FAST FREQUENCY RESPONSE STUDY SCOPE & FINAL FIELD TEST REQUIREMENTS

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1.0 STANDARDS

The Generator Facility Owner (GFO) is responsible for reviewing and complying with the latest version of the following documents:

- ATCO's DER Interconnection Guideline
- ATCO's Technical Interconnection Requirements for Inverter-Based Generation
- AESO DER Trip and Ride-Through Performance Requirements
- ATCO's Effective Grounding and Transient Study Info Sheet
- IEEE 1547
- IEEE 1547.1
- IEEE C62.92.1
- CSA C22.3 No.9

2.0 OBJECTIVE AND STUDY/FIELD REQUIREMENTS

The purpose of this document is to specify the required authenticated study and field test reports to be provided to the Distribution Facility Owner ("ATCO") by the GFO that intends to participate in the ancillary services with the AESO for Fast Frequency Response (FFR) within the Alberta Integrated Electrical System (AIES).

NOTE:

- The frequency is to be detected at the Point of Common Coupling (PCC)
- The measurement accuracy requirement is as outlined in Section 7.1.3 of CSA C22.3 No.9:20 for both steady state and transient conditions.
- When the frequency goes below 59.6 hertz, the FFR is to provide full output up to the MC within 12 to 18 cycles which would equate to a minimum ramp rate of Maximum Capability (MC) MW/18 cycles.

To provide study results that confirm of compliance to IEEE C62.92.1 and ATCO "Inverter-Based Distribution Energy Resources Technical Interconnection Requirements[1]" for effective grounding throughout the FFR, an EMT study is required. Time domain simulations shall be done with a time-step of 30 microseconds or less. Simulation durations of at least 1 minute is required following the underfrequency event for all FFR cases. Simulation durations of at least 16 minutes is required after being directed to ramp to full output for the Contingency Reserve (CR) cases. The study shall be performed with the inverter in constant power factor mode. The power factor must be as indicated in the Distribution Planning Study and Joint Operating Agreement (JOA). The system shall be studied at the lowest and highest 25 kV base voltage as specified by the DFO. (25.67 & 26.29 kV at the source substation)

[1] See ATCO generation connection requirements at https://electric.atco.com/en-ca/products-services-rates/new-services-changes/connecting-grid.html

To Be Provided by AESO:

AESO will provide the bulk system configuration at the substation connection point. This will be the configuration the AESO expects for the Distributed Energy Resources (DER) to participate in the ancillary services market. For multiple configurations, the weakest system configuration (the one with the lowest short circuit availability) shall be used. AESO will also provide the equivalent impedance for the bulk system at the substation connection point. Finally, AESO will provide the expected voltage fall/rise, and frequency fall/rise for the weakest system case to capture the dynamics of the bulk system.

To be Provided by ATCO:

ATCO will provide the equivalent impedance at the substation and at the DER PCC, and the minimum and maximum load of the feeder upstream and downstream of the DER PCC. ATCO will also provide system data for study accuracy. Each study case is required to use a load model which can be used to test voltage impact on load power consumption. Each case will use a distribution feeder impedance from the PCC to the Point of Delivery (POD) substation and from the PCC to the downstream loads.

If required, ATCO will provide the inverter models and system equivalents for other DER on the same feeder, in order to ensure study accuracy.

Prior to FFR field testing by the GFO, study reports must be submitted to ATCO providing sufficient evidence that the voltage at the PCC does not exceed 1.07 pu during the FFR ramp rate[2] , voltage variation during entering service should be within 3% (RMS value at the PCC) under the worst-case scenario identified below, and compliance to IEEE C62.92.1 is maintained. Mitigation strategies and further study results must be included in the authenticated study report should study voltages exceed the limits. Graphical and tabular 25 kV voltages and durations must be provided at both the PCC and source substation 25 kV bus for all study cases as detailed below:

- A steady state case.
- A case where the system frequency drops to 59.61 Hz. It is expected the DER shall not engage.
- A case where the system frequency drops to 59.6 Hz. FFR study simulation to include the pre-FFR 25 kV voltages and post-FFR peak 25 kV voltages for the worst case FFR step change from 0 MW to the MC MW injection of the BESS at the PCC as well as at the 25 kV substation supply bus for a period of up to 90 seconds after which the substation tap changers and other voltage regulating devices are regulating;
    - Study to include a worst-case scenario defined by AESO combined with the highest specified 25 kV voltage of 26.29 kV at the substation bus and no feeder load prior to FFR simulation;
    - For Battery Energy Storage Systems (BESS), a simulation of the transition from the maximum charging rate to the maximum discharging capability during FFR.
- Each simulation will provide results that include the pre- and post- peak RMS voltages at the PCC and supply substation bus in both tabular and graphical format with voltage versus time and MW versus time. Graphs showing compliance to IEEE C62.92.1 and ATCO "Inverter-Based Distribution Energy Resources Technical Interconnection Requirements" for effective grounding as per *Figure 6. Transient Overvoltage Limits* of the requirements document will be included.
- GFO must measure the rapid voltage change for power quality concerns at the PCC.
- Additional report information for the FFR simulation: Frequency vs time graphs. For all graphs (V vs time, MW vs time and Freq vs time) both a 'zoomed in' focus of the 0-18 cycle post-FFR and stabilization period at MC,

[2] During entering service, use the voltage limits specified in CSA C22.3 No:9:20 Clause 7.4.6.2.1 and Table 8. IEEE 1547 also has requirement for enter service criteria and it is inline with the CSA standard.

and 0-90 seconds with a minimum of 18 cycles pre-FFR will be included. Each phase sinusoidal waveform will also be provided for the 'zoomed in' focus period.

- The simulation will be repeated with different 25 kV bus voltage to mimic the low and high end of tap changer deadband which are 1.0268 Vpu to 1.0517 Vpu with 25kV as a base voltage
- The AESO requires simulation measurements on power flow at the feeder load, at the PCC, and at the 25 kV feeder breaker.
- Provide mitigation and further study simulation results should the voltage go above 1.07 pu at the PCC.
- After formal written approval by ATCO, complete FFR field testing and provide the field test report for the 0 MW to the MC MW injection at the 25 kV bus voltage at the GFO site using a measurement device with sampling rates that allows for harmonic measurements up to the 51st harmonic to capture sub-cycle voltage. Authenticated report to include at a minimum:
    - Measurement device used, sampling rate, detection set-up and measurement location/connections;
    - Field test result maximum voltages and duration in tabular form as well as RMS curves and waveforms for the FFR at the GFO 25 kV bus. Any transient over-voltage measurements are also to be provided;
    - Based upon the field test results and EMT information, provide the worst-case voltage projection for the FFR at the GFO site based upon 26.29 kV at the substation bus.
    - Provide an overall comparison summary table of the field test results and study results.

3.0 DOCUMENTATION REQUIREMENTS

Provide clear simulation documentation of the model used which must include the:

- Source impedance assumptions.
- Distribution feeder impedances from the PCC to the source substation.
- Interconnecting PCC transformer.
- Any supplemental grounding devices that will impact the three phase FFR simulation accuracy.
- Vendor detailed inverter model information (specific inverter model must be used, generic models will not be accepted).
- Protective device details including manufacturer, model number, CT/PT information and trip settings.
- The GFO will specify the ramp rate they will be using for participation in the FFR and CR markets and the minimum time to full export. Note: AESO requires the maximum time for full export to be 300 milliseconds for the FFR market and 15 minutes for the CR market.

The FFR simulations must clearly indicate pick-up at, but not above the required 59.6 Hz and for the maximum step change from 0 MW to MC MW within 12 to 18 cycles as outlined in section 1.0. The authenticated report must include at a minimum;

1. Clear identification that no tripping of the BESS will occur based upon the simulation scenarios.
2. The FFR impacts on the 25 kV voltages and compliance with effective grounding requirements. Study simulations showing voltage response as outline in section 1.0 including considering the worst-case scenario maximum voltage at the PCC and supply substation bus.
3. Type test vendor documentation as applicable.
4. Potential mitigation strategies and further simulations to alleviate any overvoltage identified above the 1.07 pu limit at the PCC.

5. Upon approval by ATCO to proceed with final FFR field testing, a separate report comparing the field test results to the study simulations along with any mitigation to ensure the maximum voltage of 1.07 pu is not exceeded at the PCC.

The GFO must provide at least one week notice prior to FFR field testing and ensure the date and time of the test is provided and updated to ATCO to facilitate retrieval of any ATCO field recordings for validation.