# Micro-Generation / Distributed Energy Resource Interconnection Guide

CITY OPERATIONS - ELECTRIC

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Medicine Hat

# Micro-Generation / Distributed Energy Resource Interconnection Guide

## 1 Scope

The intent of this Guide is to establish the interconnection requirements of micro-generation with the City of Medicine Hat Electric (City Electric) distribution system. While every precaution has been taken in the preparation of this Guide, it may contain inaccuracies or inconsistencies. The authors of this Guide assume no liability for errors or omissions, or damages resulting from the use or reliance upon the information contained herein.

This Guide has been developed without regard to whether its adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatsoever to parties adopting this Guide.

## 2 Purpose

This document is an interconnection application guide that applies to grid-dependent and grid-interactive micro-generation systems.

It establishes minimum uniform requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection of micro-generation systems with City Electric distribution system and is based on the following principles:

- The addition of micro-generation systems to the distribution system will not appreciably change the distribution system and its characteristics.
- The micro-generation inverter must meet the requirements of this Guide.
- Users, owners, and operators of micro-generation systems need not have any technical expertise.
- The installation shall meet the requirements of the latest version of the Canadian Electrical Code.
- Micro-generation systems are deemed to be operating unattended.
- Micro-generation installations shall require a permit from the City of Medicine Hat Safety Code Services or the authority having jurisdiction in the City of Medicine Hat Electric service area outside the corporate boundaries of Medicine Hat.
- City Electric personnel will need to be aware of the micro-generation system specifications, operating characteristics, and installed location, as well as changes to existing systems.

## 3 Limitations

The criteria and requirements in this guide are applicable to micro-generation facilities with a maximum rated generation capacity, as determined by the City, that use a single phase or three phase inverter, or stand alone AC generator, to generate AC electricity that is in parallel with City Electric distribution system and have a nominal operating voltage of 600 volts phase to phase AC or lower.

## 4 General Interconnection and Protection Requirements

The Micro-generator's interconnection installation must meet all applicable national, provincial and local construction and safety codes.

The Micro-generator is required to install, operate and maintain in good order and repair at all times, in conformity with good electrical practice, the equipment required by this Guide for the safe parallel operation with City Electric distribution system.

## 4.1 Distribution System

A Micro-generator's inverter shall be certified to meet this Guide's provisions, as detailed in this section, which defines the power quality and characteristics of City Electric system to which the Micro-generator is interconnecting. It is the manufacturer's responsibility to ensure that the inverter operates in this environment.

### 4.1.1 System Frequency

The distribution system operates at 60 hertz. Frequency deviations are typically 59.7 Hz to 60.2 Hz.

### 4.1.2 System Voltage

| **Nominal System Voltages** | Recommended voltage variation limits for circuits up to 600V, applicable at service entrance | | | |
|---|---|---|---|---|
| | Operating Conditions | | | |
| | Extreme | Normal | | Extreme |
| **Single Phase** | | | | |
| 120/240 | 106/212 | 110/220 | 125/250 | 127/254 |
| 240 | 212 | 220 | 250 | 254 |
| 480 | 424 | 440 | 500 | 508 |
| 600 | 530 | 550 | 625 | 635 |
| **Three Phase 4-conductor** | | | | |
| 120/208Y | 110/190 | 112/194 | 125/216 | 127/220 |
| 240/416Y | 220/380 | 224/388 | 250/432 | 254/440 |
| 277/480Y | 245/424 | 254/440 | 288/500 | 293/508 |
| 347/600Y | 306/530 | 318/550 | 360/625 | 367/635 |
| **Three Phase 3-conductor** | | | | |
| 240 | 212 | 220 | 250 | 254 |
| 480 | 424 | 440 | 500 | 508 |
| 600 | 530 | 550 | 625 | 635 |

***Source: CSA CAN3-C235, Table 2 (R2015)***

## 4.2 Micro-Generation Equipment

### 4.2.1 Inverter Operational Settings Sheet

The Micro-generator owner needs to ensure that the inverter has an Inverter Operational Settings Sheet (IOS) document. The IOS document must certify that the inverter operates within the ranges specified in Section 4.1. Both ride-though settings and maximum tripping times must be adhered together.

### 4.2.2 Synchronism

Inverters will automatically restart following automatic re-closing of distribution facility electrical equipment as per CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741). It will not be possible for City Electric to co-ordinate inverter restart. A synchronizing scheme does not need to be submitted for grid-dependent inverters. However, synchronism will be required for all stand alone AC generators.

### 4.2.3 Voltage Regulation and Power Factor

The Micro-generator shall be responsible for ensuring that the voltage levels at the point of interconnection are maintained within the guidelines prescribed by City Electric and/or at least equal to the voltage levels, at all feeder load conditions, prior to the interconnection. City Electric will decide if voltage regulation is expected to be a concern and identify possible solutions at time of application. The Micro-generator is not required to be capable of adjusting the power factor but shall operate in the range of ±0.9. City Electric will not require the inverter to operate in a power factor control mode.

### 4.2.4 Frequency Control

Under frequency over frequency protection that automatically disconnects the Micro-generator as per corresponding tables in Section 15 - Frequency Tripping Requirements.

## 4.3 Interconnection Facility

### 4.3.1 Safety

Safety of personnel, the public and of equipment is of primary concern in the design of the interconnection.

### 4.3.2 Point of Common Coupling (PCC)

The PCC will be considered to be the service entrance unless otherwise stated.

### 4.3.3 Point of Disconnection

Low Voltage Disconnecting Means - To enable City Electric personnel to work on their facilities, a manual disconnecting means is required between City Electric facilities and the Micro-generator's inverter or AC generator. The Micro-generator is responsible for installation of the disconnecting means.

The characteristics of this disconnecting means must meet the following requirements and be subject to the approval of the authority having jurisdiction enforcing the Canadian Electrical Code:

- Must provide safe isolation for City Electric personnel from the inverters or AC generators.
- Not required to have a lockable, direct, visible means to verify contact operation.
- Do not need a City Electric switch number, and
- Do not need to undergo annual inspections and maintenance.
- For DER systems with multiple DER units, one disconnecting means shall have the capability of isolating all distributed energy resources simultaneously from the distribution system.

All low voltage disconnecting means must:

- Be adequately rated to break the connected generation/load;
- Allow simultaneous disconnection of all ungrounded conductors of the circuit;
- Be externally operable without exposing the operator to contact with live parts;
- Be capable of being closed without risk to the operator when there is a fault on the system;
- Be capable of being energized from both sides;
- Plainly indicate whether in the “open” or “closed” position; and
- Meet all applicable CSA Part II standards and all applicable codes.

No switching, clearance, and tagging procedures will be required of the Micro-generator. For all grid-interactive inverters, the manual disconnecting means must also:

- Be as close as possible to the Micro-DG source and within 5 meters horizontal walking distance of the PCC, unless otherwise approved by City Electric;
- Be readily accessible to City Electric.

### 4.3.4 Interconnection Grounding

Single-phase & Three-phase generating systems must be grounded as per the manufacturer's recommendations and the Canadian Electric Code Part 1.

The inverter manufacturer or protection scheme designer shall certify that their inverter/relay isolates all sources of fault contribution from a faulted line or distribution element, blocks the transmission of harmonic currents and voltages; and protects the low voltage side from high fault current damage.

### 4.3.5 Phase and Ground Fault Protection

The Micro-generator shall use an inverter or protection scheme that detects faults or power outages occurring on all ungrounded conductors to which it is connected and then promptly ceases to energize such conductors and does not re-energize until at least 5 minutes after the normal voltage of City Electric system is restored.

The Micro-generator shall employ over-current protection in their interconnection equipment.

### 4.3.6 Overvoltage and Undervoltage Protection

Overvoltage and undervoltage protection as per corresponding tables in Section 14 - Voltage Tripping Requirements.

Provided that the inverter utilized by the Micro-generator is certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741), the Micro-generator will not be required to install additional relays to trip the circuit breaker when the voltage, measured phase to ground is outside the predetermined limits in. All non inverter type generation will requrie over & undervoltage protection.

This recognizes:

- That the certification to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741) guarantees and tests the appropriate protection functionality to operate on abnormal voltage;
- The Micro-generator's generating equipment operates automatically and unattended;
- The generating facility is not manually controlled nor operated by the Micro-generator beyond being turned off and on

The inverter manufacturer shall indicate the time delay for reconnection after City Electric distribution system voltage and frequency return to normal range and are stabilized. Minimum time for reconnection to be 5 minutes as per CSA-C22.2 NO. 107.1. Non-interverter generation will have the same reconnection delay.

The Micro-generator and City Electric will work together to arrive at a solution to any concerns about the voltage levels on the distribution facility.

The Micro-generator's automatic reconnection will not be governed by any local operating orders that require manual reconnection upon authorization from City Electric.

### 4.3.7 Over frequency and Under frequency Protection

Over frequency and under frequency protection as per corresponding tables in Section 15 - Frequency Tripping Requirements.

### 4.3.8 Anti-Islanding

The Micro-generator's generation facility must be equipped with protective hardware and software designed to prevent the generator from being connected to a de-energized circuit owned by City Electric.

Certification of the Micro-generator's inverter by an accredited certification organization shall be deemed to meet the anti-islanding requirements of this Guide without any further assessment requirements

The Micro-generator is responsible for any damage caused to his equipment or City Electric infrastructure resulting from improper operation of the Micro-generator's anti-islanding protection.

In spite of the above certification of inverters, it is recognized that the effect on anti-islanding schemes used by different inverters may require on site testing and/or further evaluation when there is a mixture of generation connected to the same feeder.

### 4.3.9 Special Interconnection Protection

No special inverter-specific protection and controls, such as out-of-step or loss of synchronism, will be required.

City Electric recognizes that the Micro-generator's inverter and its manufacturer preset protection limits are the prime protection mechanism that the Micro-generator will be employing. No additional protection other than the already specified will be required.

For non-inverter AC Generation the minimum protections as per Table 1 - Single and Three Phase Synchronous and Induction. Additional protections maybe required and are application and location specific.

### 4.3.10 Flicker

The micro-generation system shall not cause objectionable flicker on the distribution system. It is recognized that flicker is a site-dependent condition. See CAN/CSA-C61000-2-2 and City Electric for specific site requirements.

### 4.3.11 Harmonics

The micro-generation system employing an inverter certified to CSA-C22.2 NO. 107.1 is assumed to comply with harmononic distortion limits of City Electric. It is recognized that voltage harmonics is a site-dependent condition. Exceeding the limits may require the Micro-generator or City Electric to take compensatory measures the cost of which would be borne by the Micro-generator.

Current harmonics are specified in CSA-C22.2 NO. 107.1.

## 4.4 Typical Interconnection Requirements

An Inverter Operational Settings document shall be made available by the Micro-generator to City Electric to determine if the interconnection equipment and settings are acceptable to its system requirements.

City Electric will work closely with customer to determine whether interconnection and operation within a specific distribution facility is possible.

The interconnection equipment shall meet the required protective functions specified in the following sections.

### 4.4.1 Synchronous and Induction Generators

Table 1 - Single and Three Phase Synchronous and Induction, of this Guide shows the protective functions for synchronous and induction generators.

### 4.4.2 Single-Phase Inverters

Table 2 - Single Phase Inverters Interconnection, of this Guide shows the protective functions required to meet this Guide. Inverters must be certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741).

### 4.4.3 Three-Phase Inverters

Table 3 - Three Phase Inverters Interconnection, of this Guide shows the protective functions required to meet this Guide. Inverters must be certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741).

### 4.4.4 Mitigation of Protection Scheme Failure

If the protective device functions required in Table 2 - Single Phase Inverters Interconnection and Table 3 - Three Phase Inverters Interconnection are performed by the micro-generatoration's control, then the micro-generation shall be designed to have self-diagnostic and fail-safe features. In case of failure of the micro-generation's protection function, the micro-generation shall automatically cease to operate in parallel with City Electric system.

### 4.4.5 Maximum Generator Power to be Exported

A Micro-generator's micro-generation system output shall never exceed the maximum approved system size as determined by the City of Medicine Hat.

## 4.5 Interconnection Protection Approval

The Micro-generator shall provide to City Electric complete inverter documentation for review against the requirements of this Guide and for potential impacts on City Electric distribution system.

The documentation should include:

- A completed Micro-Generation Application form,
- An overall description of the inverter and its protection functions, including the manufacturer, model, and Inverter Operational Settings document along with Independent Testing Laboratory certification documentation or equivalent documentation provided by the inverter manufacturer that describes its protection settings,
- A detailed single-line diagram.
- The disconnecting means details (i.e., manufacturer, model and associated certification).
- The Micro-generator shall revise and re-submit the inverter or protection information for any proposed modification.

# 5 Construction

## 5.1 General

The Micro-generator's generation facility must be constructed and installed to meet all applicable regulations. All permitting and safety code requirements must be completed and copies of inspection reports must be provided to City Electric.

The microgeneration system must be designed and installed by a qualified installer and system components meet the Canadian Standards Association requirements for electrical safety, or equivalent certification to applicable Canadian standards and must be grid connected in accordance with the Government of Alberta's Micro-Generation Regulation (AR27/2008), as amended from time to time. The minimum installation size requirement is 1.5 kilowatts (kW).

All Single Line Diagrams provided to City Electric shall be drawn in accordance with IEEE standards and conventions. Professional stamps shall only be required where required by permitting authorities.

Micro-generation installations must be preapproved by the City of Medicine Hat. A system size review is required and the installed system size must not exceed the maximum system size as determined by the City's review. System size is based on historic consumption for existing properties and on comparable sites for new construction. Any deviation from the approved system size (watts DC or watts AC) may result in the installation being considered non-compliant, which may delay the installation of the bi-directional meter until the situation is resolved.

# 6 Metering

## 6.1 General

Metering must comply with Measurement Canada requirements and the latest revision of City Electric Bylaw 2244.

Bi-directional metering shall be installed so that kWh (delivered) and kWh (received) are separately recorded.

## 6.2 Meter Requirements

For micro-generation systems the bi-directional billing meter will be supplied and installed by City Electic. Cost of metering equipment will be borne by City Electric, but labor, equipment and material associated with the installation of the metering equipment and commissioning will be charged to the customer.

# 7 Environmental Attributes

## 7.1 Ownership of Attributes

The Applicant confirms ownership of any attribute of an environmental or similar nature that is created or otherwise arises from the generation of electricity from solar powered energy. The Applicant further attests that said attributes have not been claimed, sold, or otherwise transferred to another party.

## 7.2 Aggregation of Attributes

The Applicant consents that the City of Medicine Hat shall be the aggregator of the solar generator with ownership of any attribute of an environmental or similar nature that is created or otherwise arises from the generation of electricity from solar powered energy. As such, the Applicant consents that the City of Medicine Hat shall be allowed access and shall take all steps necessary to provide the City of Medicine Hat access to appropriate tracking data until a time in which operation of the solar generator is permanently suspended.

# 8 Inspection

The Micro-generator shall maintain a quality control and inspection program according to the recommendations of the inverter manufacturer.

In addition to the Micro-generator's normal inspection procedures, City Electric reserves the right to witness any part of work that concerns the subject equipment; to inspect materials, documents and installation procedures, to witness tests and to evaluate results of non-destructive examinations.

The Micro-generator shall supply City Electric with a complete set of detailed drawings, which will be used by City Electric to assist in the inspection during the testing of equipment.

# 9 Testing

## 9.1 Type Testing

Is performed or witnessed once by an independent testing laboratory for a specific protection package. Once a package meets the type testing criteria described in this section, the design is accepted by City Electric.

## 9.2 Verification Testing

Prior to completion of commissioning of a micro-generation system, or when interconnection system hardware or software is changed, a verification test shall be performed. City Electric reserves the right to witness verification testing or to require written certification that the testing was performed. All verification tests relating to the interconnection system prescribed by the manufacturer or developed by the Micro-generator that are agreed to by City Electric shall be performed prior to interconnection. The Micro-generator shall maintain verification test reports for inspection by City Electric.

Any system that depends upon a battery for trip power shall be verified to be of fail-safe design by disconnecting the battery and verifying that the system ceases to energize the distribution system.

## 9.3 Protective Function Testing

If microprocessor-controlled protective functions are used, and production line testing has been done according to section 9.1, then a repeat of the production line testing, except for non-islanding, in the field is not required.

The non-islanding function shall be checked by operating a disconnecting means to verify that the inverter ceases to energize its output terminals and does not restart for the required time delay after the disconnecting means is closed.

# 10 Information Requirements

The following table identifies the drawings and information the Micro-generator is required to submit to City Electric when applying for interconnection to City Electric distribution system.

| Required Documentation | Application Submission | Scheduling of Commissioning |
|---|---|---|
| **City of Medicine Hat System Size Approval:** Completed by owner and shared with Contractor. This must show "Maximum System Size (DC)". | X | |
| **Micro-Generation Application Form:** Reviewed, all filled out and signed. | X | |
| **Net Billing Connection Agreement for Micro-Generators:** Reviewed and signed. | X | |
| **Micro-Generation Single-Line Drawing:** Must show all interconnection protection function requirements base on system. | X | |
| **Manufacturer's Equipment Data Sheet:** Including inverter operational settings document, commissioning report c/w protection settings & operating manual. | X | |

*(continued)*

| | | |
|---|---|---|
| **Site Plan:**<br>Existing electric service to building (overhead or underground). Proposed location of solar array, wind turbine, etc. How DC/AC supply line will be installed to the residence / building. Location of disconnecting means. | If Applicable | |
| **Application Fee:**<br>A non-refundable application fee as per City of Medicine Hat current standard charges. This applies to new micro-generation systems and micro-generation expansion, if there is a change to the inverter(s) as this requires inspection / commissioning. | X | |
| **Electrical Permit & Site Inspection Report:**<br>Submit A copy when contacting City Electric Operations advising you are ready to be connected. | | X |

# 11 Marking and Tagging

The disconnecting means shall be clearly marked in accordance with the Canadian Electrical Code Part 1. City Electric may choose to place warning tags or labels on parts of the Service Entrance.

# 12 Maintenance

The Microgenerator has full responsibility for routine maintenance of the Microgenerator's complete system, control and protective equipment up to and including the PCC in accordance with the manufacturer's recommendations, and the keeping of records for such maintenance.

The Micro-generator must maintain the equipment to accepted industry standards. Failure to do so may result in disconnection of the micro-generator at the PCC.

# 13 Protection Function Requirements

## 13.1 Table 1 - Single and Three Phase Synchronous and Induction

| ANSI Device# | Protection Function | Required |
|---|---|---|
| 52 or 89 | Circuit Breaker or Interconnection Switch | X |
| 25/25A | Synchronizing check | X |
| 27 | Undervoltage Relay | X |
| 50 | Instantaneous Overcurrent Relay | X |
| 51 | AC Time Overcurrent Relay | X |
| 59 | Overvoltage Relay | X |
| 78V | Out-of-Step / Vector shift** | X |
| 81O | Over Frequency | X |
| 81U | Under Frequency | X |
| 81R | Rate-of-Change Frequency* | X |
| - | Additional Elements | If Required |

* May be provided by magnetic circuit breakers or fuses.

** May be required for export applications where passive anti-islanding protection is an option.

Notes:

1. To be in accordance with the Canadian Electrical Code.
2. Exporting to City Electric system may require coordination of operations with City Electric.
3. All elements used must be shown on the SLD.

## 13.2 Table 2 - Single Phase Inverters Interconnection

| Function | ANSI Device# | Protection Function | Required |
|---|---|---|---|
| E.g. “AC Source Disconnect” | - | Inverter Disconnect Means | X |
| - | 25 | Automatic Synchronizing* | X |
| - | 27 | Undervoltage Relay | X |
| - | 51 | AC Time Overcurrent Relay | X |
| | 59 | Overvoltage Relay | X |
| - | 81O | Over Frequency | X |
| - | 81U | Under Frequency | X |
| AI | - | Anti-Islanding** | X |
| - | - | Additional Elements | If Required |

* For inverters with standalone capability.

** As required in Section 4.3.8.

Notes:

1. To be in accordance with the Canadian Electrical Code.
2. Exporting to City Electric system may require coordination of operations with City Electric.
3. All elements used must be shown on the SLD.

## 13.3 Table 3 - Three Phase Inverters Interconnection

| Function | ANSI Device# | Protection Function | Required | # of Phases to be Monitored |
|---|---|---|---|---|
| E.g. “AC Source Disconnect” | - | Inverter Disconnect Means | X | 3 |
| - | 25 | Automaitc Synchronizing* | X | 1 |
| - | 27 | Undervoltage Relay | X | 3 |
| - | 50 | Instantaneous Overcurrent Relay | X | 3 |
| - | 51 | AC Timed Overcurrent Relay | X | 3 |
| - | 59 | Overvoltage Relay | X | 3 |
| - | 81O | Over Frequency | X | 3 |
| - | 81U | Under Frequency | X | 3 |
| AI | - | Anti-Islanding** | X | 3 |
| - | - | Additional Elements | If Required | - |

* For inverters with standalone capability.

** As required in Section 4.3.8.

Notes:

1. To be in accordance with the Canadian Electrical Code.
2. Exporting to City Electric system may require coordination of operations with City Electric.
3. All elements used must be shown on the SLD.

# 14 Voltage Tripping Requirements

## 14.1 Inverter-based DERs

### 14.1.1 Table 4 - Mandatory Voltage Tripping Requirements

| Trip function | Default Settings | |
|---|---|---|
| | Voltage (% of nominal voltage) | Clearing times (s) |
| OV2 | 120 | 0.16 |
| OV1 | 110 | 2.0 |
| UV1 | 88 | 10.0 |
| UV2 | 45 | 0.16 |

***Source: AESO - DER Ride-Through Performance Recommendations, Table 3 (June 2022)***

### 14.1.2 Table 5 - Voltage Range Tripping Capability

| Voltage range (% of nominal voltage) | Minimum ride-through time (s) (design criteria) | Maximum response time (s) (design criteria) | Response |
|---|---|---|---|
| V > 120 | N/A* | 0.16 | Cease to energize |
| 117.5 < V ≤ 120 | 0.2 | N/A | Mandatory operation |
| 115 < V ≤ 117.5 | 0.5 | N/A | Mandatory operation |
| 110 < V ≤ 115 | 1 | N/A | Mandatory operation |
| 88 ≤ V ≤ 110 | Infinite | N/A | Continuous operation |
| 65 ≤ V < 88 | Linear slope of 8.7s/1p.u. voltage starting at 3s@0.65p.u.: $T_{VTR} = 3s + \frac{8.7s}{1p.u.}(V - 0.65p.u.)$ | N/A | Mandatory operation |
| 45 ≤ V < 65 | 0.32 | N/A | Mandatory operation |
| 30 ≤ V < 45 | 0.16 | N/A | Mandatory operation |
| V < 30 | N/A* | 0.16 | Cease to energize |

* Cessation of current of DER in not more than the maximum specified time and with no intentional delay. This does not necessarily imply disconnection, isolation, or a trip of the DER.

***Source: AESO - DER Ride-Through Performance Recommendations, Table 4 (June 2022)***

## 14.2 Machine-based DERs

### 14.2.1 Table 6 - Mandatory Voltage Tripping Requirements

| Trip function | Default Settings | |
|---|---|---|
| | Voltage (% of nominal voltage) | Clearing times (s) |
| OV2 | 120 | 0.16 |
| OV1 | 110 | 2.0 |
| UV1 | 88 | 2.0 |
| UV2 | 45 | 0.16 |

***Source: AESO - DER Ride-Through Performance Recommendations, Table 5 (June 2022)***

### 14.2.2 Table 7 - Voltage Range Tripping Capability for Machine-based DERs

| Voltage range (% of nominal voltage) | Minimum ride-through time (s) (design criteria) | Maximum response time (s) (design criteria) | Response |
|---|---|---|---|
| V > 120 | N/A* | 0.16 | Cease to energize |
| 117.5 < V ≤ 120 | 0.2 | N/A | Mandatory operation |
| 115 < V ≤ 117.5 | 0.5 | N/A | Mandatory operation |
| 110 < V ≤ 115 | 1 | N/A | Mandatory operation |
| 88 ≤ V ≤ 110 | Infinite | N/A | Continuous operation |
| 70 ≤ V < 88 | Linear slope of 4s/1p.u. voltage starting at 0.7s@0.7p.u.: $T_{VTR} = 0.7s + \frac{4s}{1p.u.}(V - 0.7p.u.)$ | N/A | Mandatory operation |
| 50 ≤ V < 70 | 0.16 | N/A | Mandatory operation |
| V < 50 | N/A* | 0.16 | Cease to energize |

* Cessation of current of DER in not more than the maximum specified time and with no intentional delay. This does not necessarily imply disconnection, isolation, or a trip of the DER.

***Source: AESO - DER Ride-Through Performance Recommendations, Table 6 (June 2022)***

# 15 Frequency Tripping Requirements

## 15.1 Table 8 - Mandatory frequency tripping requirement for DERs

| Trip function | Default Settings | |
|---|---|---|
| | Frequency (Hz) | Clearing times (s) |
| OF2 | 62.0 | 0.16 |
| OF1 | 61.2 | 300.0 |
| UF1 | 58.5 | 300.0 |
| UF2 | 56.5 | 0.16 |

***Source: AESO - DER Ride-Through Performance Recommendations, Table 7 (June 2022)***

## 15.2 Table 9 - Frequency tripping for DERs

| Frequency range (Hz) | Minimum ride-through time (s) (design criteria) |
|---|---|
| f > 62.0 | N/A |
| 61.2 < f ≤ 62.0 | 299 |
| 58.8 < f ≤ 61.2 | Infinite<br>(Applicable only for a per-unit ratio of voltage/frequency limit of V/f ≤ 1.1) |
| 57.0 < f ≤ 58.8 | 299 |
| f ≤ 57.0 | N/A |

* Applicable only for a per-unit ratio of voltage/frequency limit of V/f ≤ 1.1.

***Source: AESO - DER Ride-Through Performance Recommendations, Table 8 (June 2022)***

## 15.3 Table 10 - Parameters of Frequency-Droop (Frequency/Power) for inverter-based DER

| Parameter | Default Settings |
|---|---|
| $db_{OF}$, $db_{UF}$ (Hz) | 0.036 |
| $k_{OF}$, $k_{UF}$ | 0.05 |
| $T_{response}$ (s) | 5 |

***Source: AESO - DER Ride-Through Performance Recommendations, Table 9 (June 2022)***

# 16 Appendix 1 – Definitions

The following terms are defined here to assist in the understanding of micro-generation. Though some of these terms are not used in this Guide, they may arise in discussions of micro-generation systems and so would be useful to understand.

**Alternating current (AC)**
Electric current that regularly reverses its direction of flow, which in Canada is at 60 times per second.

**Anti-islanding**
Technology in a micro-generation system that prevents it from feeding electricity into a distribution system during a utility electrical outage. Its purpose is to protect utility workers from working on a live distribution system.

**Bi-directional cumulative meter**
Electricity-measuring device that measures in two separate data points the total electricity that has flowed in a circuit from one reading date to the next. One data point shows the amount of electrical energy that has been exported to the grid. The other data point shows the amount of electrical energy that has been imported from the grid.

**Clearing time**
The time between the start of an abnormal condition and the DER ceasing to energize City Electric. It is the sum of the detection time, any adjustable time delay, the operating time plus arcing time for any interposing devices (if used), and the operating time plus arcing time for the interrupting device (used to interconnect the DER with City Electric).

**Direct current (DC)**
Electric current that flows in one direction.

**Disconnecting Means**
A device, such as switches, which disconnects a circuit from its source of supply.

**Distributed Energy Resource (DER)**
A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an electric power system. DER includes DG and MG.

**Distributed generator (DG)**
Electric generator that is connected to a distribution system.

**Distributed generator (DG) source disconnect**
A disconnecting switch placed between a generator's output terminals and the wiring of its electrical loads and a distribution system.

**Distributed generator (DG) system disconnect**
A disconnecting switch placed between a generator's output terminals and a distribution system required to ensure the safety of electrical utility workers.

**Generator**
Device that converts energy from one form into electrical energy.

**Generator rated capacity (kW)**
Basic measurement unit for electrical energy. It is the rate at which electrical energy is produced by a generator at a defined set of operating conditions. A kWh is simply the rate (measured in watts) at which electrical power flows

in a circuit multiplied by the time (measured in hours) that the power is flowing at that rate. For example, one kWh equals 1,000 watts flowing for one hour, or 100 watts flowing for 10 hours.

**Grid-connected inverter**
Inverter that can operate in parallel with a distribution system.

**Grid-Dependent Mode**
An inverter which automatically ceases to operate upon loss of voltage from City Electric and resumes operation when City Electric voltage is restored.

**Grid-Interactive Mode**
An inverter which operates in parallel with City Electric and contains provision for synchronizing with City Electric.

**Inverter**
An electronic device that converts DC electricity into AC electricity and acts as the interface between your electricity generator and the City of Medicine Hats' electrical distribution system. Electricity from your generator (solar PV, fuel cells, wind turbines, etc..) is converted to a form that can be supplied to the utility grid.

**Islanding**
A condition in which a portion of City Electric is energized by a Micro-generation facility thru a PCC while that portion of City Electric is separated from the rest of City Electric distribution system. Islanding is not permitted in Alberta.

**Micro-generator (MG)**
Typically, a residential or small commercial generator with a capacity less than or equal to one MW that is connected to the electrical distribution system. The electricity produced is for personal use and it is generally expected that on an annual basis generation will be equal to consumption.

**Point of Common Coupling (PPC)**
The point where City Electric is connected to the Micro-generator's facility.

**Ride-through**
Ability to withstand voltage or frequency disturbances.

**Single-phase Inverter**
An inverter that generates a single-phase electrical output.

**Solar photovoltaic (PV) generator**
Generator that uses solar radiation as its energy source.

**Stand-Alone Mode**
An inverter which operates in isolation from the City of Medicine Hat Electric Distribution System (City Electric).

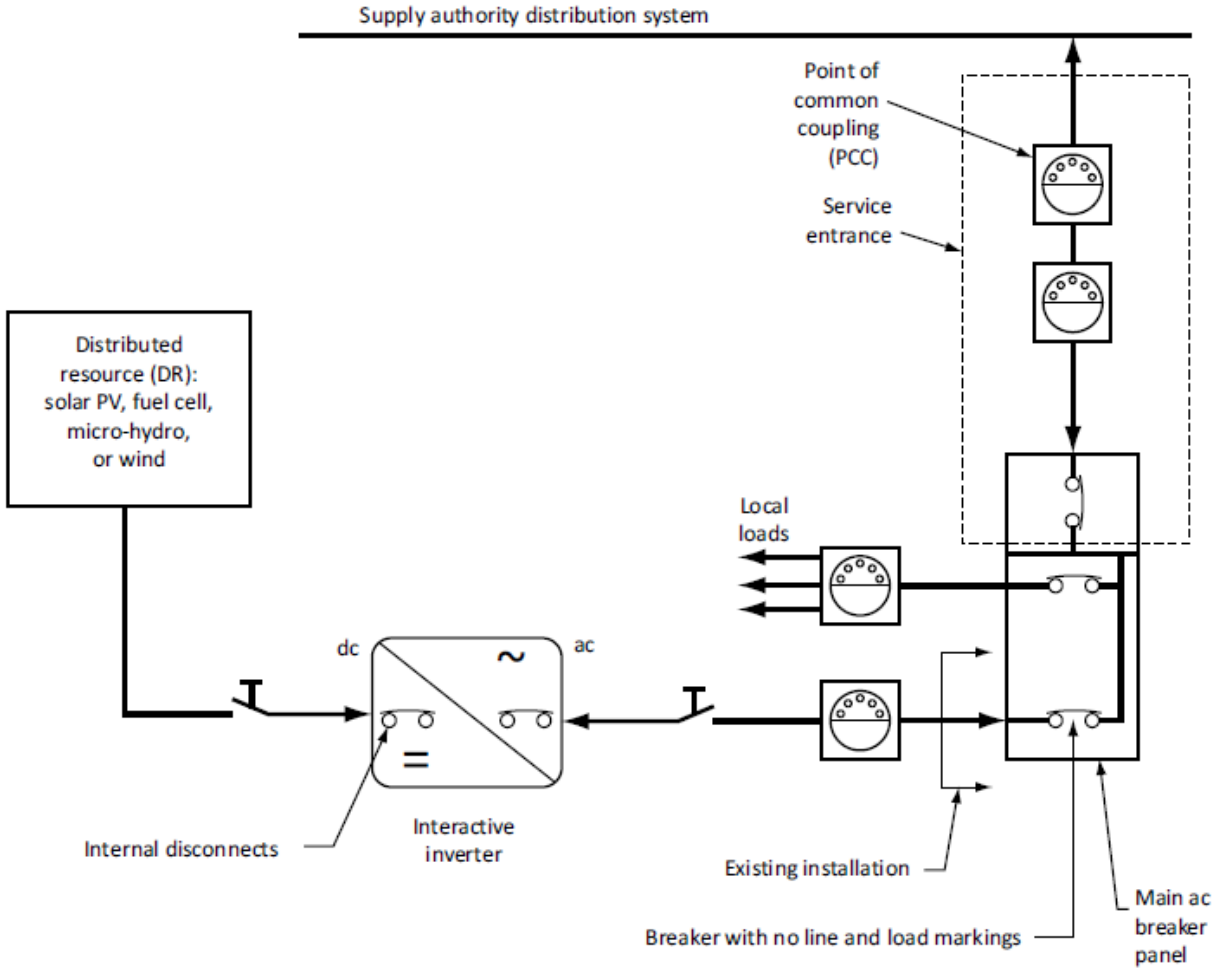
**Synchronous inverter**
Electrical inverter that changes direct-current (DC) electricity to alternating-current (AC) electricity.

**Three-phase (multi-phase) inverter**
An inverter that generates a three-phase electrical output.

**Trip**
Cessation of output without immediate return to service; not necessarily disconnection.

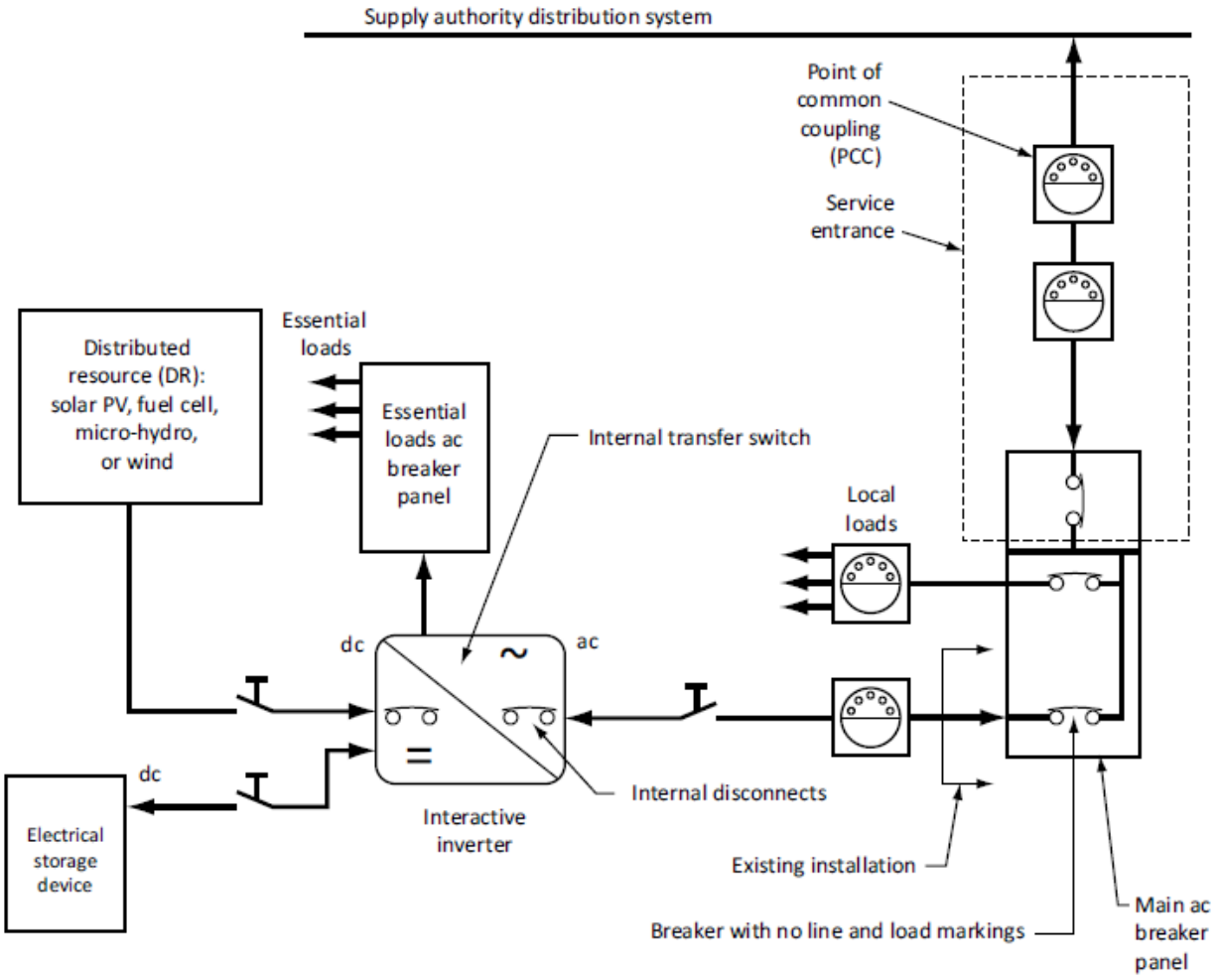
**Voltage-Following Inverter**
An inverter in which the output follows the waveform of an external device.

# 17 Appendix 2 – Grid-Dependent Single Line Diagram for Micro-Distributed Generator Systems




***Source: Canadian Electrical Code, Part 1 Figure B64-1 (R2021)***

# 18 Appendix 3 – Grid-Interactive Single Line Diagram for Micro-Distributed Generator Systems




***Source: Canadian Electrical Code, Part 1 Figure B64-2 (R2021)***