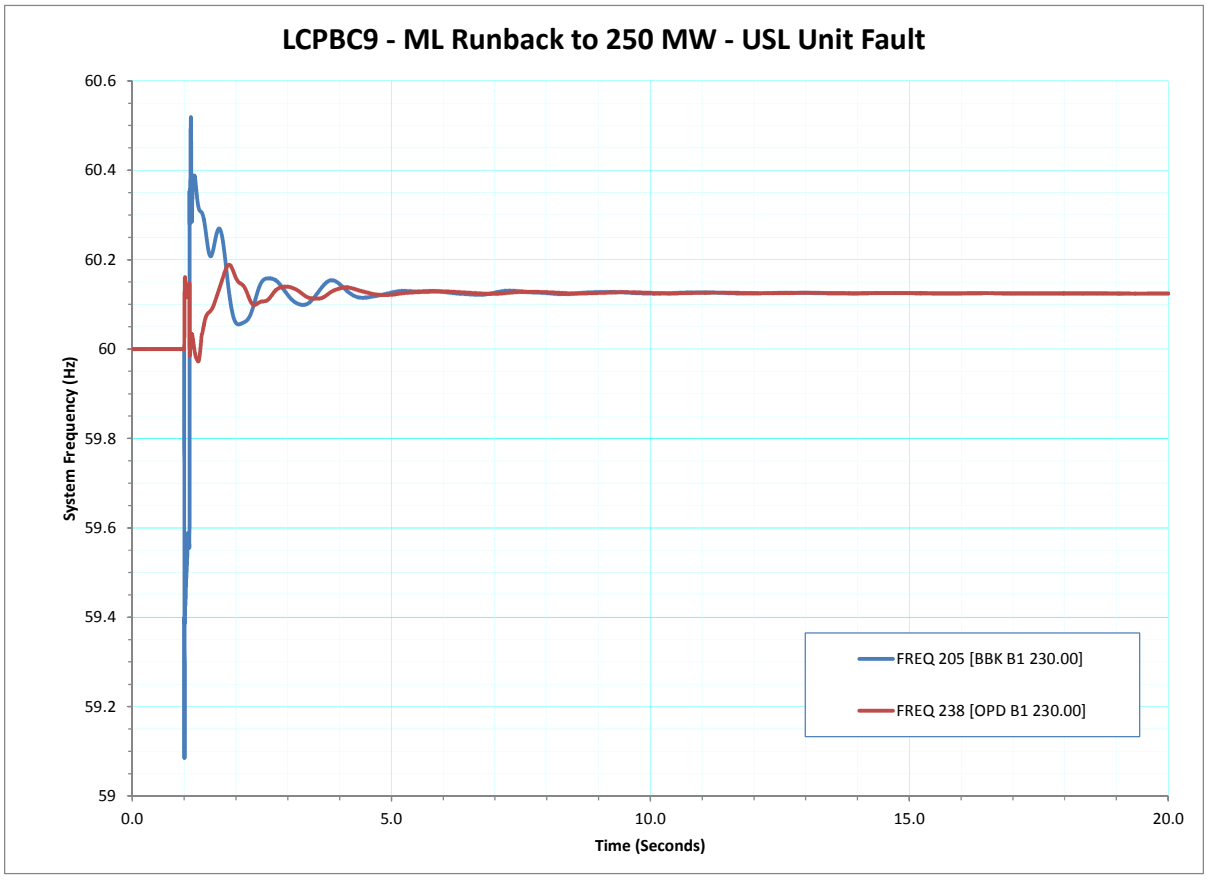

Figure 458 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - System Frequency (Hz)

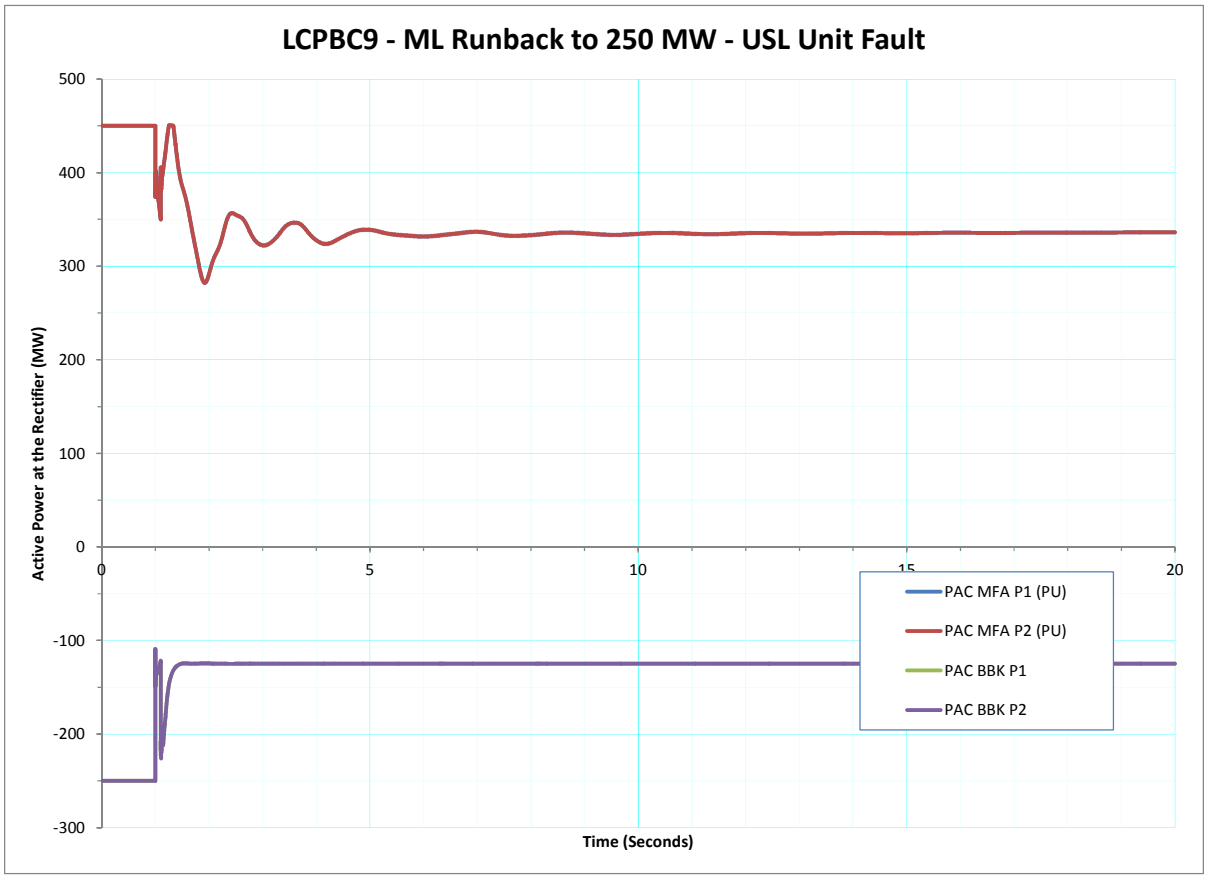

Figure 459 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - Active Power at the Rectifier (MW)

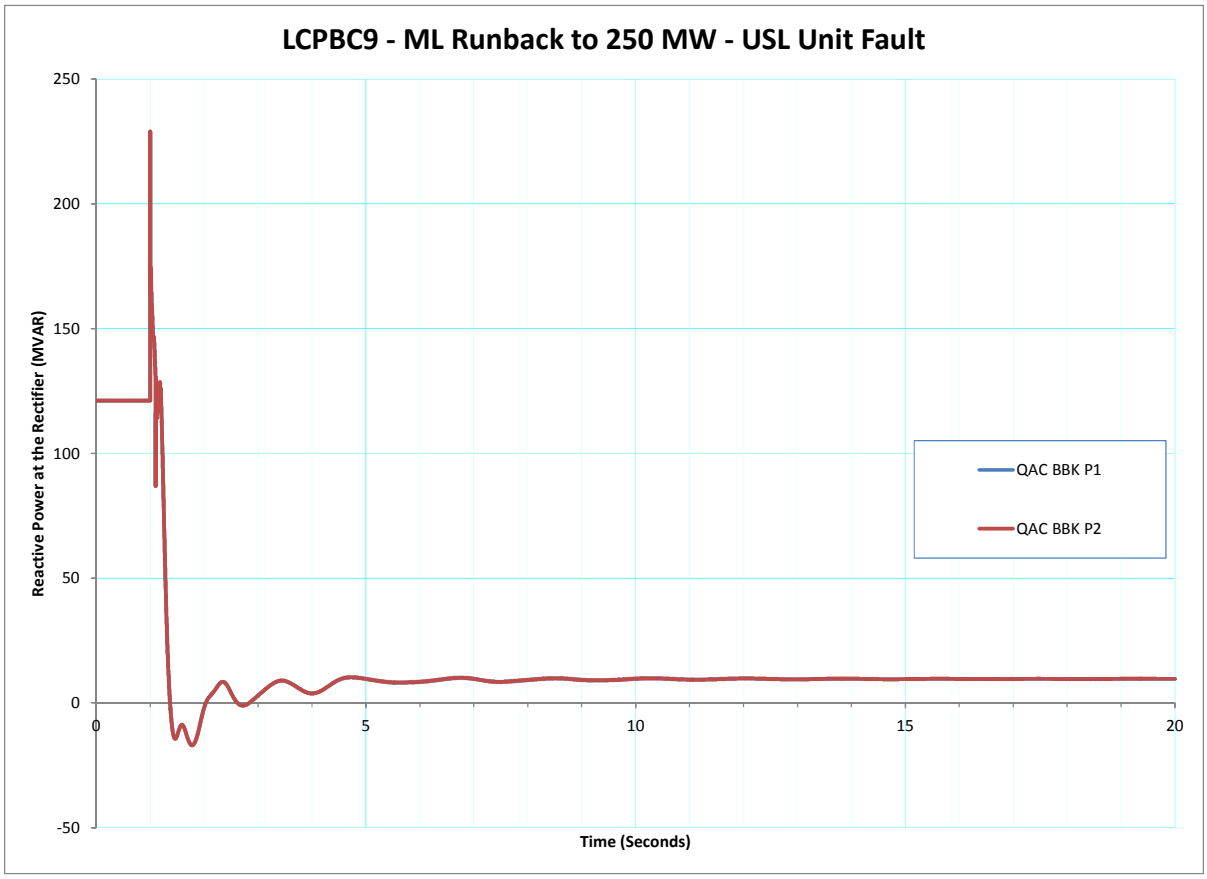

Figure 460 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

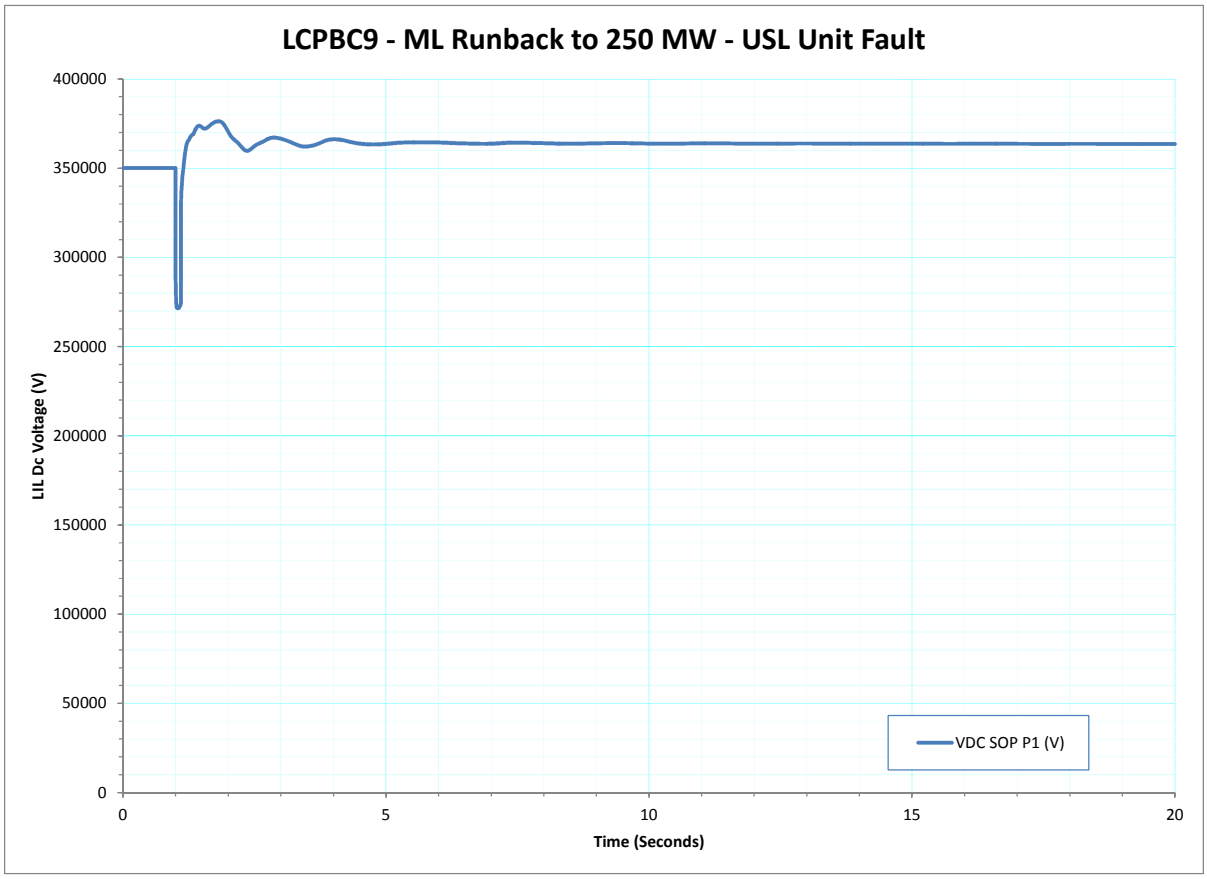

Figure 461 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - LIL Dc Voltage (V)

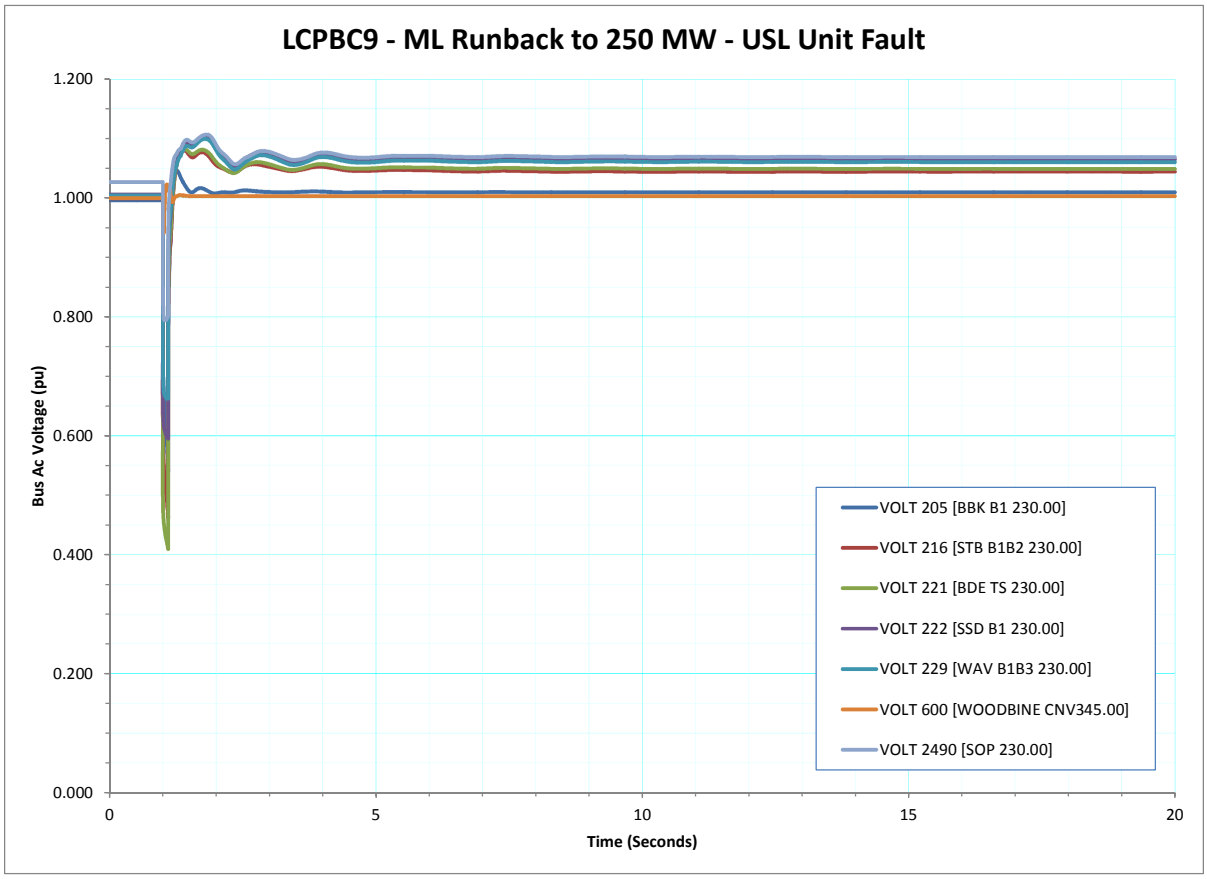

Figure 462 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - Bus Ac Voltage (pu)

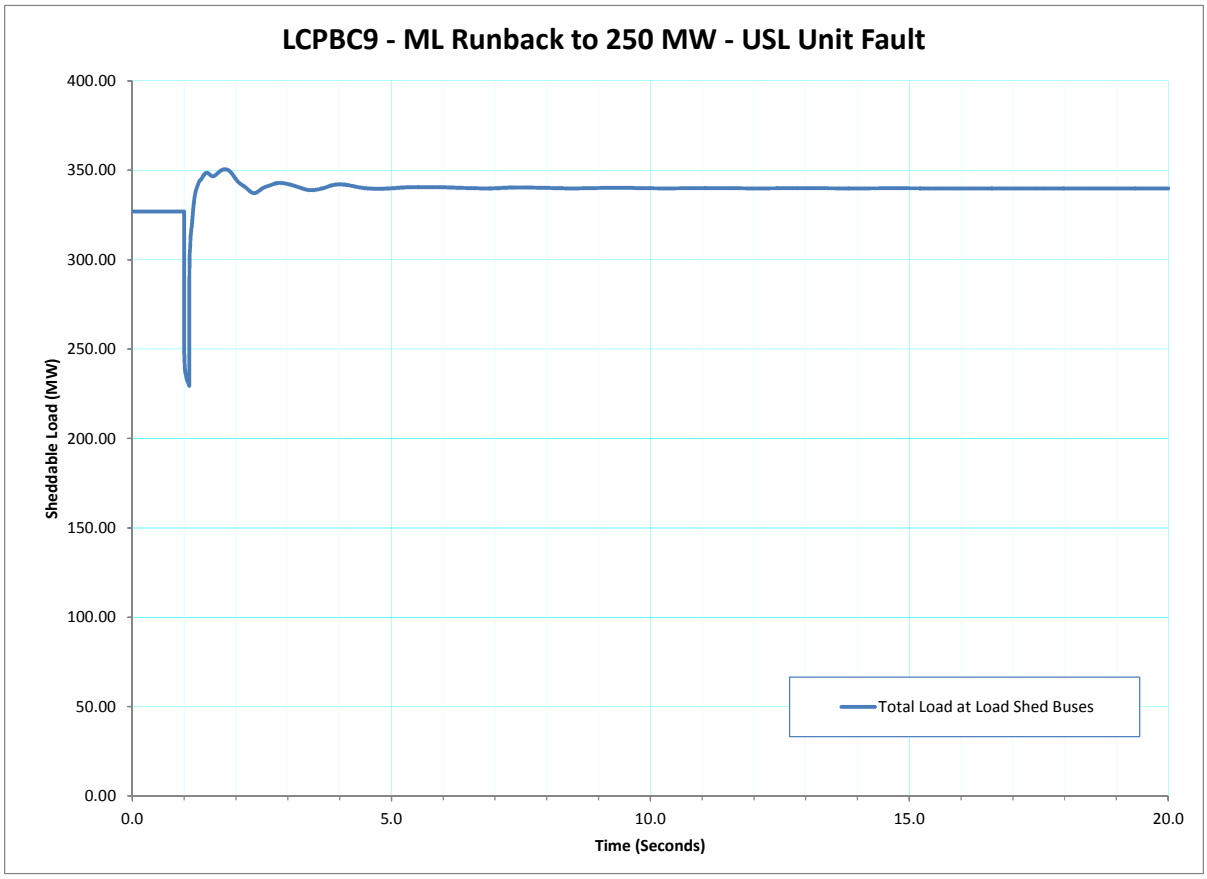

Figure 463 - LCPBC9 - ML Runback to 250 MW - USL Unit Fault - Sheddable Load (MW)

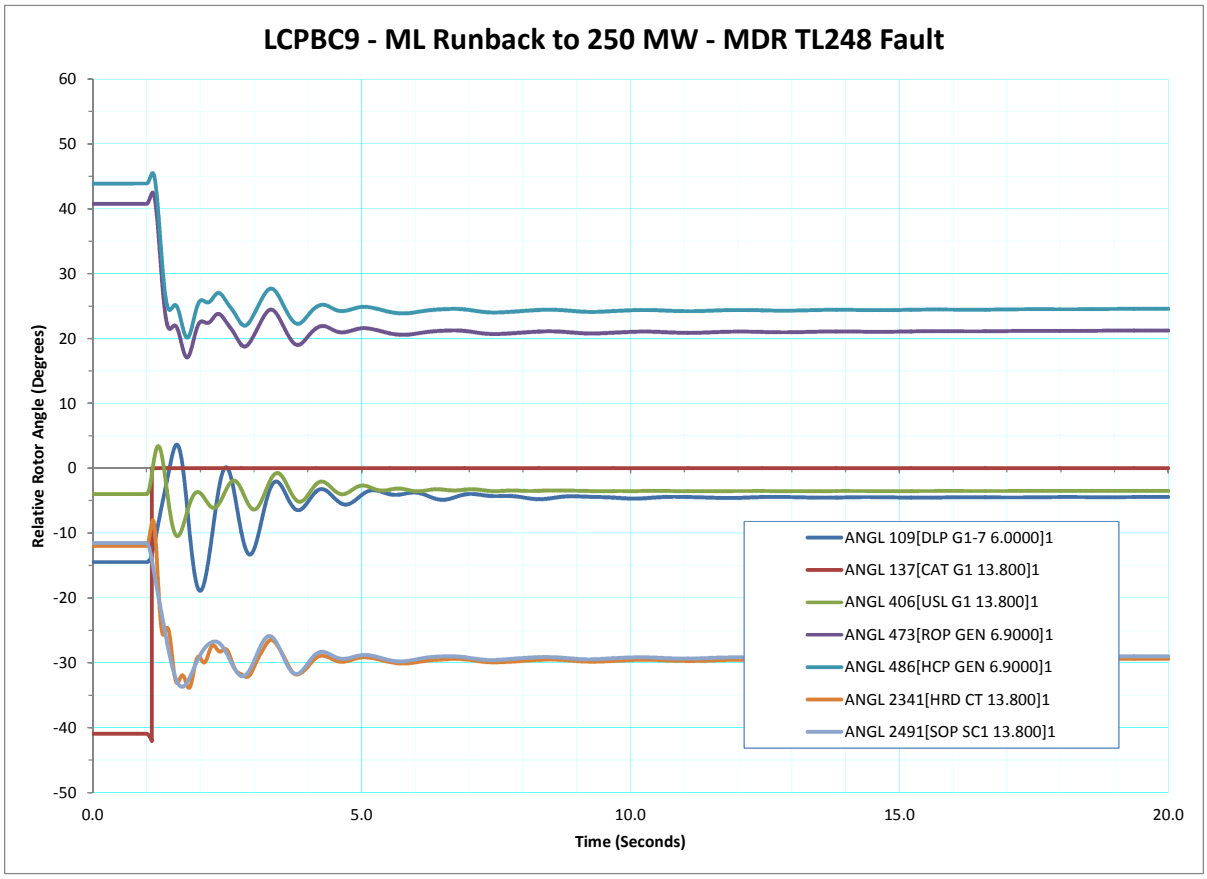

Figure 464 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

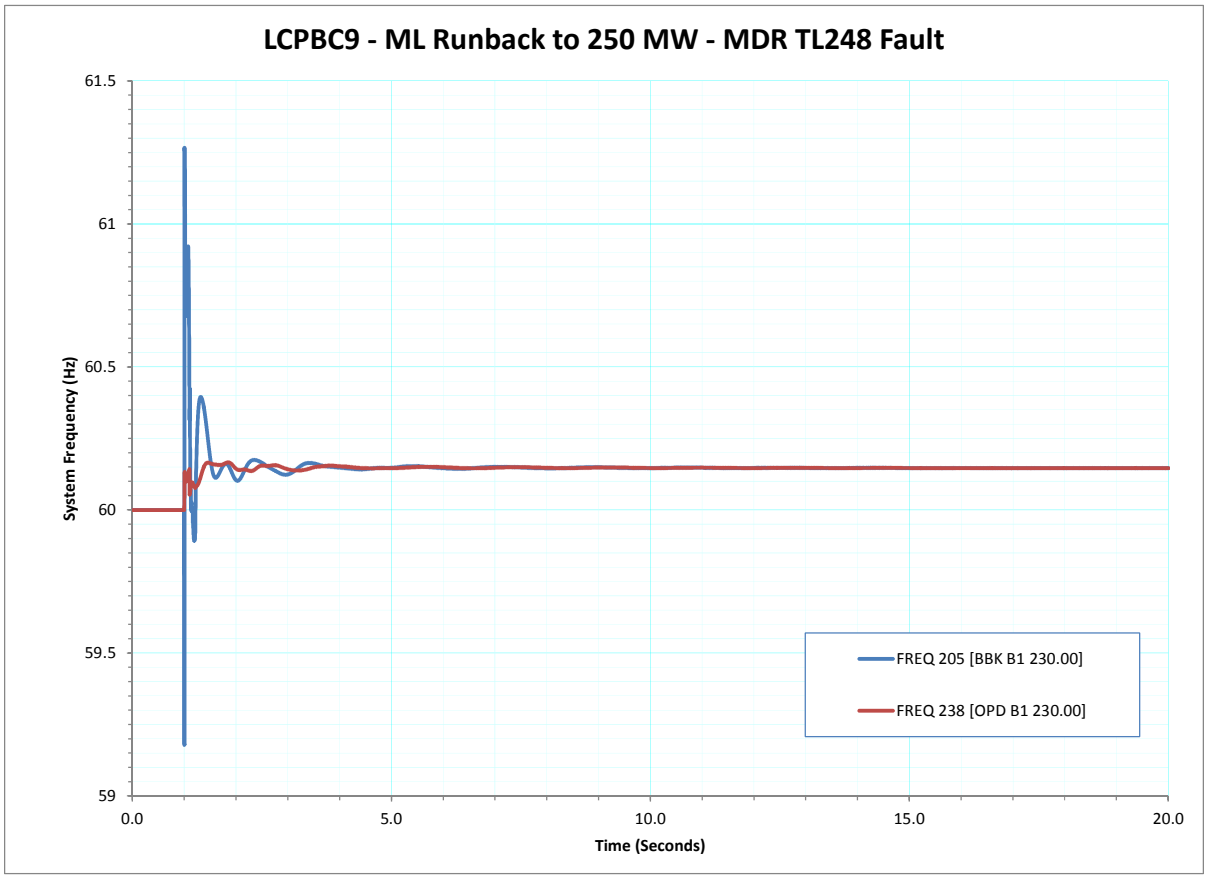

Figure 465 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - System Frequency (Hz)

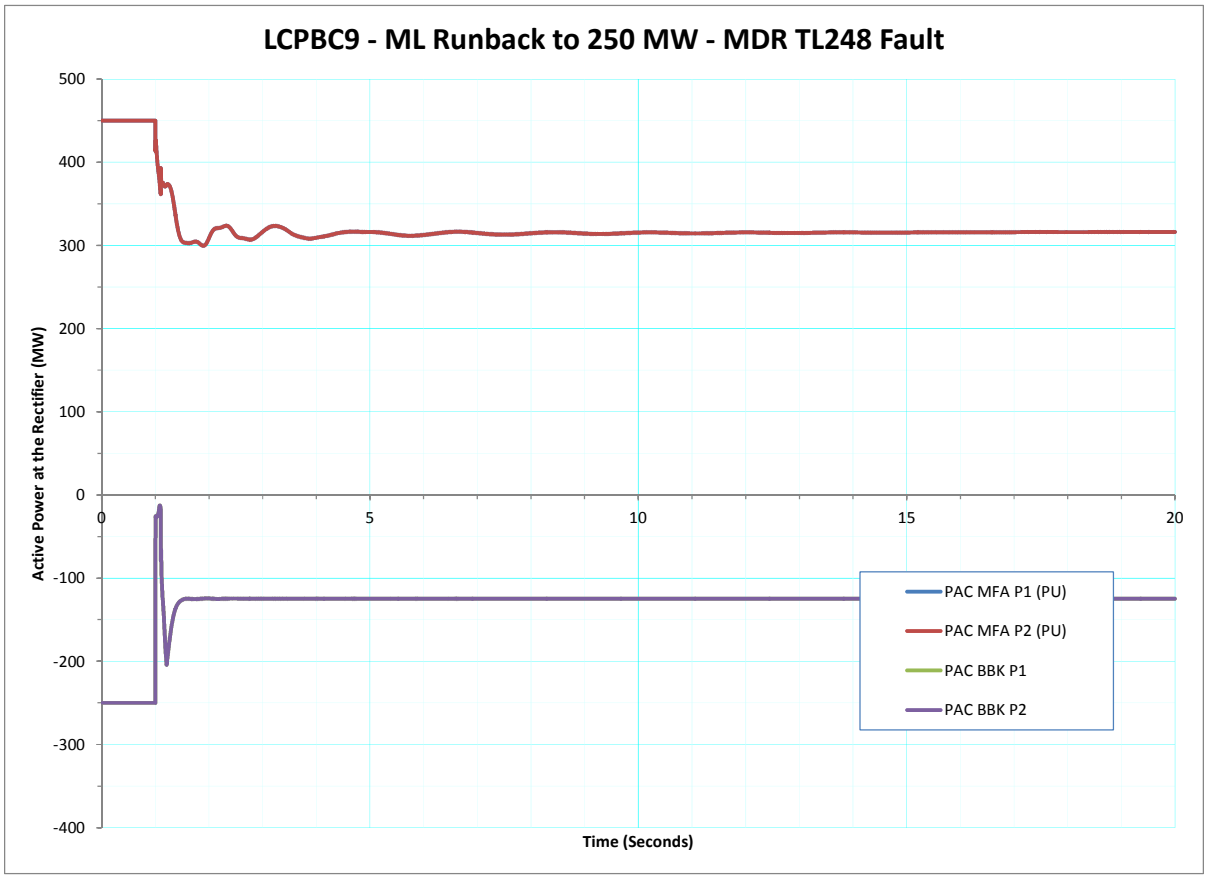

Figure 466 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

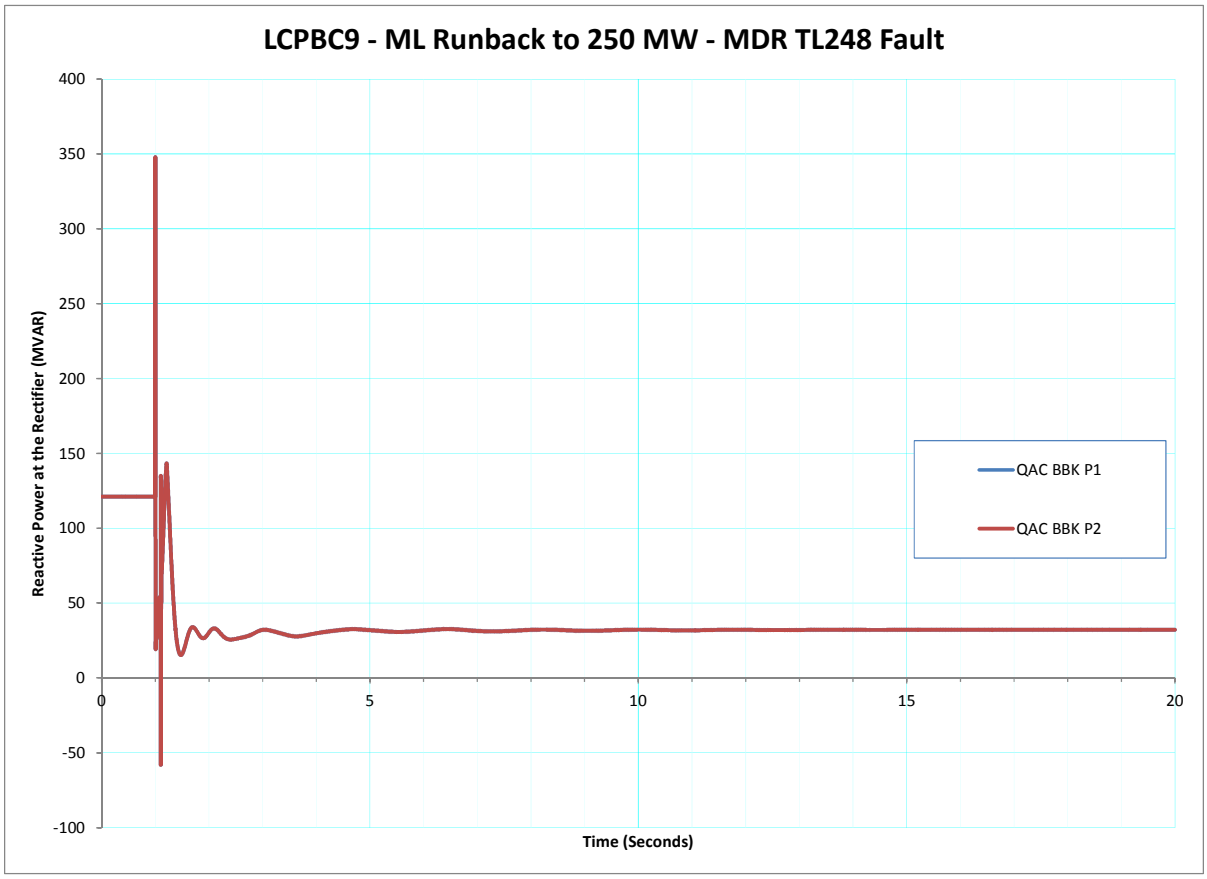

Figure 467 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

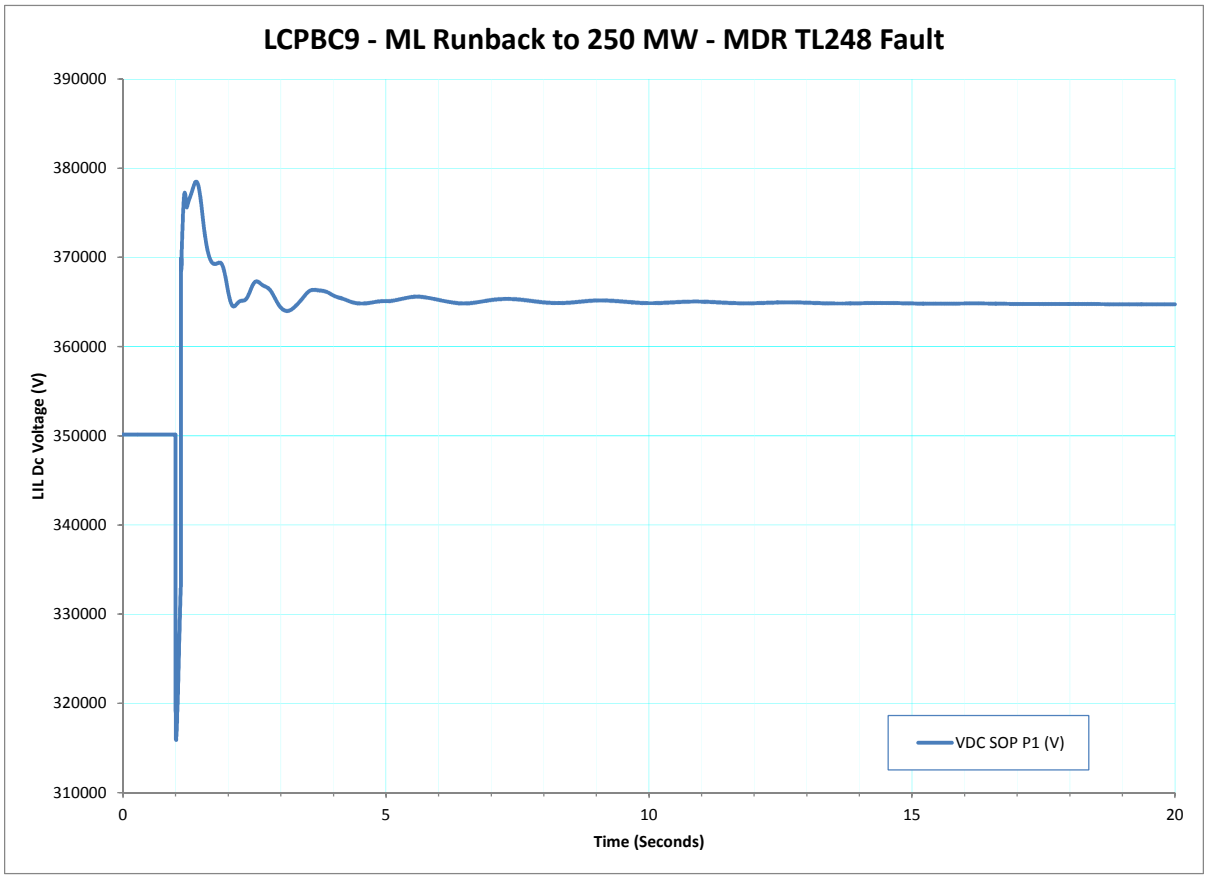

Figure 468 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - LIL Dc Voltage (V)

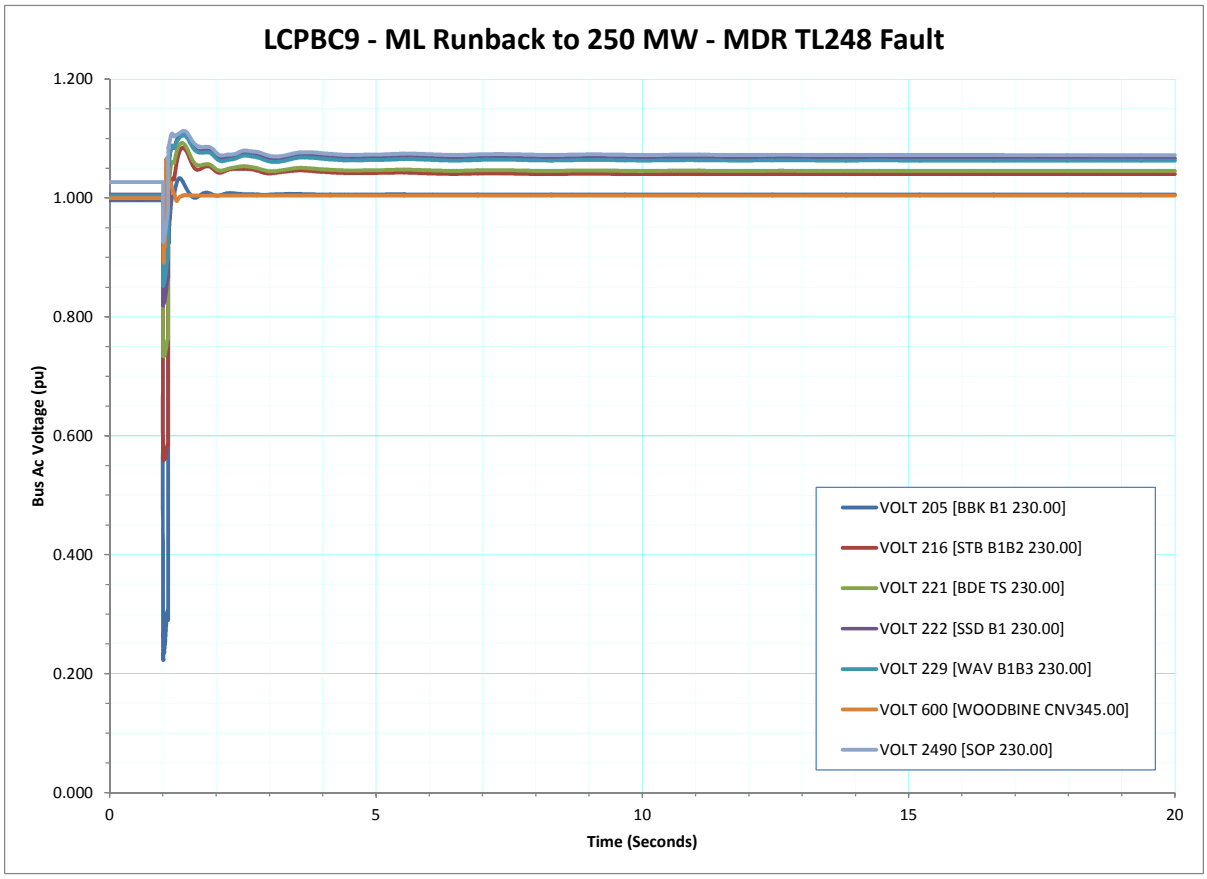

Figure 469 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

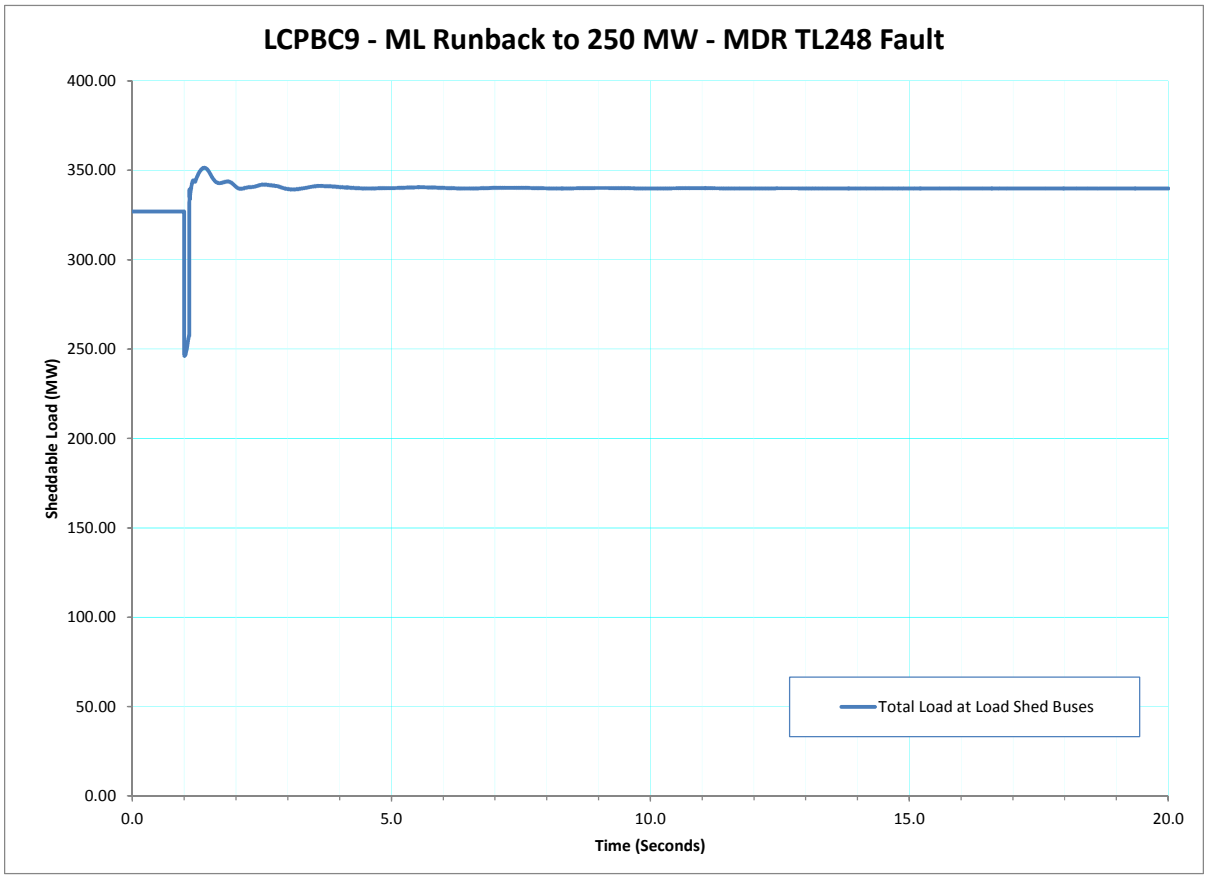

Figure 470 - LCPBC9 - ML Runback to 250 MW - MDR TL248 Fault - Sheddable Load (MW)

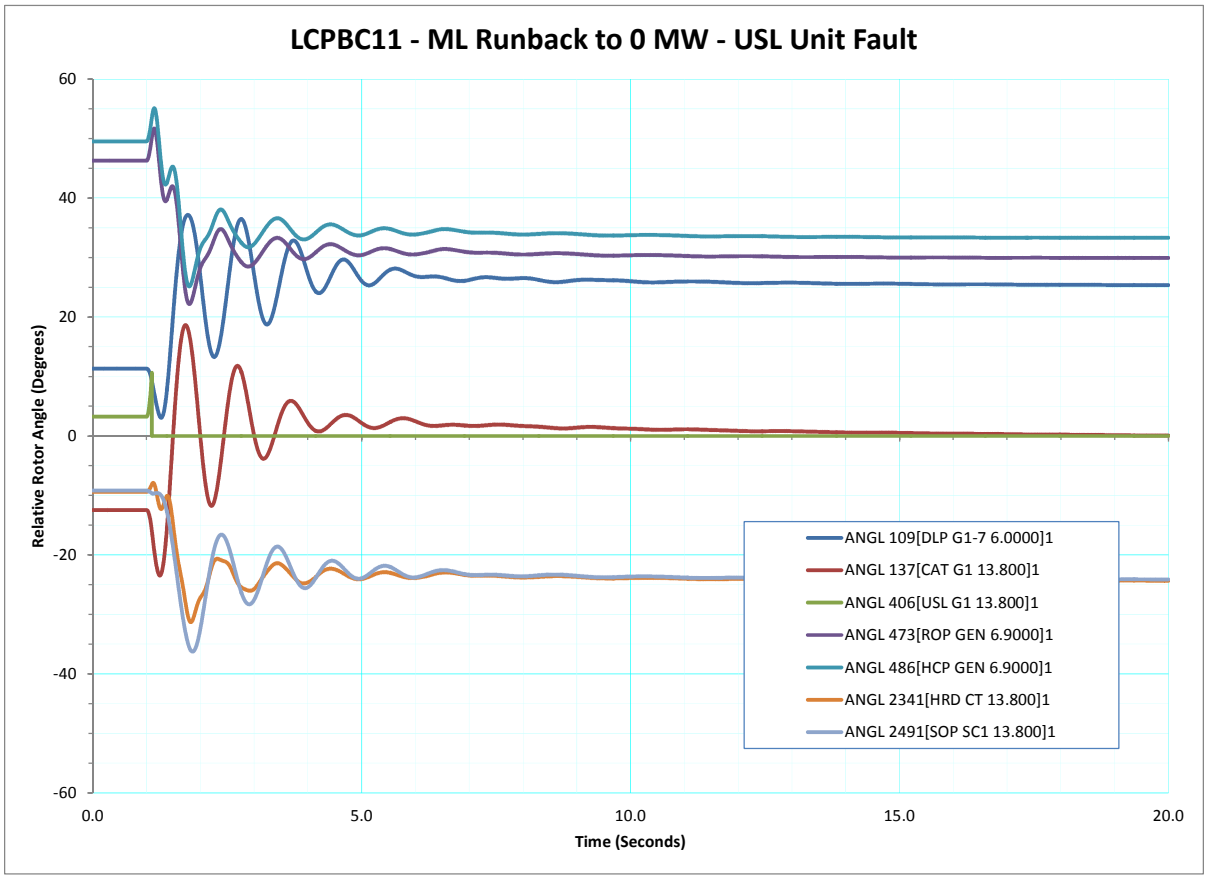

Figure 471 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - Relative Rotor Angle (Degrees)

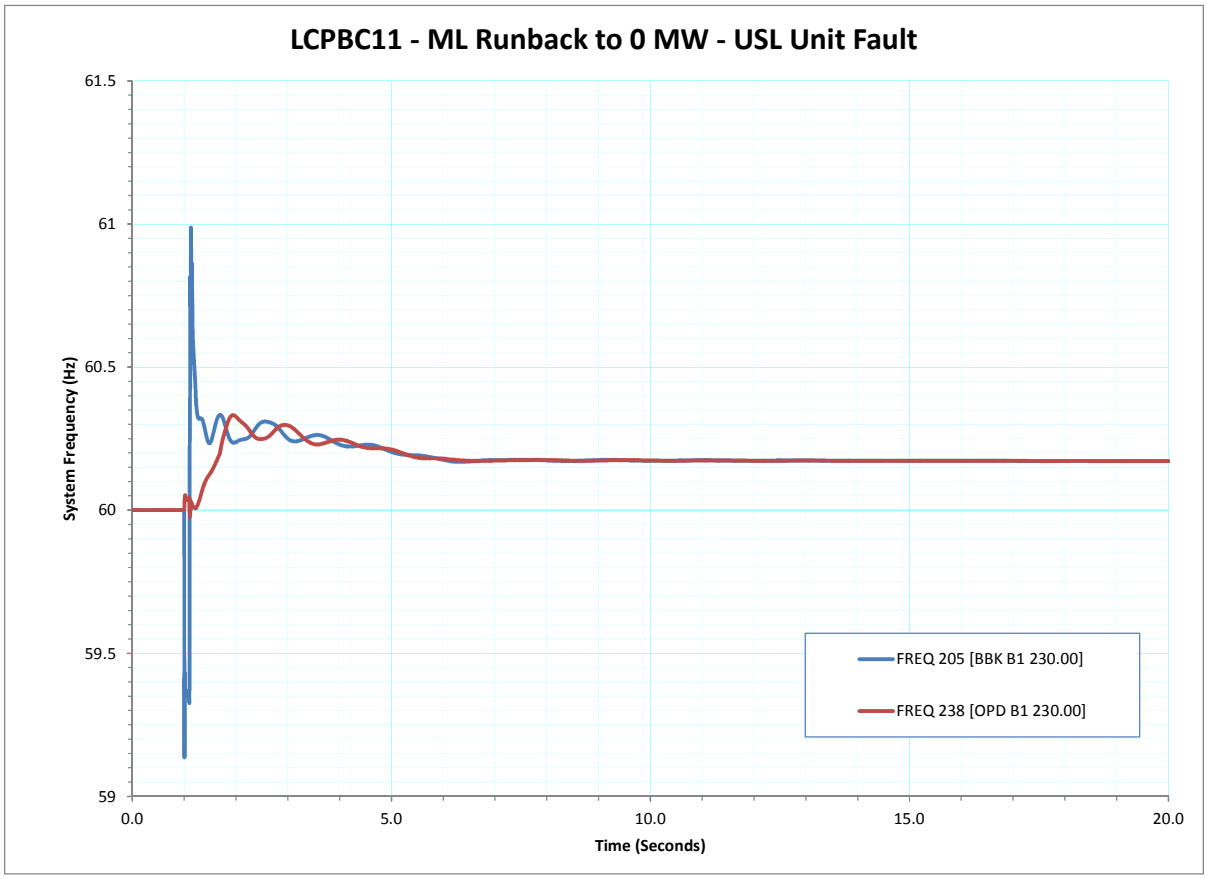

Figure 472 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - System Frequency (Hz)

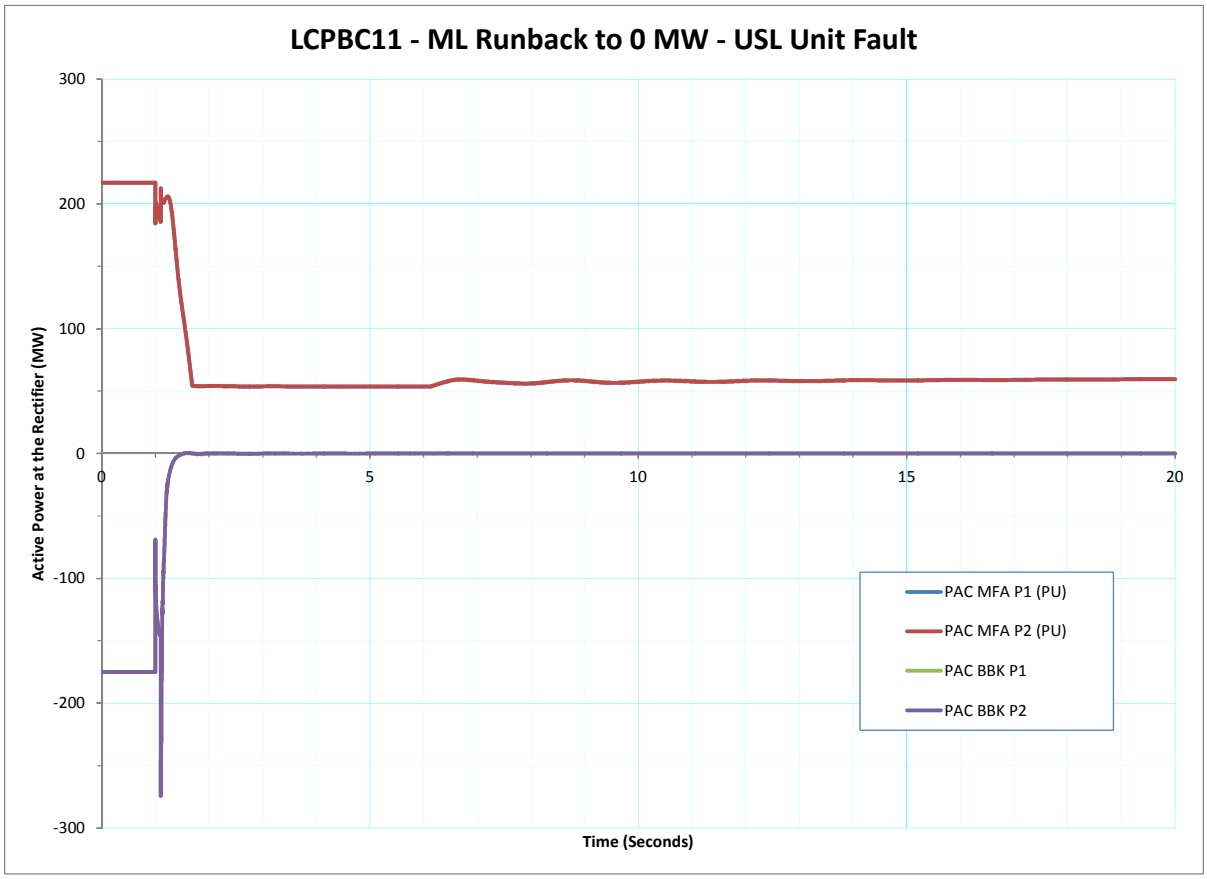

Figure 473 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - Active Power at the Rectifier (MW)

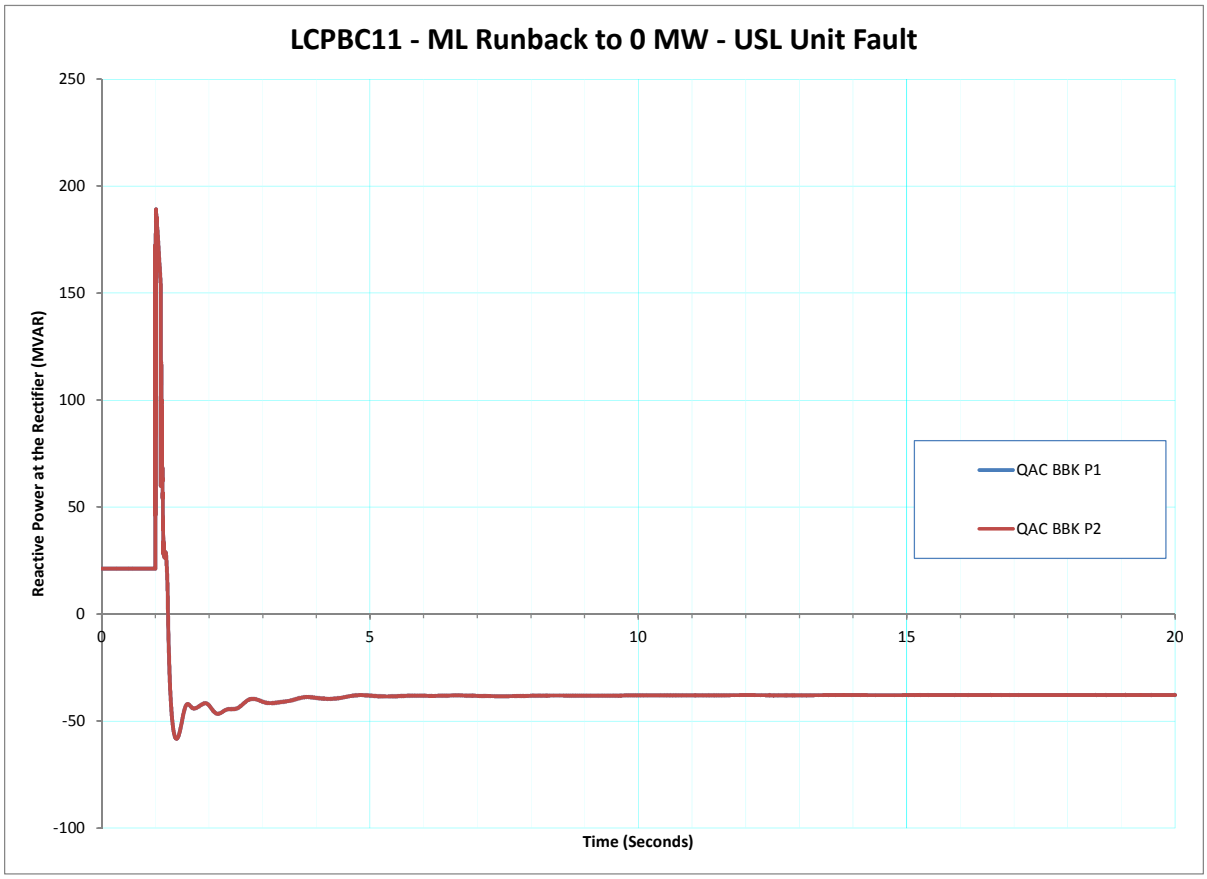

Figure 474 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - Reactive Power at the Rectifier (MVAR)

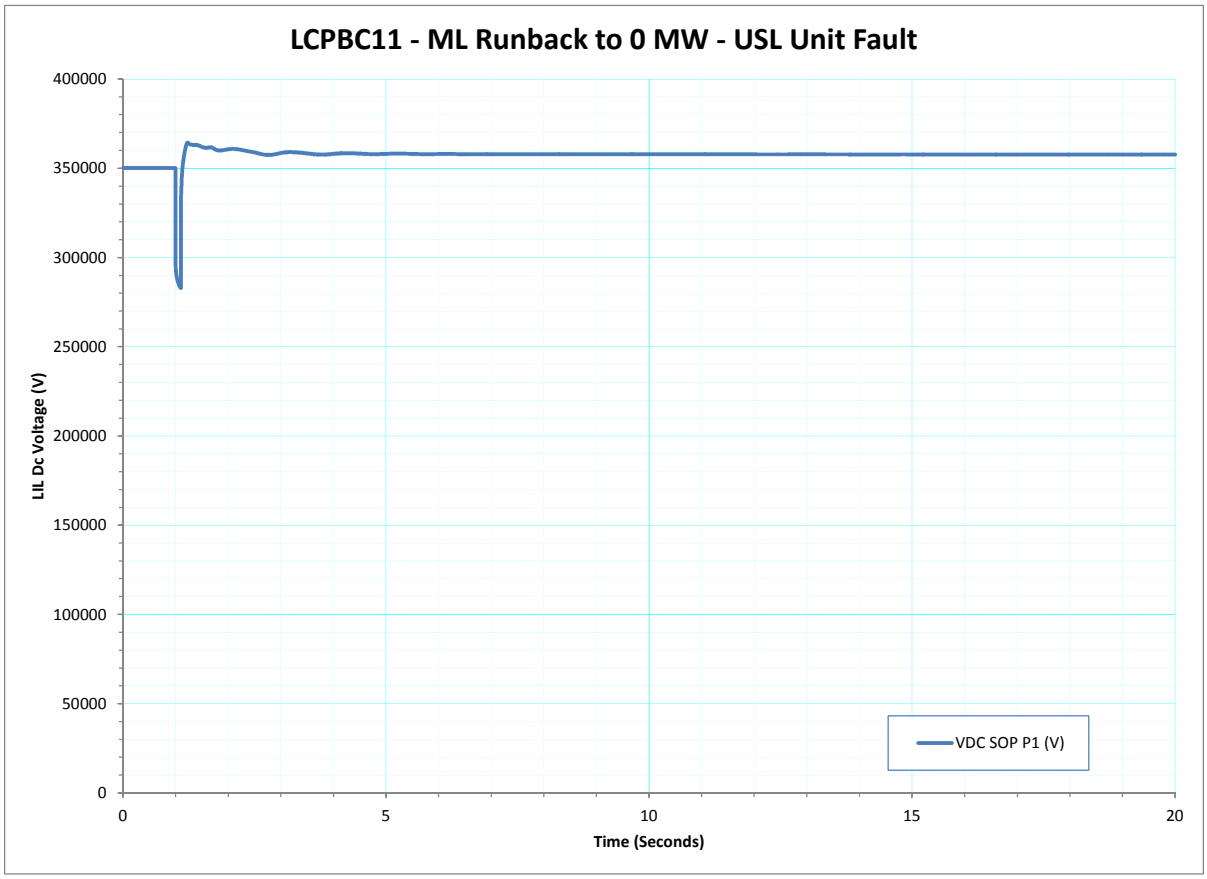

Figure 475 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - LIL Dc Voltage (V)

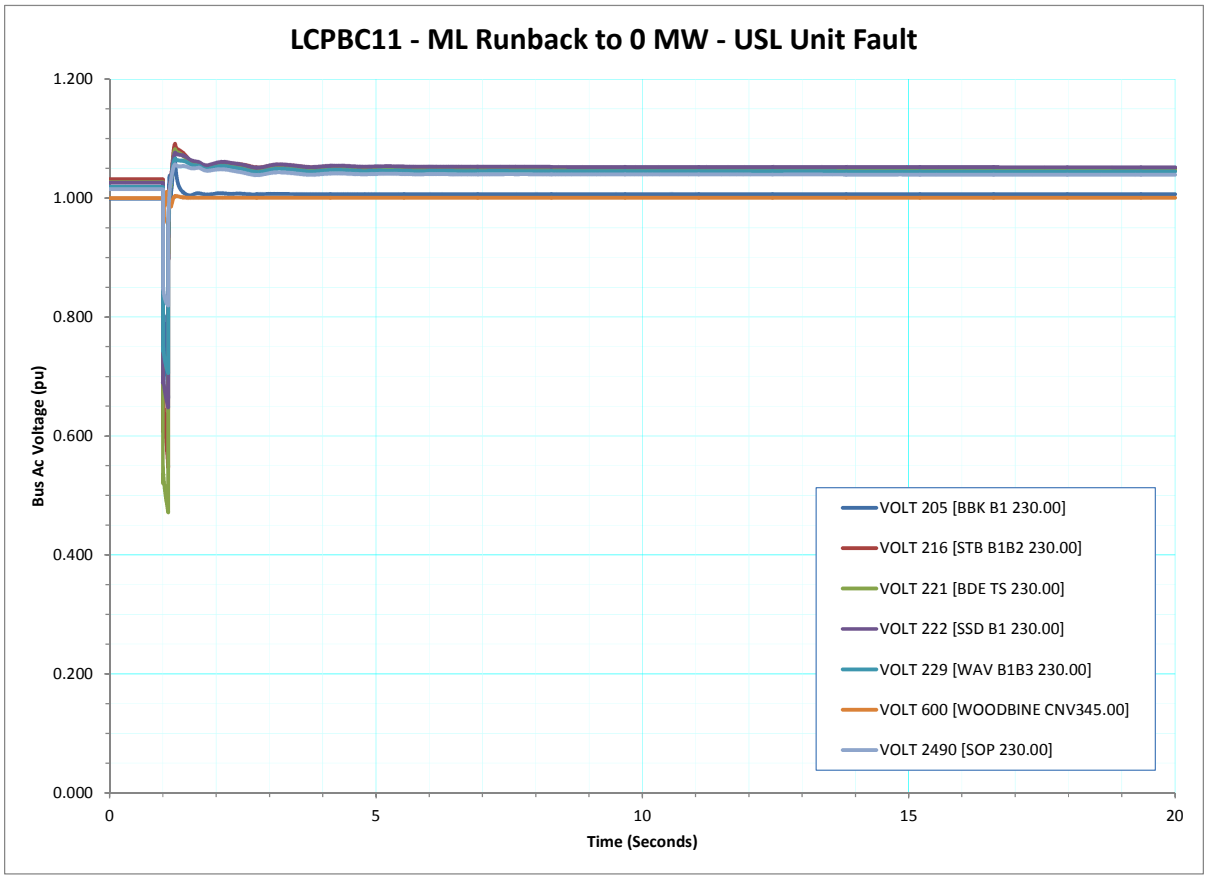

Figure 476 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - Bus Ac Voltage (pu)

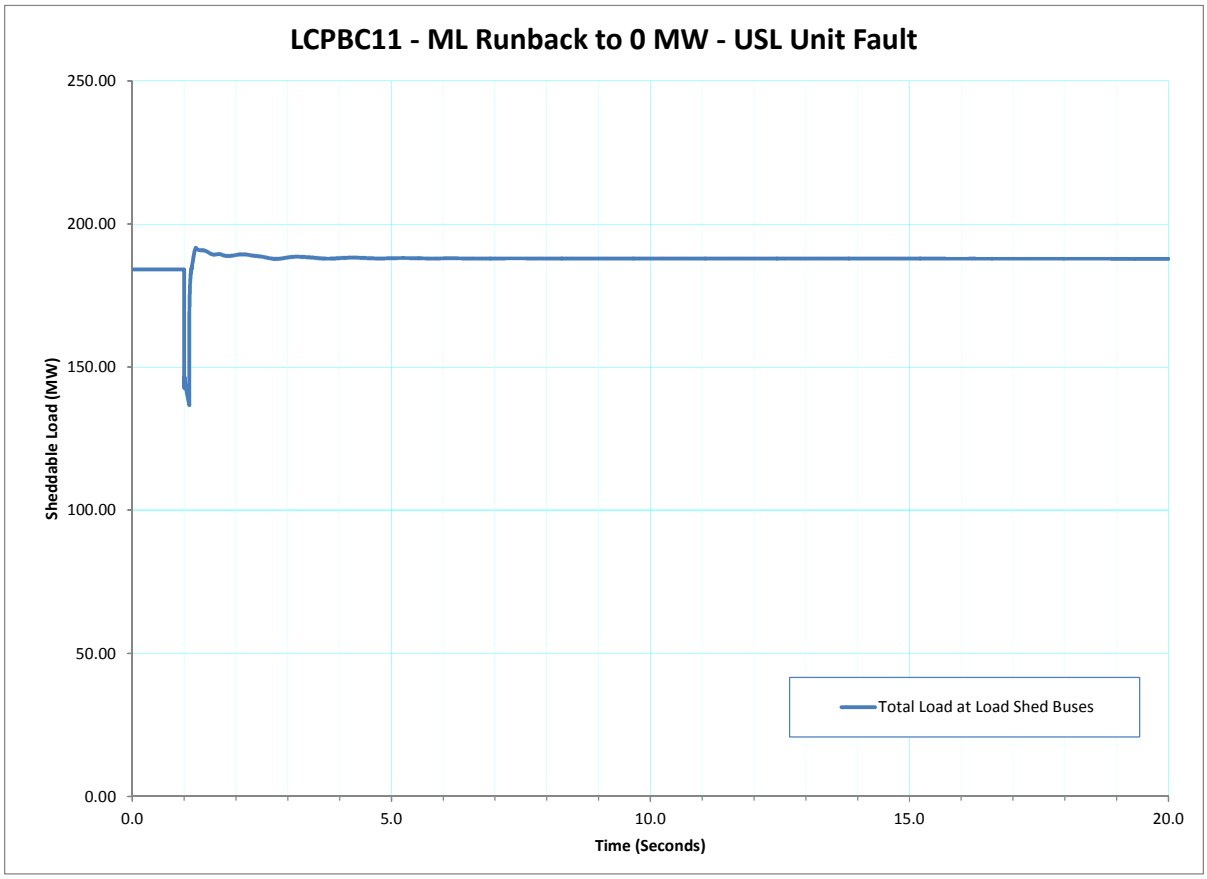

Figure 477 - LCPBC11 - ML Runback to 0 MW - USL Unit Fault - Sheddable Load (MW)

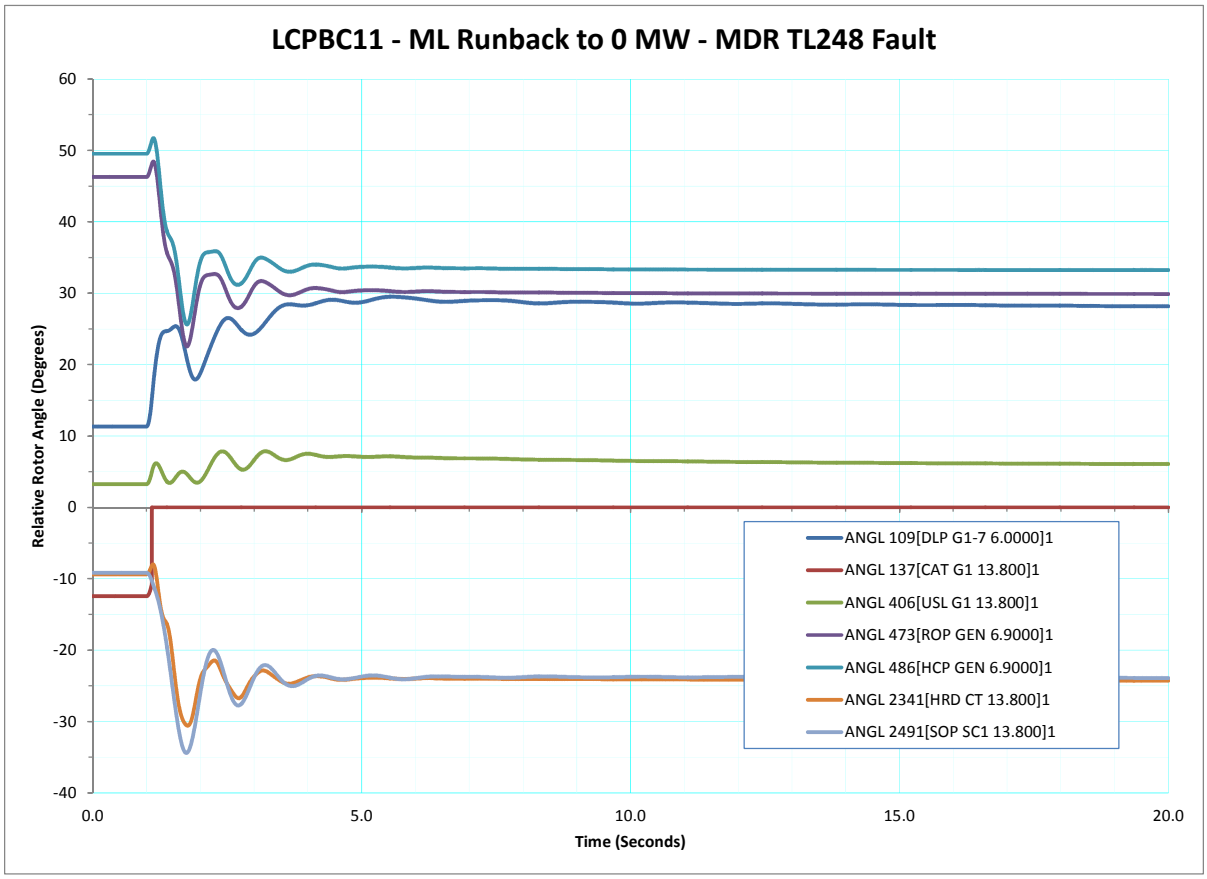

Figure 478 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - Relative Rotor Angle (Degrees)

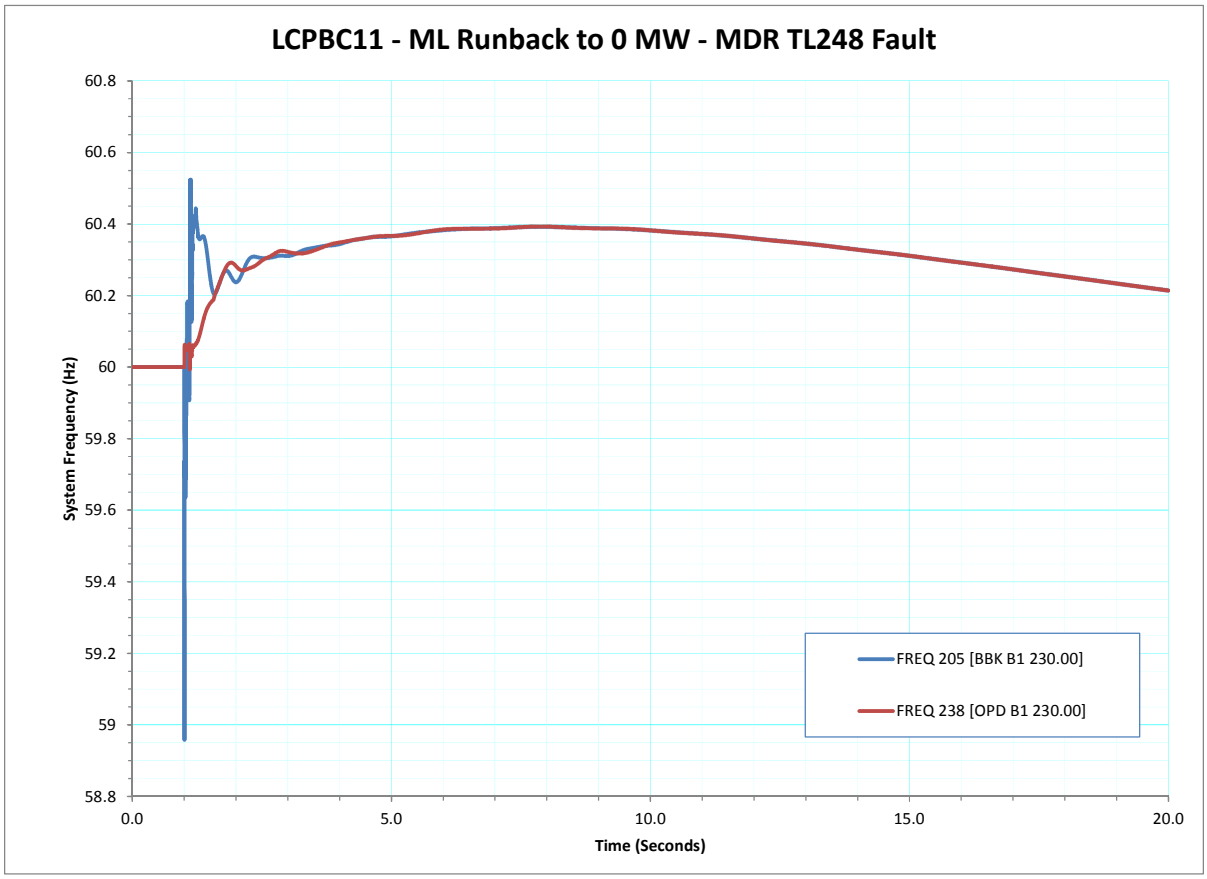

Figure 479 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - System Frequency (Hz)

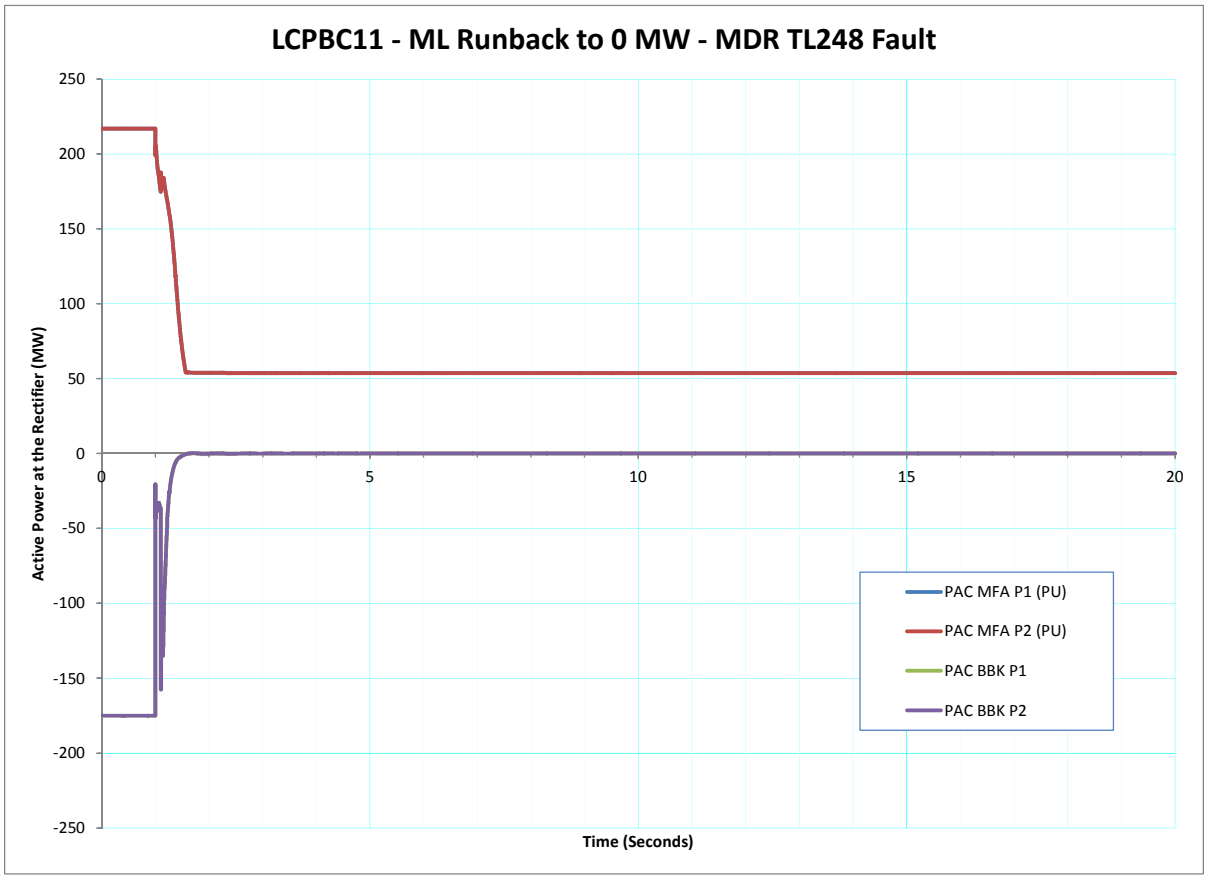

Figure 480 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - Active Power at the Rectifier (MW)

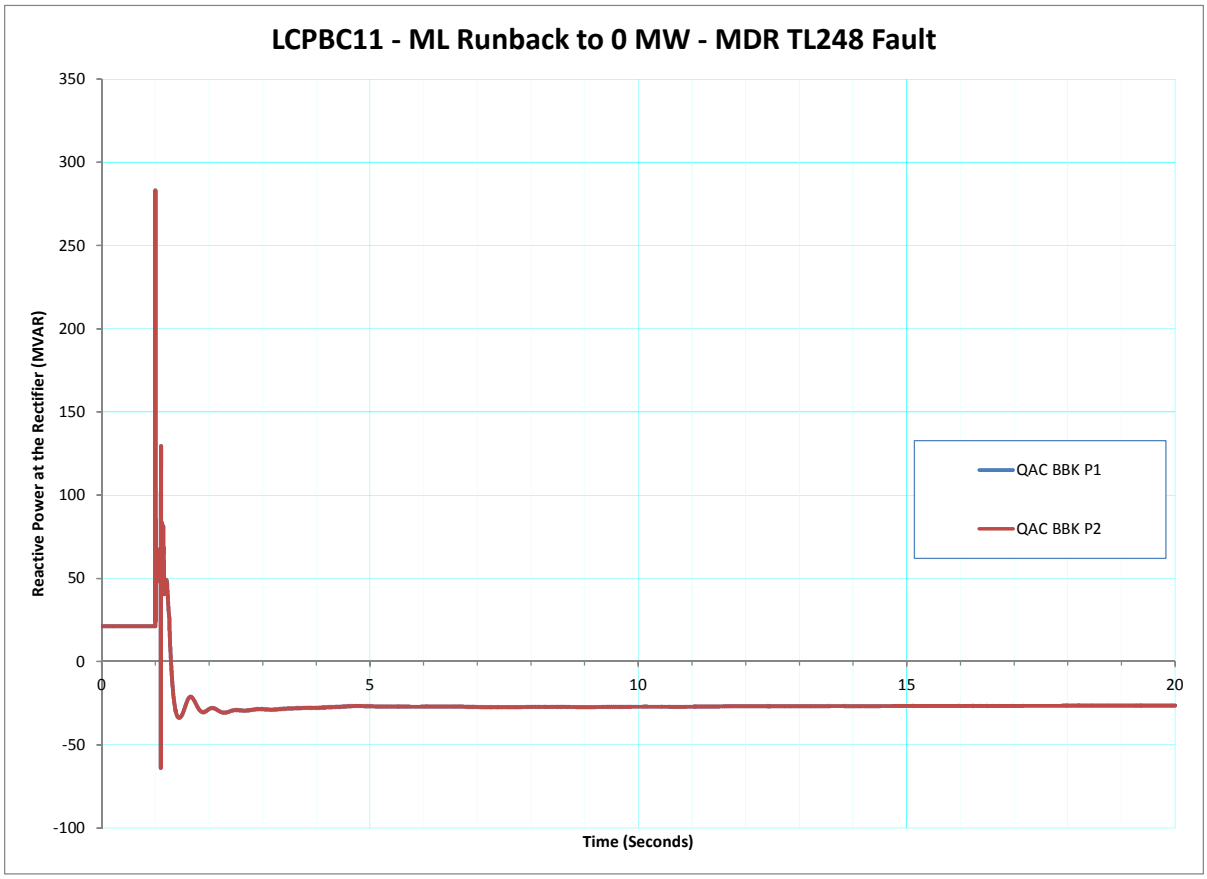

Figure 481 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - Reactive Power at the Rectifier (MVAR)

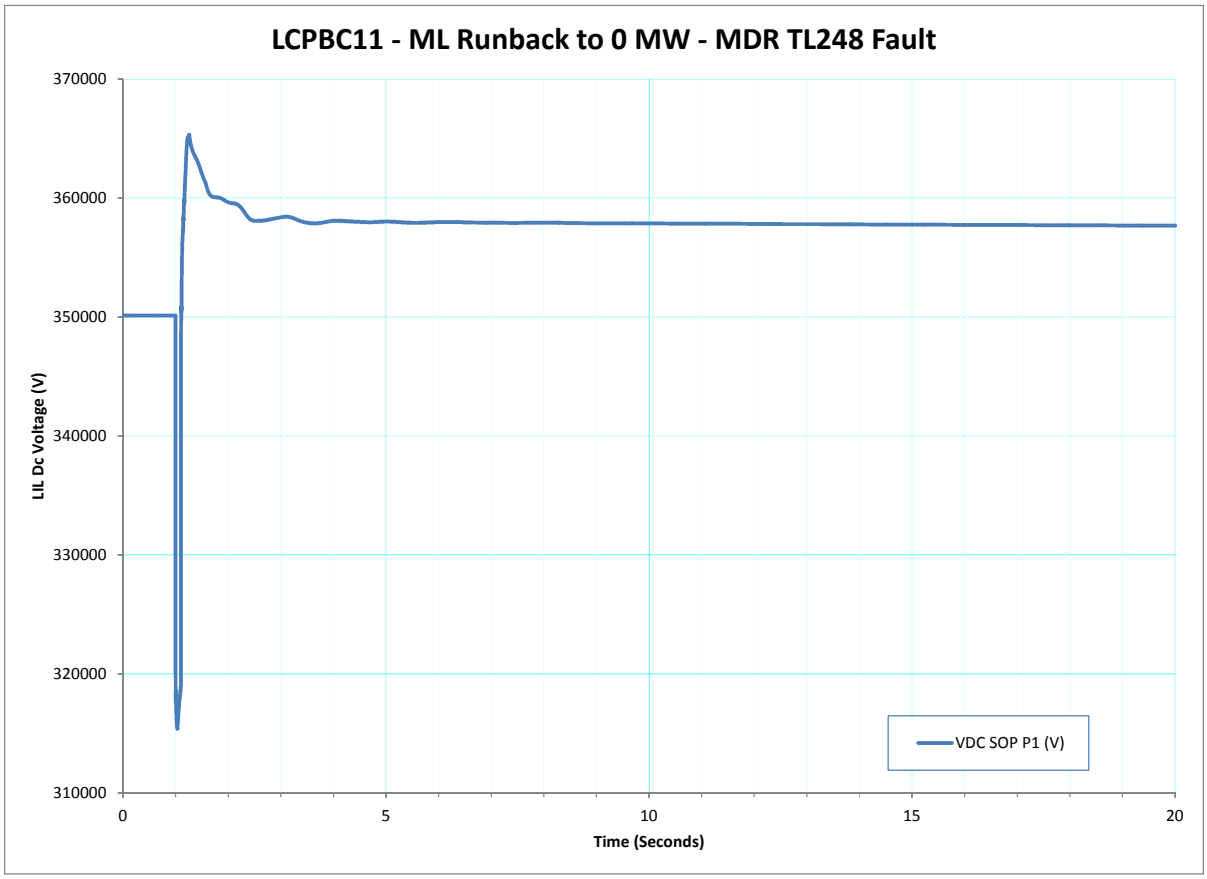

Figure 482 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - LIL Dc Voltage (V)

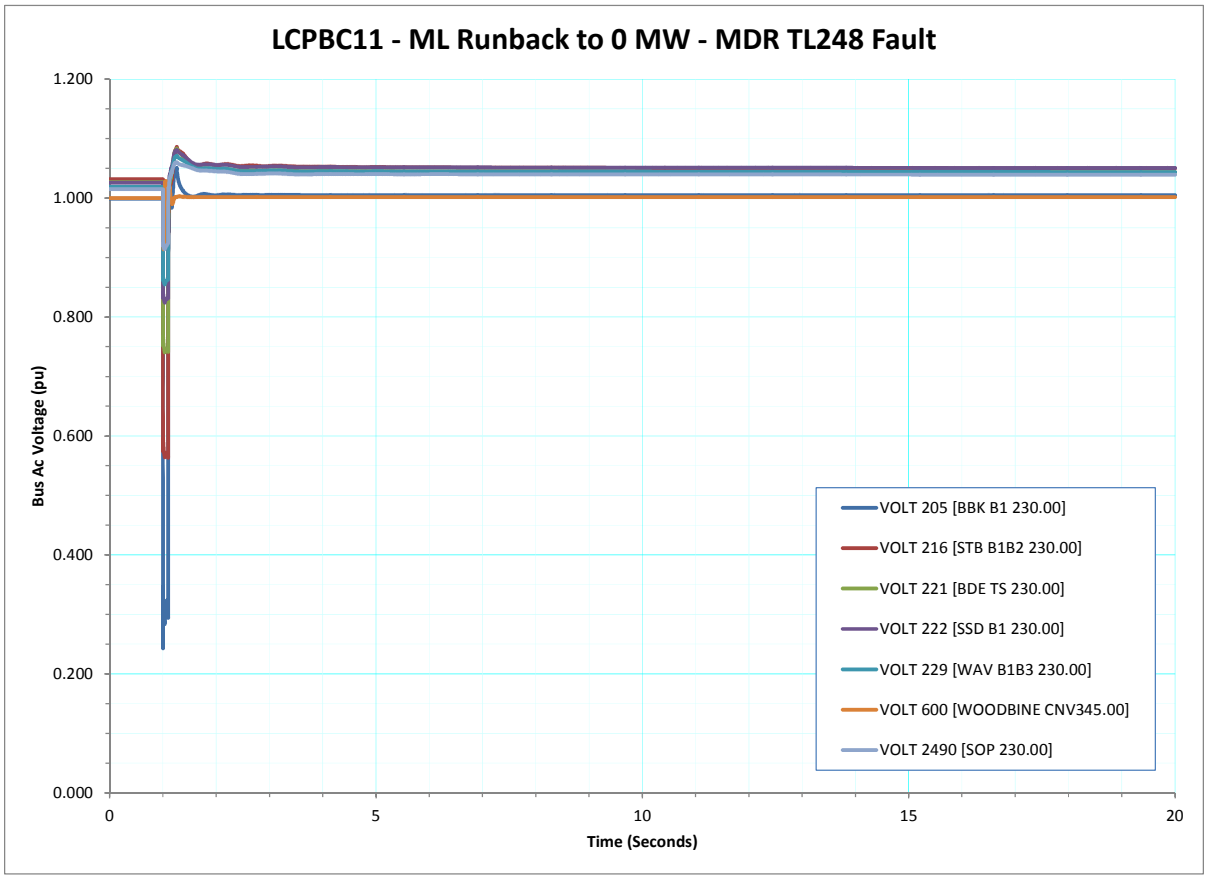

Figure 483 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - Bus Ac Voltage (pu)

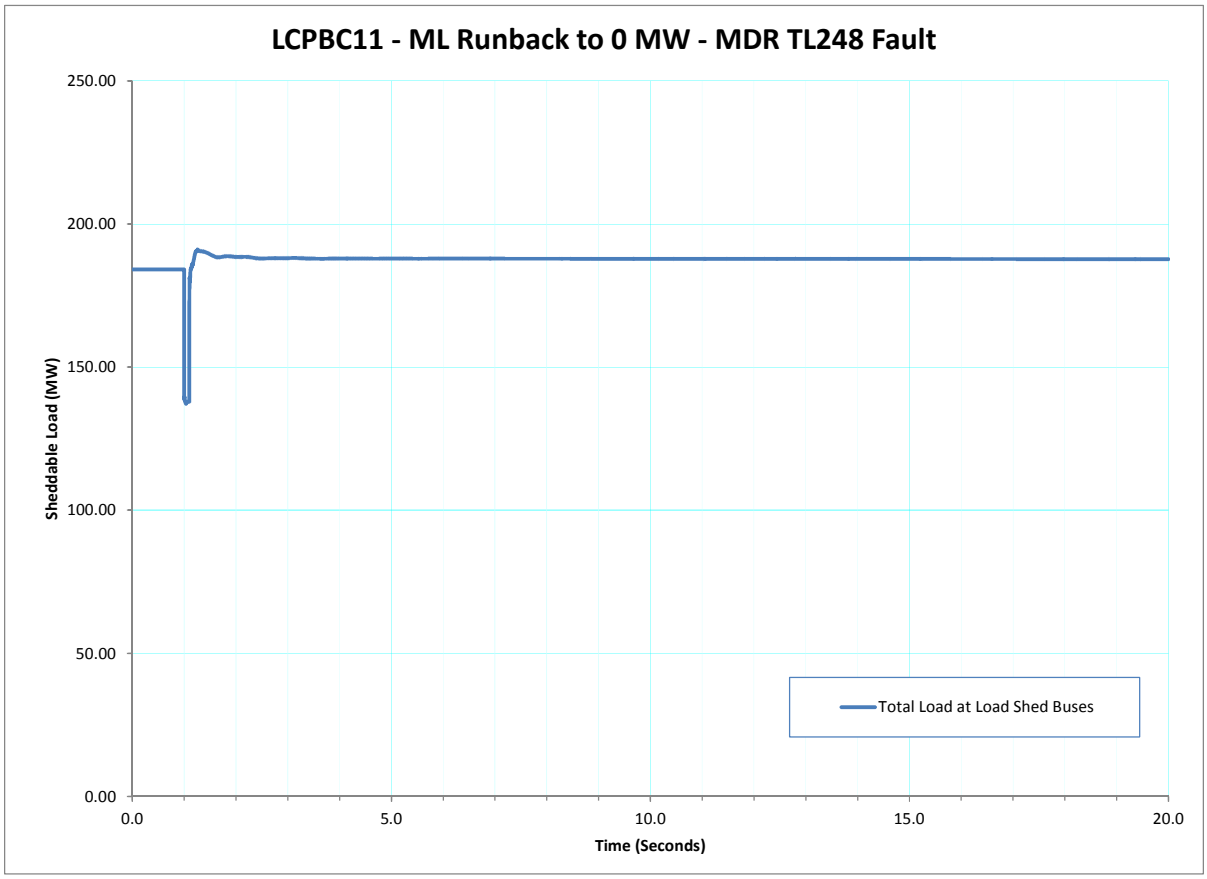

Figure 484 - LCPBC11 - ML Runback to 0 MW - MDR TL248 Fault - Sheddable Load (MW)