FortisAlberta – Bulk System Fast Frequency Response and Contingency Reserve Requirements for DER Interconnections

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This document is not intended or provided as a design specification or as an instruction manual.

The DER owner, employees or agents recognize that they are, at all times, solely responsible for the generator plant design, construction and operation.

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Revision History

Version	Date	Revision Details
1.0	01 Sept. 2023	New Standard Issued (1.1, Nov 2023) change to minimum injection time from 250 milliseconds to 150 milliseconds due to bulk system requirements.

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PURPOSE

This document is to serve as a standard for requirements and aid on procedures for DER Fast Frequency Response (FFR) and contingency reserve (CR) participation and provide an assessment framework for suitability.

1.0 Resources

The following documents should be understood for the purposes of DER participation in FFR and CR ancillary service markets.

- DER-02 – FortisAlberta Technical Interconnection Requirements
- DER-02A – FortisAlberta Engineering Study Requirements for DER Interconnections
- IEEE 1547-2018 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

2.0 Glossary

Fast frequency response (FFR): a fast-acting transmission reliability service that facilitates the arrest of, and recovery from, frequency decay caused by events such as loss of generation.

Contingency reserve (CR): used to restore the balance between the supply and demand for electricity following an unexpected event affecting the reliable operation of the interconnected electric system.

Injection time: the difference in time from when the DER is at zero active power output versus full active power output.

Ramp rate: The average rate of change of active power output from a DER.

3.0 Review Methodology

This section is to serve as a guide to determine anticipated impacts to the distribution system. The impacts are largely driven by system characteristics, size of the DER facility and operating conditions.

The main factors to consider in FFR studies are:

- Distribution system characteristics including:
  - X/R ratio: Systems with higher X/R ratios are more conducive to voltage fluctuations caused by reactive power changes from DERs, while the effects of real power injection are less. In contrast the opposite is true for lower X/R ratios.
  - System short circuit availability. System strength is typically measured on short circuit capabilities. For systems with higher short circuit capacity, rapid DER injection/absorption of reactive power is less likely to cause undesirable transient conditions. However, in some cases the load flow solution can become undesirable for stronger systems.
- DER FFR injection time: Faster injection times can create higher voltages during transient conditions. The injection time is defined as the time for the DER to go from zero output to full power generation output.
- DER real power injection
- DER operating mode/state: constant power factor operating modes are more susceptible to changing the operating voltage at the PCC when compared to Volt Var mode. Currently Volt Var mode is not permitted by FAI but is expected to be available in the future.
- Connected feeder information and load/generator models under the same and nearby feeders under the same substation.

3.1 PROCEDURE FOR FFR PARTICIPATION

For a DER to participate in FFR/CR the following procedure must be followed:

1) The DER owner must notify their stakeholder relations manager of their intent to participate in AESO's FFR and/or CR program. The applicable fees must be paid.
2) A new detailed study is to be performed by FAI to determine initial suitability for program participation or potential costs of the project.
3) Once the detailed study is completed, the DER owner must complete an EMT study as outlined in this document. This is to be submitted to FAI for approval and serves as the preliminary report.

4) If the preliminary EMT study is approved, the DER will be allowed to violate the ramp rate specified in DER-02 to be compatible with rapid power injection. The initial approval is for testing only and does not certify the site to participate in the program.
5) Following approval for testing the DER site is to perform commissioning tests as per this document. The results are to be added to the preliminary EMT study report and submitted to FAI for formal approval. This is the final report.
    a. NOTE: an updated interconnection protection settings and commissioning document is required to be submitted to FAI for approval to account for the exemptions expressed in Section 4.6.
6) Following approval of the final report, the DER will be permitted to join the FFR or CR program formally.
7) FAI reserves the right to request additional studies and information as required. FAI reserves the right to deny FFR or CR participation of DER based on study results.
8) FortisAlberta may deny the application for FFR/CR participation of a DER for reasons outside of this document. An example of this is if the DER's participation adversely affects programs such as underfrequency load shedding or firm load shedding. Should a reason outside of this document arise, it will be communicated to the DER owner.

4.0 Engineering Electromagnetic Transient Study Requirements

The following information is designed to aid DER owners in providing FAI with an EMT study to determine suitability for FFR or CR participation. An EMT simulation is not required if the DER confirms that it will not violate the ramp rate requirements specified in DER-02 Section 6.1.2, this is only applicable to CR participation as FFR participation will always require ramp rate violations.

4.1 TO BE PROVIDED FROM AESO

FAI requires the following information from the AESO to support fast ramp studies to be conducted by DER owner. The main factors to consider in fast ramp studies are:

- The equivalent impedance of the bulk system at the applicable high side point of delivery (POD) substation connection point for the weakest system case. The weakest system case is the one with the lowest short circuit availability.

4.2 TO BE PROVIDED FROM FORTISALBERTA

FAI will provide the DER owner with the following:

- The equivalent impedance of the bulk system at the 25kV bus.
- Volt Var curve for Volt Var simulations.
- FortisAlberta constant power factor simulation results.
- Minimum load (the detailed load model and its settings) of the feeder upstream and downstream of the DER PCC.
- Peak load (the detailed load model and its settings) of the feeder upstream and downstream of the DER PCC.
- The regulation band for the DER including the upper limit of the band, lower limit of the band and mid point of the band. The regulation band is defined as the range of nominal operating voltages seen at the DER PCC.
- Relevant settings for transformer tap changers and voltage regulators.
- EMT models or data to construct relevant models of DERs on neighbouring feeders on the same substation. Models will only be provided in EMTP-RV or PSCAD formats.

4.3 REQUIREMENTS OF THE DER OWNER

The DER owner shall note the following requirements for FFR/CR studies:

- EMT modelling requirements:
  - The DER owner is to use a detailed model in an EMT software. DER owners are free to use an EMT software of their choice. The model must be provided and validated by the manufacturer to confirm suitability for application.
  - Time domain simulations shall be done with a time-step of 30 microseconds or less.
  - Simulation times are required to be at least 10 seconds after the underfrequency event for all FFR cases.
  - 2 Modes of operation shall be considered for the inverters: 1) Constant power factor mode (the current FAI standard) and 2) Volt Var mode.
  - All loads are to be modelled as constant impedance loads unless otherwise specified by FAI.
  - Minimum load of the feeder upstream and downstream of the DER PCC.
  - Peak load of the feeder upstream and downstream of the DER PCC.
  - DERs on neighbouring feeders must be included in simulations.

- Site Specific Requirements:
  - The DER owner shall specify the ramp-up rate they will be using for participation in the FFR and CR markets and the minimum time to full export (injection time).
  - The DER owner shall specify their protective device details including the relevant trip settings. Note: the protective devices do not need to have their trip settings implemented in the EMT model.
  - If an effective grounding study has not been approved by FAI as per DER-02B, the DER owner shall perform an effective grounding study prior to the EMT simulations specified in this document.
  - The DER owner is required to have a Power Quality monitor permanently installed at the PCC for participation in FFR/CR. The power quality monitor shall, at minimum, be capable of capturing all voltages and currents at 512 samples/cycle with half cycle RMS. The data exchange shall be provided in IEEE 1159.3 PQDIF format.
  - The DER owner is responsible for determining if frequency sensitive loads at their site will be able to ride through voltage fluctuations caused by DER injection for FFR.
  - DERs are not permitted to violate the rapid voltage change requirements specified in DER-02. Violations of the rapid voltage change requirements will result in non-permission from FAI for the DER to participate in FFR/CR. This includes during the transient period following injection.
  - DER owners are to determine their own power factor operating set point within the following requirements:
    - For constant power, the power factor shall be within the range of -0.9 (0.9 leading) to unity.
    - The voltage excursion caused by the DER shall not be greater than two times the voltage regulation band from the nominal operating voltage. E.g., for a nominal operating voltage of 125V with a regulation band of 1.5V the voltage is not permitted to settle to a steady state value higher than 128V or less than 122V following DER power injection.
- Submission Requirements
  - The generator EMT model is required to be provided to FAI for use in the EMTP-RV software and PSCAD software. The full system model is not required to be provided.
  - DER FFR Report as per Section 4.4.

4.4 EMT SIMULATION CASES

The following EMT simulations are required:

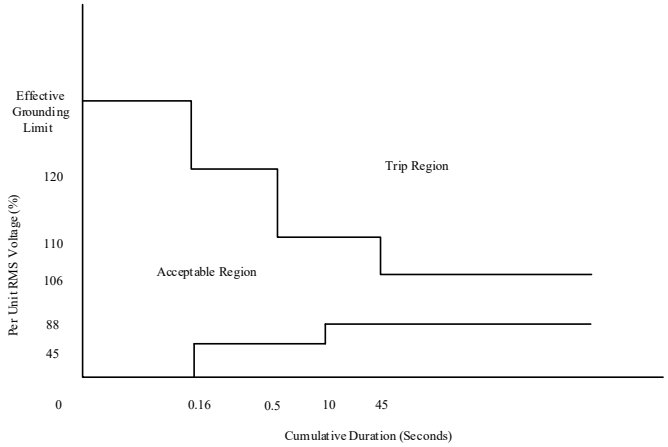
- All simulations need to be done for constant power factor mode and volt var mode.
- A case where the system frequency drops to 59.6 Hz. The DER is required to ramp up to full output within the specified injection time with the ramp-up rate provided by the DER owner. This needs to be done in 2 parts:
    - With the DER completely idle and ramping to full capacity within the DER owner's specified FFR minimum time to full export. This case shall be done under the following loading scenarios:
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with no load on the feeder.
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with minimum load of the feeder. The minimum load shall be split between upstream and downstream of the PCC.
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with peak load of the feeder. The peak load shall be split between upstream and downstream of the PCC.
        - For sites that have neighbouring DERs the simulations must be conducted with all the DERs at full output and at no output. The neighbouring DERs shall be modelled at the substation 25kV bus.
        - Any additional cases as specified by FAI.
    - With the DER charging (applicable only to BESS DERs) at their full load contract and then ramping to full capacity within the DER owner's specified FFR/CR minimum time to full export.
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with no load on the feeder.
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with minimum load of the feeder. The minimum load shall be split between upstream and downstream of the PCC.
        - For steady state voltages of the upper limit, mid point, and lower limit of the regulation band with peak load of the feeder. The peak load shall be split between upstream and downstream of the PCC.
        - For sites that have neighbouring DERs the simulations must be conducted with all the DERs at full output and at no output. The neighbouring DERs shall be modelled at the substation 25kV bus.

- Any additional cases as specified by FAI.

- A case where the system is operating at steady state minimum load AND the DER is required to ramp to full output within the time limit for CR participation. NOTE: This is for the Contingency reserve market participation. This simulation is not required IF the DER owner confirms that the ramp rate shall comply with Section 6.1.2 of DER-02.

For each simulation case the following shall be reported and displayed:

- Each phase RMS voltage and each phase peak sinusoidal waveforms. The voltage shall be measured at both the PCC and at the substation. NOTE: the 120%, 110% and 106% voltage trip point shall be overlayed onto the RMS voltages.
- The RMS and sinusoidal current and power (real and reactive) flow direction at the substation and at the PCC.
- The frequency of the system at the PCC and substation.
- Demonstrate what the Rapid voltage change (RVC) will be at both the PCC and the substation.
- Report the maximum voltage seen by the system at the PCC and the substation.
- Report the maximum duration that the voltage is above or below any of the voltage trips settings (120%, 110%, 106%, 88%) at the substation and the PCC. Only the maximum duration that the voltage is above or below the set points (120%, 110%, 106%, 88%) is required to be reported. If the DER's selected relay does not reset by dropping below or raising above the trip set point, the maximum cumulative duration may be longer than the voltage set point (e.g., if the relay only resets if the voltage drops below 97% of the trip setting, then the maximum cumulative duration will be longer); this will need to be accounted for in reporting.
    - For voltage durations the following graph shall be used for displaying purposes.



4.5 COMMISSIONING TEST REQUIREMENTS

Following approval of the preliminary EMT report, commissioning tests are required for formal participation approval in FFR/CR. If mitigation measures are required, these measures are to be installed before the commissioning tests may take place. For the DER to participate in FFR/CR the following commissioning tests will be required.

- Prior to performance of injection commissioning tests, the DER owner is required to commission the PCC protective device and submit an updated interconnection protection settings and commissioning form to FAI for approval. This is to capture the overvoltage settings that are expressed in the exemptions in Section 4.6.
- An injection test where the DER owner ramps to the output specified for FFR/CR. This is to be done within the prescribed injection time provided by the DER owner. The following is required for the test:
    - Notice is to be provided to AESO, the transmission facility owner and FAI at least 30 days in advance.
    - Immediately before the test, the DER owner shall request FAI to record the current loading on all feeders (MW and MVAR) and the substation bus voltage. FAI will provide this data to the DER owner following the completion of the test.
    - The DER owner is required to capture the injection with the installed power quality monitor. The data is required to be sent to FAI for review.
- Following the injection test the DER owner is required to perform a comparison EMT study. Using the data provided the DER owner shall perform another EMT simulation to capture the behaviour seen by the power quality monitor.
    - The results shall be added to the preliminary EMT study report and a direct comparison with the power quality data shall be made.
    - The final report shall be submitted to FAI for review.
    - Discrepancies may require the original EMT simulations in Section 4.4 to be completed again. This is subject to the discretion of FAI.

NOTE: sites participating in CR that have had the EMT study requirement waived by FAI are not required to perform the commissioning tests outlined in this document.

4.6 DER-02 EXEMPTIONS AND ADDITIONS

Following formal approval of the final EMT report and permission to participate in DER FFR/CR markets the following additions/exemptions shall apply to the DER facility.

- The DER shall be allowed to violate the ramp rate requirements specified in DER-02 for injection purposes only (ramp-up only). This is only applicable to sites where an EMT study

has been completed. This exemption is only applicable to the ramp up rate and does not apply to the ramp down rate.

- The minimum injection time for FFR participation from FAI shall be 150 milliseconds.
- The DER shall be allowed to disable the OV1 setting specified in DER-02 shall trip requirements when injecting for FFR/CR only. This is only applicable for ancillary services and the setting must be remain in place when generating for the energy market. A new interconnection protection setting and commissioning document shall be submitted to FAI for approval and the PCC device will be required to be re-commissioned.
- The DER shall change the OV2 setting specified in DER-02 shall trip requirements to a clearing time of 0.5 seconds. A new interconnection protection setting and commissioning document shall be submitted to FAI for approval and the PCC device will be required to be re-commissioned.
- The following additional DNP points shall be mapped to FAI SCADA:

DNP3 Index #	Signal Type (Analog/Binary)	Signal	State 1 "0"	State 2 "1"	Class	Variation
011	BINARY INPUT	ARMED FOR FFR	OFF	ACTIVE	1	2
012	BINARY INPUT	ARMED FOR CR	OFF	ACTIVE	1	2

5.0 Approval / Sign-off

The preliminary EMT Study shall be submitted to FAI following the FAI detailed study. A final study shall be submitted following the commissioning tests for FFR/CR participation. Both the preliminary and final studies must be authenticated by a professional engineer accredited to APEGA and submitted to FAI for review and approval.

For sites participating in the CR market and will not violate ramp rate requirements specified in DER-02, a letter is required stating that the site will remain in compliance with the ramp rates. This letter must be authenticated by a professional engineer accredited to APEGA and submitted to FAI for review and approval.

DERs participating in FFR/CR may be required to re-perform all simulations and tests in this document if there are significant changes to the distribution system characteristics. This will require re-approval from FAI to participate in the FFR/CR market. Significant changes will be at the discretion of FAI, acting reasonably, within the requirements of the Terms and Conditions to operate a safe and reliable system.