# INTERCONNECTION PROTECTION SETTINGS & COMMISSIONING

## LIMITATION OF LIABILITY AND DISCLAIMER

This document is not a replacement for electrical codes or other applicable standards.

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, operation and maintenance.

FortisAlberta Inc. (FAI), and any person employed on its behalf, makes no warranties or representations of any kind with respect to the DER requirements contained in this document, including, without limitation, its quality, accuracy, completeness or fitness for any particular purpose, and FAI will not be liable for any loss or damage arising from the use of this document, any conclusions a user derives from the information in this document or any reliance by the user on the information it contains. FAI reserves the right to amend any of the requirements at any time. Any person wishing to make a decision based on the content of this document should consult with FAI prior to making any such decision.

## SECTION 1: Protection Settings Validation

### Interconnection Protective Equipment Nameplate Information

Use a separate form for each piece of equipment providing interconnection protective functions. For system protection requirements, review FortisAlberta's *DER-02: Technical Interconnection Requirements Standard*
*Note: Individual inverters only require certification*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **FortisAlberta Project #** | | | | **Date** | | | |
| **Facility Status** | **New** | ☐ | **Upgrade** | ☐ | **Existing** | ☐ | |
| **Aggregate Generation Capacity** | | **Generation Type** | | **Facility Nominal Voltage (VAC)** | | | |
| **Device Identifier (as per SLD)** | | | **Associated Relay Identifier (as per SLD)** | | | | |
| **Relay Manufacturer** | | | **Relay Model** | | | | |
| **Inverter certified to UL1741** | ☐ | | **Inverter certified to CSA C22.2 107/1** | ☐ | | | |

### Overcurrent Trip Settings

Provide below the protection settings that have been implemented or are intended to be utilized for the interconnection protection. *Note: Always verify upstream coordination with FortisAlberta.*

**(50/51) Overcurrent Trip Settings: Use 25kV / 14.4kV as the base**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Current Pickup (Amps)** | **Phase** | | **CT Ratio** | **Ground** | | **CT Ratio** |
| **Curve Type** | | | | | | |
| **Time Dial/Modifier** | | | | | | |
| **Instantaneous Trip (Amps)** | | | | | | |

**(67/67N/32R) Directional Overcurrent / Reverse Power Trip Settings: Use 25kV / 14.4kV as the base**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Element Pickup (Amps or Watts)** | **67P** | | **67N** | | **32R** | |
| **Curve Type** | | | | | | |
| **Time Dial/Modifier** | | | | | | |
| **Instantaneous Trip (Amps)** | | | | | | |
| **Trip Direction (FTS to DER) (DER to FTS)** | | | | | | |

**TCC coordination and description with FortisAlberta devices (To be completed by Fortis Alberta):**

| | | | |
|---|---|---|---|
| **Assessment Completed By:** | | **Overcurrent Settings Approved:** | ☐ Yes ☐ No |

## Required Protection Settings

The following are the **required** protection settings for any interconnection to FortisAlberta's distribution system. Any variance to the below settings must be approved by FortisAlberta. If settings cannot be met, please provide justification in the comments section.

### Frequency Protection

| (81U) Under-Frequency Trip | | (81O) Over-Frequency Trip | |
|---|---|---|---|
| **Required Setting** | **Maximum Clearing time** | **Required Setting** | **Maximum Clearing time** |
| UF1 = 58.5 Hz | 300sec | OF1 = 61.2 Hz | 300sec |
| UF2 = 56.5 Hz | 0.16sec | OF2 = 62.0 Hz | 0.16sec |

The frequency settings are as per Table 2 of FortisAlberta's *DER-02* standard.

**Use the comment section for any variance to the tables.**

### Voltage Protection

| (59) Over-Voltage Trip | |
|---|---|
| **Required Setting** | **Maximum Clearing time** |
| OV1 = 106% | 45sec |
| OV2 = 110% | 2sec |
| OV3 = 120% | 0.16sec |

The frequency settings are as per Table 1 of FortisAlberta's *DER-02* standard.

**Use the comment section for any variance to the tables.**

| (27) Under-Voltage Trip | | | |
|---|---|---|---|
| Inverter-Based Generation | | Machine-Based Generation | |
| **Required Setting** | **Maximum Clearing time** | **Required Setting** | **Maximum Clearing time** |
| UV1 = 88% | 10sec | UV1 = 88% | 2sec |
| UV2 = 45% | 0.16sec | UV2 = 45% | 0.16sec |

## System Synchronizing

| (25) Synchronizing | | | |
|---|---|---|---|
| **Requirements** | **< 0.5 MVA** | **0.5 – 1.5 MVA** | **> 1.5 MVA** |
| Frequency Difference | 0.3 Hz | 0.2 Hz | 0.1 Hz |
| Voltage Difference | 10 % | 5 % | 3 % |
| Phase Angle Difference | 20 Degrees | 15 Degrees | 10 Degrees |

The DER facility shall meet the synchronization requirements from *CSA C22.3 No.9:20. Section 7.4.6.2*

**Use the comment section for any variance to the tables.**

## Anti-Islanding

| Anti-Islanding | | | |
|---|---|---|---|
| **Requirements** | | | |
| Open Phase Detection | < 2 seconds | | |
| Loss of Utility Voltage | | | |
| Unit Restart Delay after Utility Voltage Returns | ≥ 5 minutes | | |
| Dead Bus | No start | | |
| Communication Failure (upon detection of comm loss) | < 0.6 seconds | | |
| **DER Facility Method of Detection** | | | |
| **Active** | ☐ | **Passive** | ☐ |
| Islanding Detection Method: (E.g., Sandia Frequency Shift, Active Frequency rift, or other) | | | |
| **Anti-Islanding Scheme Description:** | | | |

The DER facility shall meet the **Anti-Islanding** requirements from FortisAlberta's *DER-02, Section 7.2*.

**Based on the criteria in DER-02, please indicate below the Anti-Islanding detection method and scheme**

## Voltage/Frequency Ride Through

| Ride Through Requirements | | |
|---|---|---|
| ☐ Requirements outlined in Section 7.2 in Fortis Alberta's DER-02 have been met. | | |
| **Voltage Ride Through Settings (Machine Based)** | | |
| **Voltage Range (%)** | **Maximum Response Time** | **Minimum Ride Through** |
| V > 120 | 0.16sec | N/A |
| 117.5 < V ≤ 120 | N/A | 0.2sec |
| 115 < V ≤ 117.5 | N/A | 0.5sec |
| 110 < V ≤ 115 | N/A | 1sec |
| 88 ≤ V ≤ 110 | N/A | Infinite |
| 70 ≤ V < 88 | N/A | $T_{VTR}(sec) = 0.7 + 4(V - 0.7pu)$ |
| 50 ≤ V < 70 | N/A | 0.16 |
| V < 50 | 0.16 | N/A |
| **Frequency Ride Through Settings (Machine Based)** | | |
| **Frequency Range (Hz)** | | **Minimum Ride Through** |
| f > 62 | | N/A |
| 61.2 < f ≤ 62 | | 299sec |
| 58.8 ≤ f ≤ 61.2 | | Infinite |
| 57 ≤ f < 58 | | 299sec |
| F < 57 | | N/A |

The DER facility shall meet the **ride through** requirements from FortisAlberta's *DER-02, Section 7.2*.

**Ride through settings for inverter based DERs are confirmed by the manufacturer and certification. Machine based DERs are required to implement ride through settings.**

***NOTE: both ride through settings and maximum tripping times must be adhered to together.***

## Breaker Failure Protection

| Breaker Failure (BF) | |
|---|---|
| **Requirements** | |
| **Fortis to Review BF Scheme** | |
| Breaker Failure (upon detection of a BF condition) | ≤ 0.3 second (pick-up) |
| | < 2 seconds (trip of secondary isolation point) |
| **Breaker Failure (BF) Scheme Description:** | |

The DER facility shall meet the **Breaker Failure** requirements from FortisAlberta's *DER-02, Section 7.4*.

**Breaker Failure protection shall be indicated on the *Electrical Single Line Diagram* with notes describing the protection philosophy.**

**Additional Comments / Protection Variances:**

## The following items must be attached/completed with this submission:

**Electrical Single Line Diagram:** Please ensure the most up to date issue for construction (IFC) Electrical SLD of the facility corresponds to this submitted IPSC document, meeting *Section 5.1* of FortisAlberta's DER-02. The SLD shall indicate the required protection elements and clearly outline the breaker failure scheme as indicated in *Section 7.4* in Fortis Alberta's DER-02.

☐ **Description of anti-islanding detection method and scheme**

Please provide the manufacturer datasheet for the anti-islanding scheme. See *Section 7.2* in Fortis Alberta's DER-02 for required information.

☐ **Description Ride-through Settings**

Please provide the ride-through settings with submission as per *Section 7.2* in Fortis Alberta's DER-02.

| **Provided by:** | **Reviewed by:** |
|---|---|
| Power Producer (Name / Company) | FortisAlberta |
| Title (P.Eng Required) | Title |
| Signature | Signature |
| Date | Date |

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## SECTION 2: Protection Performance and Equipment Commissioning

### Protection Settings and Testing

Please provide in the table below the current settings of each of the system protection elements (section outlined in red). If an element differs from FortisAlberta's requirement provide justification to the variance in the additional comments section. If the element is not applicable to the system indicate in the table as nonapplicable and provide a comment stating why it is not required.

**Interconnection Protection Validation:** Refers to the testing of the protection elements / schemes and system equipment during start-up commissioning or maintenance activities. Indicate in the table below the period at which the interconnection protection settings have been tested. **All validation testing reports must be made available upon request from FortisAlberta.**

Please refer to FortisAlberta's *DER-02: Technical Interconnection Requirements Standard* for system requirements.

| FortisAlberta Project # | | Facility Name | | Date |
|---|---|---|---|---|
| | | | | |
| **Interconnection Protection Validation** | | | | |
| **New Commissioning** ☐ | | **Testing Completed ≤ 3 Years** ☐ | | **Testing Completed > 3 Years** ☐ |
| **System Protection Elements and Validation** | | | | |
| **Protection Elements** | | **Settings** | | **Reference** |
| | | **FortisAlberta Requirement** | **Facility Interconnection Settings** | |
| **Overcurrent (non-directional)** | | | | |
| **51** | **Phase Time Overcurrent** | Unique to System Configuration | Fill out Separate Overcurrent Trip Table | FortisAlberta DER-02, *Section 7.5* |
| **50** | **Phase Instantaneous** | | | |
| **Directional (non-export)** | | | | |
| **67** | **Phase Directional Overcurrent** | 10% of Total Generation Capacity | Fill out Separate Table | FortisAlberta DER-02, *Section 7.6* |
| **67N** | **Ground / Neutral Directional Overcurrent** | 10% of Total Generation Capacity | Fill out Separate Table | |
| **32R** | **Reverse Power** | 1% of Total Generation Capacity | Fill out Separate Table | |

| | | | | |
|---|---|---|---|---|
| **Voltage** | | | | |
| **59** | **Over Voltage** | **OV1** = 106 %<br>**Clear Time** = 45 sec | **OV1** =<br>**Trip** = | FortisAlberta DER-02, *Section 7.1* |
| | | **OV2** = 110 %<br>**Clear Time** = 2 sec | **OV2 =**<br>**Trip =** | |
| | | **OV3** =120 %<br>**Clear Time** = 0.16 sec | **OV3** =<br>**Trip** = | |
| **27** | **Under Voltage**<br>*Inverter-Based (I)*<br>*Machine-Based (M)* | **UV1** = 88%<br>**Clear Time** = (I) 10 sec<br>(M) 2 sec | **UV1** =<br>**Trip** = | FortisAlberta DER-02, *Section 7.1* |
| | | **UV2** = 45 %<br>**Clear Time** = 0.16 sec | **UV2** =<br>**Trip** = | |
| **Frequency** | | | | |
| **81O** | **Over Frequency** | **OF1** = 61.2 Hz<br>**Clear Time** = 300 sec | **OF1** =<br>**Trip** = | FortisAlberta DER-02, *Section 7.1* |
| | | **OF2** = 62.0 Hz<br>**Clear Time** = 0.16 sec | **OF2** =<br>**Trip** = | |
| **81U** | **Under Frequency** | **UF1** = 58.5 Hz<br>**Clear Time** = 300 sec | **UF1** =<br>**Trip** = | FortisAlberta DER-02, *Section 7.1* |
| | | **UF2** = 56.5 Hz<br>**Clear Time** = 0.16 sec | **UF2** =<br>**Trip** = | |
| **System Synchronizing** | | | | |
| **25** | **Frequency Difference** | 0.1 - 0.3 Hz | **FD** = | FortisAlberta DER-02, *Section 7.3* |
| | **Voltage Difference** | 3 - 10 % | **VD** = | |
| | **Phase Angle Difference** | 10 - 20 Degrees | **AD** = | |
| **Effective Grounding – Transient Overvoltage (TOV)** | | | | |
| **Load Rejection Overvoltage** (LROV) | | Review Reference Material | **Compliant with DER-02B** ☐<br>*PQ Report Required | FortisAlberta DER-02, *Section 5.8*<br>FortisAlberta DER-02B<br>IEEE 1547-2018 *Section 7.4.2* |

| Anti-Islanding | | | |
|---|---|---|---|
| Loss of Utility Voltage | **Clear Time** ≤ 2 sec | **Clear Time** = | FortisAlberta DER-02, *Section 7.2* |
| Open Phase | | **Clear Time** = | |
| Transfer-Trip | | **Clear Time** = | |
| Method of Detection | Review Reference Material | | FortisAlberta DER-02, *Section 7.2* |
| Generator Start after Voltage Restoration | **Block Start** ≥ 300 sec | **Start** = | |
| Dead Bus | **No Start** | | |
| Loss of Communication (upon detection of comm. loss) | **Clear Time** ≤ 0.6 sec | **Clear Time** = | |
| **Voltage Ride Through (Only applicable to machine based DERs)** | | | |
| V > 120 | **Clear Time** ≤ 0.16 sec | **Clear Time** = | FortisAlberta DER-02, *Section 7.2* |
| 117.5 < V ≤ 120 | **Clear Time** ≥ 0.2 sec | **Clear Time** = | |
| 115 < V ≤ 117.5 | **Clear Time** ≥ 0.5 sec | **Clear Time** = | |
| 110 < V ≤ 115 | **Clear Time** ≥ 1 sec | **Clear Time** = | |
| 88 ≤ V ≤ 110 | **NO TRIP** | | |
| 70 ≤ V < 88 | **Clear Time** ≥ $0.7 + 4(V - 0.7pu)$ | **Clear Time** = | |
| 50 ≤ V < 70 | **Clear Time** ≥ 0.16 sec | **Clear Time** = | |
| V < 50 | **Clear Time** ≤ 0.16 sec | **Clear Time** = | |
| **Frequency Ride Through (Only applicable to machine based DERs)** | | | |
| f > 62 | **Clear Time** ≤ 0.16 sec | **Clear Time** = | FortisAlberta DER-02, *Section 7.2* |
| 61.2 < f ≤ 62 | **Clear Time** ≥ 299 sec | **Clear Time** = | |
| 58.8 ≤ f ≤ 61.2 | **NO TRIP** | | |
| 57 ≤ f < 58 | **Clear Time** ≥ 299 sec | **Clear Time** = | |
| F < 57 | **Clear Time** ≤ 0.16 sec | **Clear Time** = | |

| Breaker Failure | | | |
|---|---|---|---|
| BF Detection | **Pickup** ≤ 0.3 sec | **Pickup** = | FortisAlberta DER-02, *Section 7.4* |
| Secondary Isolation | **Clear Time** ≤ 2 sec | **Clear Time** = | |

**(50/51) Overcurrent Trip: Use 25kV / 14.4kV as the base**

| | | | | |
|---|---|---|---|---|
| **Current Pickup (Amps)** | **Phase** | | **Ground** | |
| **Curve Type** | | | | |
| **Time Dial/Modifier** | | | | |
| **Instantaneous Trip (Amps)** | | | | |
| **CT Ratio** | | | | |

**(67/67N/32R) Directional Overcurrent / Reverse Power Trip: Use 25kV / 14.4kV as the base**

| | | | | |
|---|---|---|---|---|
| **Element Pickup (Amps)** | **67P** | | **67N** | |
| **Curve Type** | | | | |
| **Time Dial/Modifier** | | | | |
| **Instantaneous Trip (Amps)** | | | | |
| **Element Pickup (Watts)** | **32R** | | | |
| **Time Delay** | | | | |

## Interconnection Equipment Testing

The DER Owner is responsible for the inspection, testing, and calibration of its equipment, at the PCC / PoC. Testing shall be conducted prior to the initial energization of the facility and on a periodic basis for maintenance purposes. Review DER-02, *Section 9.0* and CSA C22.3 No. 9: 20, *Section 8.5.2.1* for inspection and testing requirements.

The following interconnection equipment at the PCC / PoC shall be included in all testing, but not limited to:

- Interrupting / Isolation devices (i.e. Breaker, Recloser, Disconnect Switch)
- Instrumentation (i.e. Current / Voltage Transformers, Sensing Devices)
- Control Wiring
- Underground Cabling
- Main Power Transformers
- Protection Function Testing
- Interconnection SCADA DNP3 Mapping: Refer to DER-02, *Annex 'A'* for requirements and mapping

**Test results shall be documented and made available upon the request of FortisAlberta**.

Refer to manufacturer guidelines for equipment testing and expected values. In the absence of the manufacturer's information, use the latest industry standards for testing equipment. Indicate below the testing period and the standard(s) used for testing

| Interconnection Equipment Testing | | | | | |
|---|---|---|---|---|---|
| **New Commissioning** | ☐ | **Testing Completed ≤ 3 Years** | ☐ | **Testing Completed > 3 Years** | ☐ |
| **Testing Standard(s) Applied** (i.e. NETA ATS 2017, CSA C22.3 No 9, IEEE 1547.1) | | | | | |

**Additional Comments / Variances:**

## Testing Certification

Your signature below indicates that the information that has been provided is accurate and the testing of the protection and facility equipment aligns with the requirements in FortisAlberta's DER-02 standard. It also indicates that all testing results have been documented and are available upon request by FortisAlberta.

| **Certified by:** | **Witnessed / Reviewed by:** |
|---|---|
| Power Producer (name / company) | FortisAlberta |
| Title | Title |
| Signature | Signature |
| Date | Date |

# REFERENCE MATERIAL

## Inspections and Tests

The following are the minimum expectations for each type of inspection and test. Refer to the equipment manufacturer for recommended routine maintenance tests, if not available use the latest NETA Acceptance Testing Standard (ATS) as a reference for applicable inspections, test procedures and expected results.

### End-to-End Wire Checks:

- Verify tightness of accessible bolted connections by use of a calibrated torque wrench. Use manufacturer specifications for required torque levels.
- Inspect, tug test and tighten all loose circuit wiring connections.
- Confirm each wire is terminated as indicated in vendor / engineered drawings.
- Verify end-to-end continuity.
- Verify single point grounding.
- Ensure proper phasing.

### Insulation-Resistance & Dielectric Withstand Testing:

- One-minute insulation resistance on each phase. Shall include both phase-to-phase and phase-to-ground tests.
- Insulation-resistance tests shall be conducted when the breaker or isolation switch is in the closed position.
- For required test voltages and expected values refer to manufacturer data, Table 100.1 or Table 100.5 (Transformers) in NETA ATS.
- Isolation switches requiring dielectric withstand tests shall be conducted with the switch in the closed position, testing each phase, phase-to-phase and phase-to-ground. Refer to manufacturer recommendations.
- Breakers requiring dielectric withstand testing (for vacuum bottle integrity) shall be conducted across the vacuum bottle when the breaker is in the open position.

### Contact Resistance Tests:

- Tests to be conducted across switchblades, fuse holders and breaker contacts in the closed position. Each phase shall be tested and compared. A low-ohm meter shall be used for each test.
- Comparing each phase, at a maximum, test values shall not differ by more than 50 percent of the lowest phase.

### Breaker Timing Tests:

- Verification of when the breaker receives an open / close signal to the actual mechanical open / close of the breaker contacts.
- Test values shall reflect manufacturers specification. In the absence of manufacturer data values times shall be recorded for maintenance purposes.

### Breaker / Isolation Switch Function Tests:

- Verify that breaker functions electrically via protection controller (inter-tie relay).
- Breaker open and close functions shall be verified manually by push button and/or mechanical lever.
- When applicable both the undervoltage and anti-pump functions of the breaker shall be tested.
- Manually operate switches to verify proper engagement of switchblades.

## Inspections and Tests Cont'd

### Analog Inputs / Configuration:

- Inject voltage and current into meter inputs to ensure accuracy.
- Confirm voltage and current ratios configured directly reflect instrument ratios and system parameters.
- Verify / configure meter for event capturing that complies to 'Annex B' of FortisAlberta's *Technical Interconnection Requirements Standard* (DER-02).

## Transformers

### Ratio / Polarity:

- (Power) Perform turns ratio test on the nominal operating tap and for each winding.
  (Instrument) Perform turns ratio test on each PT and CT at the PCC.
- (Power) Ratios shall not differ by more than 0.5% on each winding pair.
- (Instrument) Ratio errors shall conform to ANSI/IEEE C57.13

### Winding Resistance:

- (Power) Resistance shall be measured on both the high and low voltage windings at the operating tap.
- (Power) Temperature corrected winding resistance shall be compared within one percent of factory or previously obtained results.

### Excitation Current:

- (Power) Excitation current shall be measured on both the high and low voltage windings at the nominal operating tap.
- (Power) Excitation current pattern for a 2-winding transformer shall have two similar readings and one lower current reading.
- (Instrumentation - CT) Testing shall be in accordance to ANSI/IEEE C57.13.1.
- (Instrumentation - CT) Excitation results shall match the curve supplied by the manufacturer or be in accordance with ANSI/IEEE C57.13.1.

### Power Factor:

- (Power) Insulation Power Factor tests shall be performed on all windings of the transformer as per testing equipment manufacturers recommendation.
- (Power) Expected CHL values shall be less than:
  Oil (Power) = 0.5%
  Dry (Power) = 2.0%
  Dry (Distribution) = 5.0%
- (Power) Insulation Power Factor tests shall be performed on all windings of the transformer as per testing equipment manufacturers recommendation.

### Burden:

- (Instrumentation) Measured transformer burdens shall not exceed instrument transformer name-plate rating.