TECHNICAL GUIDELINE
FOR THE INTERCONNECTION OF DISTRIBUTED ENERGY RESOURCES TO EPCOR DISTRIBUTION AND TRANSMISSION INC.’S DISTRIBUTION SYSTEM

January 5, 2017
EPCOR acknowledges the use of other documents developed by the utility industry and industry committees as the framework and sources in producing this technical guideline.
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INTRODUCTION
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INTRODUCTION

A distributed energy resource (DER) is any technology that produces power and is connected to an electric distribution system (including, but not limited to, distributed generation, microgeneration and battery energy resources). A DER can use a variety of energy sources, including, but not limited to, liquid petroleum fuels, biofuels, natural gas, solar, hydro, wind and geothermal. Electricity storage devices are also DERs.

This guideline establishes criteria and requirements for the interconnection of DERs within the electric distribution system of EPCOR Distribution and Transmission Inc. (EDTI). Specifically, this guideline defines the technical requirements for connecting DERs that are not exclusively owned by EDTI, but are connected to EDTI’s distribution system with a primary operating voltage of 25,000 V (25 kV) or less. Requirements relevant to the safety, operation, performance, testing and maintenance of the interconnection are provided.

The requirements established in this document cover a broad spectrum of interests. The addition of DERs to the distribution system may change the system and its response. Attaining a technically sound, strong and safe interconnection between DERs and the distribution system mandates diligence on the part of everyone involved in the interconnection. The requirements in this guideline need to be cooperatively understood and met by everyone involved in the interconnection, including designers, manufacturers, users, owners and operators of both DERs and distribution systems.

This guideline has been developed with reference to national and international standards such as Canadian Standards Association (CSA) C22.3 No. 9-08, Interconnection of Distributed Resources and Electricity Supply Systems, and the Institute of Electrical and Electronic Engineers (IEEE) standard 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems.

This document does not constitute a design handbook. Distributed energy resource providers (DERPs) who are considering the development of a DER facility intended for connection to EDTI’s distribution system should engage the services of a professional engineer or a registered consulting firm qualified to provide design and consulting services for electrical interconnection facilities.

For inquiries relating to the connection of DERs, please contact EDTI Customer Engineering Services at distgen@epcor.com.

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1 Alberta Electric System Operator (AESO) Distributed Energy Resources Policy Recommendations
LIMITATION

The criteria and requirements in this document are applicable to all distributed energy resource technologies and to the primary and secondary voltages of EDTI’s distribution systems.

Installation of DERs on radial primary and secondary distribution systems is the main emphasis of this guideline (restrictions relating to EDTI’s downtown secondary network distribution system are described in section 1.3.8). The requirements in this document shall be met at the point of common coupling, although the location of the protective devices may not necessarily be at that point.

This interconnection guideline is a minimum requirement for the interconnection of DERs. Additional requirements may have to be met by both the DERP and EDTI to ensure that the final interconnection design meets all local, national and international standards and codes, and is safe for the application intended.

This guideline does not address any liability provisions agreed to elsewhere by both parties in a commercial agreement or tariff terms and conditions.
GENERAL INTERCONNECTION AND PROTECTION REQUIREMENTS
1.0 GENERAL INTERCONNECTION AND PROTECTION REQUIREMENTS

A DERP’s DERs and interconnection installation must meet all applicable international, national, provincial and local construction and safety codes.

Any DERP may operate 60 Hz, three-phase or single-phase generating equipment, in parallel with EDTI’s distribution system and in accordance with the EDTI Interconnection Operating and Maintenance Agreement, provided that the equipment and DERP meet or exceed the requirements of this guideline.

Sections 1.1, 1.2 and 1.3, respectively, define the following technical requirements:

- The distribution system’s technical requirements (the DERP’s equipment must be able to operate within the ranges specified in this section)
- Technical requirements to be met by the DERP
- Technical requirements to be met by the facilities interconnecting the producing facility with the distribution system

These requirements promote safe operation and minimize the impact on electrical equipment within the EDTI distribution system, including other customers. These requirements do not address the protection for the DERP’s DER equipment. It is the responsibility of the DERP to provide such protection. The DERP is responsible for protecting its DER equipment in such a manner that utility system outages, short-circuits or other disturbances, including excessive zero-sequence currents and ferroresonant overvoltages, do not damage the DERP’s DER equipment. As required in this guideline, the DERP’s protective equipment must also prevent excessive or unnecessary tripping that would affect EDTI’s reliability and the quality of power provided to other customers.

The DERP is required to install, operate and maintain, in good order and repair and in conformity with good electrical practice, the facilities required by this guideline for safe parallel operation with EDTI’s distribution system.

1.1 EDTI’S DISTRIBUTION SYSTEM

1.1.1 General Characteristics

Each distribution circuit on EDTI’s distribution system is normally radial, supplied from a single substation. EDTI’s distribution circuits operate at 4.16 kV, 13.86 kV or 24.94 kV nominal line-to-line voltages.

Some areas of the downtown core of Edmonton are operated as a secondary network system, with multiple paths for power to flow from an EDTI substation to the customers. Reverse power flow from the customer back through the secondary network is not permitted. Refer to the requirement for reverse power protection (see section 1.3.18).

Three-phase primary voltage service is available on 13.86 kV and 24.94 kV circuits.
1.1.2 System Frequency

The Alberta Interconnected Electric System (AIES) operates nominally at 60 Hz alternating current (AC). Frequency deviations are typically 59.7 Hz to 60.2 Hz for small contingencies that cause modest disturbances, when the AIES remains intact and connected to the Western system.

For large contingencies, much larger frequency deviation can occur. These variations can be experienced when a portion of the AIES becomes islanded.

1.1.3 Voltage Regulation

The CSA Standard CAN3-C235-83 Preferred Voltage Levels for AC Systems 0 to 50,000 V provides general guidance for appropriate performance as shown in Table 1.

**TABLE 1 CSA-RECOMMENDED VOLTAGE VARIATION LIMITS FOR CIRCUITS UP TO 1,000 V, AT SERVICE ENTRANCE**

<table>
<thead>
<tr>
<th>Nominal system voltage</th>
<th>Extreme operating conditions</th>
<th>Normal operating conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single-phase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120/240</td>
<td>106/212</td>
<td>110/220</td>
</tr>
<tr>
<td>240</td>
<td>212</td>
<td>220</td>
</tr>
<tr>
<td>480</td>
<td>424</td>
<td>440</td>
</tr>
<tr>
<td>600</td>
<td>530</td>
<td>550</td>
</tr>
<tr>
<td><strong>Three-phase (four-conductor)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120/208Y</td>
<td>110/190</td>
<td>112/194</td>
</tr>
<tr>
<td>277/480Y</td>
<td>245/424</td>
<td>254/440</td>
</tr>
<tr>
<td>347/600Y</td>
<td>306/530</td>
<td>318/550</td>
</tr>
<tr>
<td><strong>Three-phase (three-conductor)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>212</td>
<td>220</td>
</tr>
<tr>
<td>480</td>
<td>424</td>
<td>440</td>
</tr>
<tr>
<td>600</td>
<td>530</td>
<td>550</td>
</tr>
</tbody>
</table>

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2 CAN3-C235-83, Table 3
1.1.4 Power Quality

All interconnected equipment must comply with EDTI’s standards for power quality. The following industry standards provide guidance for appropriate performance.

- Voltage flicker: IEEE Std 519-2014 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System

According to IEEE 519-2014, the recommended practice for utilities is to limit the maximum individual frequency voltage harmonics to 3% of the fundamental frequency, and the voltage total harmonic distortion to 5% on the utility side of the point of common coupling (1 kV < V ≤ 69 kV). These harmonic voltage limits can be used as system design values for the “worst case” under normal operation.

1.1.5 Voltage Unbalance

Distribution facilities are typically three-phase systems incorporating single-phase distribution taps. Under normal operating conditions, the voltage unbalance on EDTI’s distribution system may reach 3%, due to unbalanced loading and single-phase regulation. Voltage unbalance will be calculated using the following formula derived from CSA-61000-4-30-04:

\[
\text{Voltage Unbalance (\%)} = 100 \times \frac{V_2}{V_1}
\]

Where:
- \(V_2\) is the negative-sequence voltage (fundamental frequency component)
- \(V_1\) is the positive-sequence voltage (fundamental frequency component)

1.1.6 Fault Levels

Fault levels, including maximum allowable fault levels, vary significantly throughout a distribution system. These must be considered in the design of the interconnection. Fault levels and X/R ratios must be evaluated for the equipment selected.

The DERP’s facility must not increase fault levels on EDTI’s distribution or transmission system above each system’s design levels for maximum faults (see section 1.3.11).

1.1.7 System Grounding

Distribution facilities are typically operated as effectively (solidly) grounded and wye-connected at the source substation bus.

Distribution facility grounding must conform to the Alberta Electrical and Communication Utility Code (2013).

1.1.8 Fault and Line Clearing

To maintain the reliability of the distribution system, EDTI typically uses automatic reclosing. The DERP needs to take into consideration line reclosing when designing DER protection schemes. This is to ensure that the DER is disconnected from EDTI’s
distribution system prior to the automatic reclosing of breakers. The DERP may reconnect when EDTI’s distribution system voltage and frequency return to the normal range and are stabilized.

1.1.9 Limit for DER Connection

No international or national standard specifies the maximum level of DER connection on a distribution circuit or a substation bus. Whenever the hosting capacity for a given distribution circuit is not specified, EDTI will limit the aggregated DER connected on distribution circuits at the substation bus; to the bus’s minimum load. EDTI defines hosting capacity for a given distribution circuit as the level of DER connection that maintains a safe, reliable and acceptable operation of the distribution circuit.

1.2 DER FACILITY

1.2.1 Smart Inverters

In general, there are three types of generators - synchronous generators, induction generators and inverters. EDTI requires that smart inverters, as defined in IEEE Std-1547 be used in an inverter-based DER facility.

1.2.2 Mitigation of Adverse Effects

Adding a DER facility to EDTI’s distribution system can adversely affect the electric service to existing or future electric customers. The DERP shall work with EDTI to mitigate any unfavourable conditions.

If the DER facility is adversely affecting customers, EDTI reserves the right to disconnect the DER until the concern is mitigated. The DERP will be responsible for any costs incurred as a result of these actions.

1.2.3 Synchronism

Any DER facility that can create a voltage while separated from EDTI’s distribution system must have synchronization facilities to allow its connection to EDTI’s distribution system.

Synchronization facilities are not required for induction generators that act as motors during start-up, drawing power from the electric system before they themselves generate power.

EDTI cannot synchronize to a DER facility. The DER facility is responsible for synchronizing and maintaining synchronization with EDTI’s distribution system. A proposed synchronizing scheme must be submitted and outlined in the Interconnection Operating and Maintenance Agreement.

Synchronization equipment must prevent connection to EDTI’s distribution system when the DERP’s synchronous generator and/or EDTI’s distribution system is operating outside the limits showing in Table 2.3

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3 IEEE 1547-2003, Table 5
### TABLE 2  SYNCHRONIZATION PARAMETER LIMITS FOR SYNCHRONOUS INTERCONNECTION TO EDTI’S DISTRIBUTION SYSTEM

<table>
<thead>
<tr>
<th>Aggregate rating of DER units (kVA)</th>
<th>Frequency difference (Δf, Hz)</th>
<th>Voltage difference (ΔV, %)</th>
<th>Phase angle difference (ΔΦ, °)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500</td>
<td>0.3</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>501-1,500</td>
<td>0.2</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>&gt; 1,500</td>
<td>0.1</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

Distribution facilities typically allow for automatic reclosing of electrical circuits after a variable time delay. The DERP is responsible for protecting their facility from the effects of such reclosing.

DERs can automatically restart following automatic reclosing of distribution facility electrical equipment. DERs that automatically restart must have a time delay on restart with an adjustable range of 1-5 minutes. EDTI will coordinate the settings of DER restart time delays so that DERs on any circuit can restart in a staggered order to prevent unfavorable conditions from arising during restart.

#### 1.2.4 Voltage Regulation and Power Factor

The DERP is responsible for ensuring that the voltage levels at the point of common coupling (PCC) are maintained within the guidelines prescribed by EDTI. Voltage levels must be at least equal to the voltage levels at all circuit load conditions, prior to the interconnection. DERs shall not actively regulate the voltage at the PCC, except in the following cases:

- Synchronous generators must be equipped with excitation controllers capable of controlling voltage. The generator bus voltage set point shall be stable at, as well as adjustable to, any value between 95% and 105% so that EDTI can maintain CSA voltage limits on its system.

- Inverter-type generators must be capable of adjusting the power factor in the range of ±0.9. The DERP may operate outside that range only by prior agreement with EDTI.

- EDTI will define voltage and reactive power control requirements on a project-by-project basis. The DERP and EDTI will identify the exact transformer ratio to allow the best voltage regulation on the system and determine whether an on-load tap changer is needed.

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4 IEEE 1547-2003, Clause 4.2.6
• In order to coordinate with its existing voltage-control devices, EDTI may require that the DER operate in a power factor control mode. This means operating within a constant power factor set point range. The voltage/power factor regulator must be capable of controlling the power factor of the DER between +0.9 and -0.9. EDTI shall determine the actual set point between these limits.

• In power factor control mode, the DER must have a voltage override that causes it to reduce excitation if the voltage at the PCC exceeds an upper limit to be specified by EDTI. The normal upper limit is 105% of nominal voltage; however, the DER shall have a provision to adjust this upper limit to between 100% and 110% of nominal voltage. The DER must also have a provision for a time delay between sensing an excursion of the upper voltage and initiating control action. The power factor control equipment in the DER must allow for the adjustment of this time delay between 0 and 180 seconds. EDTI will specify the required time delay.

1.2.5 Frequency Control

When EDTI’s distribution system frequency is in an abnormal range, as specified in Table 3, the DERs shall cease to energize EDTI’s distribution facilities within the clearing time indicated. Clearing time is the time between the start of the abnormal condition and the DERs ceasing to energize EDTI’s distribution facilities.

Adjustable under-frequency trip settings shall be coordinated with EDTI’s distribution operations.

Islanded operations are not allowed for DERs connected to EDTI’s distribution system (see section 1.3.16). DERs with stand-alone capability, that serve isolated systems, must be capable of controlling the frequency of the system to between 59.7 Hz and 60.2 Hz for normal operation.

<table>
<thead>
<tr>
<th>DER size</th>
<th>Frequency range (Hz)</th>
<th>Clearing time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 30 kW</td>
<td>&gt; 60.5</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>&lt; 59.3</td>
<td>0.16</td>
</tr>
<tr>
<td>&gt; 30 kW</td>
<td>&gt; 60.5</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>&lt; (59.8-57.0) (adjustable set point)</td>
<td>Adjustable 0.16 to 300</td>
</tr>
<tr>
<td></td>
<td>&lt; 57.0</td>
<td>0.16</td>
</tr>
</tbody>
</table>

5 IEEE Std 1547-2003, Table 2
1.2.6 Voltage Unbalance

The phase-to-phase voltage unbalance must not exceed 1%\(^6\) for any three-phase DER facility, as measured both with no load and with balanced three-phase loading. Voltage unbalance will be calculated using the same formula as in section 1.1.5. Single-phase DERs must not adversely unbalance the three-phase system. When they are connected in multiple units, an equal amount of DER capacity must be applied to each phase of a three-phase circuit. The group of DERs must also maintain balance when one unit trips or begins generating before or after the others. A single-phase DER may be connected alone, only if it does not cause voltage unbalance on EDTI’s distribution system in excess of 2%\(^7\).

1.2.7 Grounding

A ground grid of sufficient size to handle the maximum available ground fault current shall be designed and installed in order to limit step and touch potentials to safe levels as set forth in ANSI/IEEE Std 80 IEEE Guide for Safety in AC Substation Grounding. All electrical equipment must be grounded in accordance with the Alberta Electrical and Communication Utility Code (AECUC) and the Canadian Electrical Code’s electrical and safety regulations. The ground grid must be approved by EDTI.

1.2.8 Resonance and Self-Excitation of Induction Generators

Resonance should be considered in the design of the DERP’s facility, as certain resonance can cause damage to existing electrical equipment, including the electrical equipment of the DERP. Engineering analysis by the DERP should be a part of the design process to evaluate the existence of and to eliminate the harmful effects of:

- Ferroresonance in the transformer (see Appendix VII, Note 1)
- Sub-synchronous resonance due to the presence of series capacitor banks (see Appendix VII, Note 2)
- Resonance with other customers’ equipment due to the addition of capacitor banks to the distribution system (see Appendix VII, Note 3)

For DERPs connecting induction generators, the adverse effects of self-excitation of the induction generator during island conditions should be assessed and mitigated. The intent is to detect and eliminate any self-excited condition (see Appendix VII, Note 4).

The engineering analysis of resonance and the assessment of the effect of self-excitation of induction generators should be submitted to EDTI for approval or further evaluation.

1.2.9 Single-Phase DER Facilities

The aggregate generation on a single phase shared secondary should not exceed 20 kW\(^8\). For dedicated distribution transformer services, the limit of a single-phase generating facility shall be the transformer nameplate rating.

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\(^6\) IEEE Std 141-1993 (Red Book), section 3.8.3
\(^7\) AUC Guide for Generator Interconnection, section 3.2.5
\(^8\) AUC Micro-Generator Application Guideline, section B
1.3 INTERCONNECTION

An interconnection review study will be conducted when a DERP applies for DER connection to EDTI’s distribution system. The study will evaluate the impact that the DER will have if it is connected to EDTI’s distribution system (the scope of the study is outlined in Appendix I).

1.3.1 Safety

Abnormal conditions can arise on the EDTI’s distribution system that require a response from the connected DER. This response contributes to the safety of utility maintenance personnel and the general public, as well as the avoidance of damage to connected equipment, including the DER as per IEEE 1547.9.

The connection, installation and operation of a DER facility shall not create a safety hazard to EDTI’s personnel, customers, general public and personnel working in the DER facility.

Safety is of primary concern and shall be the main consideration when designing a DER facility. The primary objective of this technical guideline is to provide interconnection specifications to ensure that safety will be maintained.

1.3.2 Point of Common Coupling

Point of common coupling (PCC) is the point where EDTI’s electrical facilities or conductors are connected to the DERP’s facilities or conductors, and where any transfer of electric power between the DERP and EDTI takes place. The PCC will be identified in the design and on the single-line diagram. EDTI will coordinate design, construction, maintenance and operation of the facilities on the distribution side of the PCC. The DERP is responsible for the design, construction, maintenance and operation of the facilities on the DER side of the PCC.

In specific cases, either EDTI or the DERP may own equipment located on the other’s side of the PCC. For example, EDTI may own and operate communications, supervisory, or metering equipment, which is located on the DERP’s side of the PCC.

The DERP must provide a site with the necessary space for EDTI to install current transformers, potential transformers, switching equipment, meters, and any other controls or communications equipment required to interconnect with the DER facility. The site is to be approved by EDTI and a 120 V alternating-current power service is to be available for the use of portable tools.

All voltage, frequency and harmonic parameters, as specified in the following sections, shall be met at the PCC unless otherwise stated.

1.3.3 Point of Disconnection

To provide a means of electrically isolating EDTI’s distribution system from the DER, a manual and visible disconnect switch must be installed at the point of common coupling (PCC). Where the DER facilities are located far from the PCC, the DERP may be allowed to install a local point of isolation next to the DER. EDTI and the DERP will mutually agree on the exact location of the switch.

9 section 4.2, IEEE 1547-2003
If the switch is to be located on EDTI’s side of the PCC, it will be installed by EDTI at the DERP’s expense. If the switch is to be located on the DERP’s side of the PCC, it must be supplied and installed by the DERP.

When the interconnection involves three-phase DERs, the disconnect switch must be gang operated to simultaneously isolate all three-phases.

All disconnect switches must:

- Be within 5 m (horizontal) of the PCC, or an EDTI-approved location
- Be capable of being opened at rated load
- Viewing windows, through which the status (open or closed) of the disconnect switch can be verified readily
- Be readily accessible to EDTI operating personnel on a 24-hour basis
- Have provision for being locked in the “open” position
- Disconnect all ungrounded conductors of the circuit simultaneously
- Be externally operable without exposing the operator to contact with live parts
- Be capable of being closed onto a fault with complete safety for the operator
- Be capable of being energized from both sides
- Plainly indicate whether it is in the “open” or “closed” position
- Provide safe isolation for EDTI personnel from the generators and all other possible customer sources of power
- Be labelled with an EDTI switch number
- Meet applicable Canadian Electrical Code (CEC) Part I and Part II standards
- Be installed to meet all applicable codes
- Be inspected and maintained annually

The disconnect switch on the DER side of the interconnection transformer will be owned and maintained by the DERP. Refer to Appendices II, III and IV for a sample configuration.

On a site that interconnects multiple generators, one disconnect switch must be capable of isolating all the generators simultaneously.

A withdrawable circuit breaker is an acceptable disconnect device.

The DERP shall follow EDTI’s switching, clearance and tagging procedures. EDTI shall instruct the DERP on these procedures.

There may be other means of meeting the requirements of this section. EDTI must approve any other means.
1.3.4 Phasing

Since phasing is not standardized across distribution facilities, the phase sequence and the direction of rotation must be coordinated between the DERP and EDTI’s system.

1.3.5 Voltage Flicker

The DERP must not cause excessive voltage flicker on EDTI’s facilities. Any voltage flicker at the point of common coupling that is caused by the generating facility should not exceed the limits defined by the maximum borderline of irritation curve identified in Figure 10.3 of IEEE Std 519-2014 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems. The customer will also comply with the short- and long-term flicker limits as specified in Tables 2 and 6 of CAN/CSA-C61000-3-7 Electromagnetic Compatibility (EMC) - Part 3-7. This is necessary to minimize any adverse voltage effects that could be experienced by other customers on EDTI’s distribution system.

Induction generators may be connected and brought up to synchronous speed (as an induction motor) if these flicker limits are not exceeded. The DERP must submit to EDTI the expected number of starts per specific time period and the maximum starting current draw data in order to verify that the voltage dip due to starting is within the IEEE limits. At no time should the voltage drop exceed 5% as measured on EDTI’s side of the point of common coupling (PCC). Otherwise, the DERP will be required to install corrective step-switched capacitors or apply other techniques to bring voltage fluctuations to acceptable levels. These corrective measures could, in turn, cause ferroresonance; therefore, EDTI must review any measures undertaken on the DERP’s side of the PCC.

1.3.6 Harmonics

The DERP’s operation of its DER facilities must not cause an unacceptable level of harmonics. Maximum harmonic current distortion limits for a DER facility, measured at the point of common coupling (PCC), are as specified in Table 4.

The objective of the current distortion limits in CSA C22.3 No. 9-08 is to limit the harmonic injection from individual customers. This is to ensure that they do not cause unacceptable levels of voltage distortion to normal system characteristics. Ideally, the voltage distortion would then be limited to 3% of the fundamental frequency for individual harmonic frequencies and 5% voltage total harmonic distortion on EDTI’s side of the PCC.

DER facilities must not inject DC current greater than 0.5% of the full rated output current into EDTI’s distribution system under normal or abnormal operating conditions.

10 Table 3, IEEE 1547-2003 and Table 1, CSA C22.3 9-08
TABLE 4 MAXIMUM HARMONIC CURRENT DISTORTION IN PERCENT OF CURRENT (I)\textsuperscript{a,10}

<table>
<thead>
<tr>
<th>Individual harmonic order h (odd harmonics)\textsuperscript{b}</th>
<th>h &lt; 11</th>
<th>11 &lt; h &lt; 17</th>
<th>17 &lt; h &lt; 25</th>
<th>25 &lt; h &lt; 35</th>
<th>35 ≤ h</th>
<th>Total demand distortion (TDD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent (%)</td>
<td>4.0</td>
<td>2.0</td>
<td>1.5</td>
<td>0.6</td>
<td>0.3</td>
<td>5.0</td>
</tr>
</tbody>
</table>

\textsuperscript{a} I = the greater of the distribution system maximum load current integrated demand (15 or 30 min) without the DER unit; or the DER unit rated current capacity, transformed at the PCC when a transformer exists between the DER unit and the PCC.

\textsuperscript{b} The maximum distortion values specified in this table are for odd harmonics. To obtain maximum distortion values for even harmonics, multiply the value in the corresponding h-range by 25%.

1.3.7 Inadvertent Energization of EDTI's Facilities

When EDTI’s facilities are de-energized for any reason, the DERP’s DER must not energize EDTI’s facilities for any of the following reasons.

1. The DER can cause power quality problems to EDTI’s customer.

2. The DER can cause out-of-phase reclosing between EDTI’s distribution system and the DER facility.

3. The DER can create safety hazards to EDTI’s personnel, customers and general public.

1.3.8 Network System Interconnection

DER facilities that export power onto EDTI’s distribution system will not be allowed to connect to the downtown secondary network system. This restriction is required because EDTI uses network protectors for reverse power protection throughout the downtown’s networked underground distribution system. Network protector manufacturers and IEEE C37.108 specifically recommend against using network protectors in a DER application.

For non-exporting DER facilities, EDTI may allow parallel operation on the network system if:

- The DERP installs reverse power protection for the facility (see section 1.3.18)
- Reverse power protection settings prevent any cycling operation of network protectors due to the output of the DER
- The network equipment loading and fault-interrupting capacities are not exceeded by the addition of the DER

\textsuperscript{10} Table 3, IEEE 1547-2003 and Table 1, CSA C22.3 9-08
1.3.9 Dedicated Transformer

EDTI reserves the right to require a DERP’s facility to connect to the distribution system through a dedicated transformer. A dedicated transformer is a transformer with a secondary winding that serves only one customer. The transformer may be necessary to:

- Ensure conformance with EDTI safe work practices
- Enhance service restoration operations
- Prevent detrimental effects on other EDTI customers

The dedicated transformer that is part of the normal electrical service connection of a DERP’s facility may meet this requirement if no other customers are supplied from it. A dedicated transformer may not be required if the installation is designed and coordinated with EDTI to protect the EDTI system and its customers adequately from potential problems caused by the operation of the DER.

1.3.10 Interconnection Grounding

Grounding configurations shall be designed to provide:

- Solidly grounded distribution facilities
- Suitable fault detection to isolate all sources of fault contribution, including the DER, from a faulted line or distribution element
- A circuit to block the transmission of harmonic currents and voltages
- Protection of the low-voltage side from high-fault-current damage

For three-phase DERs, the EDTI-supplied distribution transformer will normally be a grounded-wye configuration on both the low- and high-voltage side.

The preferred configuration for a DERP-owned interconnection transformer is delta connection on the DER side of the transformer and a grounded-wye configuration on EDTI’s side of the transformer. If this configuration is not possible, the configuration chosen must still address the above concerns. The winding configuration for DER interconnection transformers must be reviewed and approved by EDTI.

If an interconnection transformer with delta connection on EDTI’s side is used, a special interconnection review study will be conducted to avoid temporary over-voltage issues if a line-to-ground fault on a distribution circuit were to occur.

1.3.11 Interrupting Device Ratings and Fault Levels

The design of the DER facility must consider the fault contributions from both the distribution facility and the generating facility to ensure that all circuit fault interrupters are adequately sized. EDTI will inform the DERP of the present and anticipated future fault contributions from the interconnected electric system, including fault-level design limits.

For generators that have time-variant fault-contribution characteristics, the characteristic producing the highest fundamental frequency fault current shall be used for maximum fault current calculations. For synchronous and induction generators, the subtransient reactance shall be used.
Inverter-type systems are different from rotating machines in that fault currents are typically only marginally greater than full-load current.

EDTI will perform fault-level calculations based upon the DERP’s supplied data for proposed generator and transformer impedances. EDTI will advise the DERP if the proposed facility exceeds EDTI’s maximum design fault levels. If the calculated fault contribution from the proposed facility increases the fault levels on either EDTI’s distribution or transmission system above the maximum design levels, then the DERP will be required to redesign its facility to reduce fault level contributions. This may involve one or more of the following mitigation techniques:

- Select a generator with a larger subtransient impedance
- Select a higher-impedance generator transformer
- Install current-limiting reactors or other fault-current-limiting devices

If the fault-level contributions from the facility cannot be reduced to an acceptable level, then EDTI will not allow the interconnection of the DERP’s facility.

1.3.12 Phase and Ground Fault Protection

The DERP must install protective devices to detect and promptly isolate the DER facility for faults occurring in the DER facility or on EDTI’s distribution system.

The DER facility’s protective devices must fully coordinate with protective relays on the electric system. The DERP must calculate the protective-device settings and submit the relay characteristics and settings to EDTI for review and approval.

The DER facility must be able to detect the following situations and isolate itself from the distribution facility:

- A short-circuit between any phase(s) and ground
- A short-circuit between phase(s)
- Loss of any phase(s)

1.3.13 Overvoltage and Undervoltage Protection

The DERP will operate its generating equipment in such a manner that the voltage levels on EDTI’s distribution system are in the same range as if the generating equipment were not connected to the distribution system.

The DERP must install necessary relays to trip the DER circuit breaker when the voltage, measured phase-to-ground, is outside predetermined limits.

The DERP’s interconnection device shall cause the generator to cease to energize EDTI’s distribution system within the clearing time as indicated in Table 5. The clearing time is the time between the start of the abnormal condition and the interconnection device ceasing to energize EDTI’s distribution system.
### TABLE 5: INTERCONNECTION SYSTEM RESPONSE TO ABNORMAL VOLTAGES\(^{11}\)

<table>
<thead>
<tr>
<th>Voltage range (% of base voltage)(^a)</th>
<th>Clearing time(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V &lt; 50</td>
<td>0.16</td>
</tr>
<tr>
<td>50 ≤ V &lt; 80</td>
<td>2.00</td>
</tr>
<tr>
<td>110 &lt; V &lt; 120</td>
<td>1.00</td>
</tr>
<tr>
<td>V ≥ 120</td>
<td>0.16</td>
</tr>
</tbody>
</table>

\(^a\) Base voltages are the normal system voltages stated in CSA Standard CAN3-C235-83.

The DERP may reconnect when EDTI’s system voltage and frequency return to normal range and are stabilized for a time period up to 5 minutes.\(^{12}\)

#### 1.3.14 Overfrequency and Underfrequency Protection

The DERP must install frequency-selective relays to separate the DER(s) from EDTI’s distribution system in cases of extreme variations in frequency.

Underfrequency and overfrequency relaying that automatically disconnects DERs from the distribution system must be time delayed in accordance with IEEE Std 1547-2003 as noted in section 1.2.4. The DERP may reconnect when EDTI’s distribution system voltage and frequency return to a normal range and are stabilized for a time period up to 5 minutes.

#### 1.3.15 Unbalanced Phase Protection

The DERP should be aware that single-phase protection devices exist on EDTI’s distribution system. Unbalanced current conditions caused by open conductors on the distribution system can subject the generator to a high level of negative-sequence current. The DERP is responsible for protecting its generating equipment from the effects of excessive negative-sequence currents in the event of single phasing. Negative-sequence current relaying is recommended.

#### 1.3.16 Anti-Islanding Protection

In most cases, the DER facility will routinely operate as a part of the interconnected system. A problem on EDTI’s distribution system could lead to the DER becoming islanded and inadvertently acting as the sole power resource for one or more of EDTI’s customers. This could result in damages to those customers and liability to the DERP because of irregularities in power quality. The DERP’s generator must be equipped with anti-islanding protection designed to prevent the DER from being connected to a de-energized EDTI circuit. The anti-islanding protection should meet the following requirements:

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\(^{11}\) IEEE 1547-2003, Table 1

\(^{12}\) IEEE Std 1547-2003, Clause 4.2.6
• Upon loss of voltage in one or more phases of EDTI’s distribution system, the DER facility shall automatically disconnect from EDTI’s distribution system within 0.6 s.

• All DER facilities must have passive anti-islanding protection, including:
  - Underfrequency/overfrequency protection (section 1.2.4)
  - Undervoltage/overvoltage protection (section 1.3.13)
  - Reverse power protection

• All DER facilities shall have active anti-islanding protection, which can be:
  - Sandia Frequency Shift
  - Sliding Mode Frequency Shift
  - Active Frequency Drift
  - Other method approved by CSA or ANSI/IEEE or UL

• The DERP shall demonstrate to EDTI that it shall not sustain an island for longer than 0.6 s.

Transfer trip for anti-islanding protection may be required as stipulated in section 1.3.17. Damages that are caused by a failure to separate safely during an islanding event will be the responsibility of the DERP.

1.3.17 Requirements for Transfer Trip

No international or national standard specifies the minimum DER rating at which transfer trip (TT) is required. However, EDTI should set up the threshold for TT installation on a DER site to avoid DERs running in islanding mode. In general, the minimum load on a 15 kV or 25 kV circuit is about 2,000 kVA. If a DER with 1,000 kW rating is connected to a circuit without TT, it is possible for the DER to run in islanding mode to feed the customers on the circuit when the circuit breaker is open. Therefore, all synchronous generators and inverter-based generators that are rated 1,000 kW or larger with the ability to export power onto EDTI’s distribution system must be equipped with transfer trip protection or an EDTI-approved anti-islanding relay that performs the equivalent function of transfer trip. This is to ensure that these generators do not island in the event of a substation breaker or intermediate automatic circuit recloser opening. General requirements are as follows:

1. A DER end-open signal must be sent to EDTI’s circuit breaker relay to make sure the breaker is safe to reclose after tripping on a fault.

2. Generator lockout or lockout of the main breaker (for DER facilities that want to operate in isolation) must occur at the point of common coupling location within 0.6 s\(^\text{13}\) of the EDTI substation circuit breaker or the automatic circuit recloser opening.

3. Fail-safe lockout must occur within 6 s of communication loss.

4. The DERP is responsible for detecting and tripping in the event of communication loss.

\(^{13}\) A circuit breaker or a recloser can be reclosed within 0.6 s.
If transfer trip protection is installed for a DER, the DER must operate on the specified circuit. When the DER is transferred to another circuit from the specified circuit, the DER must be turned off.

Synchronous generators and inverters of less than 1,000 kW may also require this protection, depending upon the characteristics of the particular distribution circuit to which they are connected. EDTI will inform the DERP of the requirements in these cases.

DERs of less than 1,000 kW should have provision for the capability to receive EDTI trip signals and cease generation; i.e., they should have provision for the installation of transfer trip. The actual implementation is not required when the DER is commissioned but may be requested by EDTI at a later date to be implemented at the DERP’s cost.

Unless the DERP can demonstrate that there is no potential for self-excitation, transfer-tripping requirements also apply to induction generators.

1.3.18 Reverse Power Relay Protection

Reverse power protection must be installed on non-exporting or export-limited generating facilities that are connected in parallel to the EDTI system.

Until the DERP has received all the necessary licenses and permits to operate in a parallel manner, all generating facilities require reverse power protection while connected in parallel to the EDTI system. An option for the DERP is to install an interlocking device that will prevent any electrical connection between the generator and the EDTI distribution system.

The setting for the reverse power protection (IEEE device 32) shall be the export or non-export limit as agreed to by EDTI, with a maximum 2 s time delay14.

1.3.19 Visibility and Controllability

Where a DER could adversely affect the power system, the DERP must have systems in place to inform EDTI what protective operations occurred or failed to occur. An example of an adverse effect would be the DERP’s generator providing inflow into a fault.

Each DER unit of 250 kW or more or aggregate of 250 kW or more at a single point of common coupling (PCC) shall have the provision15 for EDTI to monitor remotely the DER’s connection status, total real power output, total reactive power output, per-phase voltage and per-phase current at the point of DER connection.

Each DER unit of 250 kW or more or aggregate of 250 kW or more at a single PCC shall be controllable (turned off) by EDTI’s operators. This controllability must be implemented through 100% utility infrastructure. The DERs will be turned off only in extreme conditions—e.g., if EDTI’s distribution system must be stabilized after a blackout or if a threat to public safety exists.

14 San Diego Gas & Electric Company Rule 21, sheet 155
15 IEEE Std 1547-2003, Clause 4.1.6, provision means that the data required is available, necessary devices for communication from the DER control to EDTI’s communication devices are in place when the DER is commissioned.
1.3.20 Protection from Electromagnetic Interference

The influence of electromagnetic interference must not change the state or operation of the interconnection between EDTI’s and the DERP’s systems.

The DER facility interconnection must have the capability to withstand electromagnetic interference environments in accordance with either of the following:


b. CAN/CSA-CEI/IEC 61000-4-3-07 (R2015), using Level X, 35 V/m, in accordance with IEEE C37.90.2

The DERP shall provide documentation to show compliance with a. or b. above.

1.3.21 Surge Withstand Performance

The interconnection system must have the capability to withstand voltage and current surges in accordance with the environments described in IEEE/ANSI C62.41-2002 or C37.90.1-2012.

1.3.22 Special Interconnection Protection

In some cases, it will be necessary to provide for special generator-specific protection and controls, such as for loss of synchronism between the DERP and EDTI.

Unbalance conditions can occur in the distribution system, especially under system-fault conditions, and the design of the interconnection facilities should consider this.

For wye-delta interconnection transformers, the unbalance fault current could damage the generator interconnection transformer. The damage can occur because of the circulating current that occurs in the delta winding of the interconnection transformer in its attempt to balance the fault current. Therefore, the design may require protection for the transformer to address this potential problem.

In cases where the DERP wants to separate automatically from EDTI’s system and begin isolated operation, additional devices may have to be installed to effect separation.

1.4 TYPICAL INTERCONNECTION PROTECTIVE REQUIREMENTS

Typical interconnection requirements for safely operating the DERP’s generating equipment in parallel with EDTI’s distribution system are specified below. Specific interconnection locations and conditions may require more restrictive protective settings or hardware, especially when exporting power to the EDTI system. EDTI shall notify the DERP of special circumstances as soon as possible. An example of a restrictive area for DER interconnection is EDTI’s downtown network system. The DERP will need to work closely with EDTI to determine whether interconnection and operation within a specific network system is possible.

Protective relays shall provide DER status and analog values specified in section 1.3.19. Alarms generated by the DER facility are to be monitored by the DERP, and appropriate action should be taken by the DERP.
Only utility-grade protection devices are approved for interconnection protection.

Protective relays, electric conversion devices or other devices can comply with this guideline by demonstrating that they can accomplish the required protective function as specified in Table 6, Table 7 and Table 8.

**TABLE 6: PROTECTION FOR SINGLE-PHASE GENERATORS INTERCONNECTION CONTROL, PROTECTION AND SAFETY EQUIPMENT**

* Single-phase connected to secondary system

<table>
<thead>
<tr>
<th>Protection requirement for DER ≤ 50 kWᵇ</th>
<th>✔</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnect disconnect device</td>
<td>✔</td>
</tr>
<tr>
<td>Generator disconnect device</td>
<td>✔</td>
</tr>
<tr>
<td>Undervoltage/overvoltage trip</td>
<td>✔</td>
</tr>
<tr>
<td>Overfrequency/underfrequency trip</td>
<td>✔</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>✔</td>
</tr>
<tr>
<td>Synchronizing control (manual or automatic)ᶜ</td>
<td>✔</td>
</tr>
<tr>
<td>Anti-islanding (inverter type)</td>
<td>✔</td>
</tr>
<tr>
<td>Synch-check (at point of common coupling)</td>
<td>✔</td>
</tr>
</tbody>
</table>

ᵃ Exporting to EDTI’s system may require additional operational/protection devices and will require coordination of operations with EDTI.

ᵇ For single-phase generators larger than 50 kW, consult with EDTI on the required interconnection control, protection and safety equipment.

ᶜ For synchronous and other types of generators with stand-alone capability.
### TABLE 7 PROTECTION FOR THREE-PHASE GENERATORS

**INTERCONNECTION CONTROL, PROTECTION AND SAFETY EQUIPMENT**

Three-phase connected to primary or secondary system (all devices are three-phase unless otherwise specified)

<table>
<thead>
<tr>
<th>Device #</th>
<th>Protection requirement</th>
<th>150 ≤ DER ≤ 1,000 kW</th>
<th>DER &gt; 1,000 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnect disconnect device</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Generator disconnect device</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Synchronizing control(^b) manual (M) or automatic (A)</td>
<td>M or A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>25 Synch-check(^b) (at point of common coupling)</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>27 Undervoltage</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>59 Overvoltage</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>59N Neutral overvoltage(^c)</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>50/51 Instantaneous/timed overcurrent</td>
<td>✔(^d)</td>
<td>✔(^d)</td>
<td></td>
</tr>
<tr>
<td>50/51N Instantaneous/timed neutral overcurrent</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>81 Overfrequency and Underfrequency</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>32 Directional power</td>
<td>✔(^e)</td>
<td>✔(^e)</td>
<td></td>
</tr>
<tr>
<td>TT Transfer trip or equivalent relay</td>
<td>✔(^i)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Telemetry data communication</td>
<td>✔(^g)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Anti-islanding for inverters (IEEE Std 929, UL 1741, CSA C22.2 No. 107.1)</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Exporting to EDTI’s system may require additional operational/protection devices and will require coordination of operations with EDTI.

\(^b\) For synchronous and other types of generators with stand-alone capability.

\(^c\) Only required for generators that have their interconnection transformer’s primary winding ungrounded. Used in conjunction with three PTs in broken delta configuration rated for line-to-line voltage. For detecting ground faults on the distribution system.

\(^d\) A timed overcurrent relay with voltage restraint (51 V) may also be required to prevent nuisance trips.

\(^e\) Only required for non-exporting or export-limited generators.

\(^i\) Transfer trip or equivalent protective relay function required for all synchronous generators rated 1,000 kW and larger with export capability. May also be required for exporting synchronous generators under 1,000 kW, depending upon characteristics of the distribution circuit. EDTI will advise.

\(^g\) Telemetry required for DERs greater than 250 kW.
TABLE 8 PROTECTION FOR CLOSED TRANSITION SWITCHING INTERCONNECTION CONTROL, PROTECTION AND SAFETY EQUIPMENT GENERATORS CONNECTED TO PRIMARY OR SECONDARY SYSTEM

For six cycles or less (closed transition switching)\(^{16}\)

<table>
<thead>
<tr>
<th>GENERATOR ≤ 10 MW(^{17})</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnect disconnect device</td>
<td>✔</td>
</tr>
<tr>
<td>Generator disconnect device</td>
<td>✔</td>
</tr>
<tr>
<td>Undervoltage trip</td>
<td>✔</td>
</tr>
<tr>
<td>Overvoltage trip</td>
<td>✔</td>
</tr>
<tr>
<td>Overfrequency and underfrequency trip</td>
<td>✔</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>✔</td>
</tr>
<tr>
<td>Neutral overvoltage trip or neutral overcurrent trip(^{a})</td>
<td>✔</td>
</tr>
<tr>
<td>Directional power trip</td>
<td>✔</td>
</tr>
<tr>
<td>Synchronizing control(^{b})</td>
<td>Manual or automatic</td>
</tr>
<tr>
<td>Synch-check(^{b}) (at point of common coupling)</td>
<td>✔</td>
</tr>
</tbody>
</table>

\(^{a}\) Selection depends upon grounding connection of interconnection transformer.

\(^{b}\) For synchronous and other types of generators with stand-alone capability.

1.4.1 Single-Phase Generators

Refer to Table 6 for the protective functions required to meet this guideline. Inverter-type generators must meet the criteria in IEEE 929 Recommended Practice for Utility Interface of Photovoltaic (PV) Systems and be certified to UL 1741 and/or CSA C22.2 No.107.1.

1.4.2 Three-Phase Synchronous Generators

Refer to Table 7 for the protective functions required to meet this guideline.

The DERP’s generator circuit breakers must be three-phase devices with electronic or electromechanical control.

The DERP is responsible for:

- Properly synchronizing its generator with EDTI’s distribution system
- Ensuring that the interconnection protection device settings coordinate with EDTI’s protective device settings

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\(^{16}\) CSA C22.3 No.9-08, clause 7.4.13

\(^{17}\) IEEE 1547, section 1.3
1.4.3 Three-Phase Induction Generators and Three-Phase Inverter Systems

Refer to Table 7 for the protective functions by DER size required to meet this guideline. Inverter-type generators must meet the applicable criteria in IEEE 929 and be certified to UL 1741 and/or CSA C22.2 No.107.1.

1.4.4 Generators Paralleling for Six Cycles or Less (Closed Transition Switching)

DERs that are parallel with EDTI’s distribution system for six cycles or less shall be provided with the following protection functions:

a. Undervoltage protection, which shall ensure that the DER is not capable of energizing EDTI’s distribution system if the distribution system is de-energized

b. A six-cycle timer to ensure that the DER facility will not be parallel with EDTI’s distribution system for more than six cycles

c. A manual or automatic synchronization check

DERPs whose generators meet these criteria can submit an application and sign an Interconnection Operating and Maintenance Agreement, once they have met the other requirements of this guideline.

1.4.5 Mitigation of Protection System Failure

Relays with self-diagnostic check features provide information on the integrity of the protection system and should be used whenever possible. The protection system should be designed by a qualified professional engineer, or a competent technical person, working with EDTI engineers to ensure that this self-checking feature is integrated into the overall protection system for the safe and reliable operation of the power system.

Depending upon the system and its design, where relays with this self-diagnostic feature do not trip the appropriate breaker(s), sufficient redundant or backup protection should be provided for EDTI’s distribution system. The malfunctioning relay should also send a signal to notify operating personnel to initiate an investigation of the malfunction.

Older electromechanical relays do not generally come with self-diagnostic features. In these instances, design of protection and control systems should have fail-safes to maintain the integrity of the protection system in the case of malfunctions.

The DER facility requires a reliable power supply. Batteries and ancillaries, where provided, shall have adequate capacity and rating to ensure the operation of all protection functions when the principal source of power fails. Protection functions shall remain operational for the period of time specified in Table 3 and Table 5 following EDTI’s distribution system disturbances or loss of supply from EDTI’s distribution system. This may be achieved using batteries and a charger connected to the main supply or by using an uninterruptable power supply with sufficient capacity. Capacitors (i.e., capacitor trip) shall not be used for this purpose.
1.5 INTERCONNECTION PROTECTION APPROVAL

The DERP must provide complete documentation on the proposed interconnection protection for review against the requirements of this guideline and for potential impacts on EDTI’s distribution system.

The documentation should include:

- A completed application form
- An overall description of how the protection will function
- A detailed single-line diagram (substation name, circuit name, voltage levels, transformer ratings, point of common coupling, etc.). For examples, see Appendix II, III and IV
- Protection component details (manufacturer and model)
- Protection component settings (trigger levels and time values)
- Disconnect switch details (manufacturer, model and associated certification)
- A site plan (substation name, circuit name, voltage levels, primary circuit route, secondary circuit route, transformer location, DER location, electrical room, etc.)

The DERP shall revise and resubmit the protection information for any proposed modifications.
2.0 METERING
2.1 GENERAL

Metering equipment must comply with Measurement Canada requirements and be approved by EDTI.

The metering equipment must be:

- Suitable for use in the environmental conditions reasonably expected to occur at the installation site over the course of a typical year
- Appropriate for the power system characteristics reasonably expected to exist at the installation site under all power system conditions and events

The primary side of the interconnection transformer, which is the side connected to EDTI’s system, is the metering billing point for the DERP’s generation export conditions. The low side of the interconnection transformer, which is the side connected to the DERP’s facilities, is the metering billing point for the DERP’s import conditions. On all installations where the metering equipment is installed on the low side of the interconnecting transformer, transformer loss compensation, when required, will be applied in EPCOR’s billing system of record at a rate of 1% except if superseded by AESO regulation or if supplanted by a customer-specific loss factor approved by a professional electrical engineer or registered electrical technologist in the Province of Alberta and submitted to and approved by EPCOR.

2.2 METERING REQUIREMENTS

Metering requirements will be determined by EDTI based on the type and size of a DER. EDTI will provide and install meters at DER facilities (all meters will be bidirectional. Commercial/industrial meters will have four quadrants capability). The installation may require additional metering cabinets, metering cells and a dedicated 120 Volt AC supply to each meter cabinet. The DERP shall be required to cover the costs of additional equipment, if applicable. EDTI shall own, and have safe access to all metering equipment, including instrument transformers at all metering locations. The DERP will also be required to comply with all the metering requirements specified in section 8 of EDTI’s Customer Connection Guide.

2.3 MEASUREMENT TRANSFORMERS

The applicable winding(s) of the current and potential instrument transformers must:

- Be approved by Measurement Canada for revenue metering
- Be burdened to a degree that does not compromise the accuracy required by this guideline
- Have an accuracy class rating that equals or exceeds the values specified in Appendix V
2.4 REMOTE COMMUNICATIONS EQUIPMENT

EDTI’s advanced metering infrastructure incorporates two-way communications via radio. As such, where the metering cabinet is indoors, the DERP must provide a conduit from the metering cabinet to the outside, to accommodate a coaxial antenna cable.

2.5 SAFETY REQUIREMENTS

The installation shall conform to the requirements of:

- Measurement Canada Standard Drawings
- CSA Standard C22.2
CONSTRUCTION
3.0 CONSTRUCTION

The construction and installation of the DERP’s generating facility must meet all requirements specified in section 9 of EDTI’s Customer Connection Guide.

Copies of all permits, compliance reports and inspection documents must be provided to EDTI prior to the energization of the point of common coupling. Please contact EDTI’s Customer Engineering Services at 780-412-3128 for more information.

All single-line diagrams provided to EDTI must be drawn in accordance with CSA standards and conventions as shown in Annex A of CSA C22.3 No. 9-08 and Appendix II, Appendix III and Appendix IV in this guideline, and must be stamped by a professional engineer assuming responsibility for the design.
4.0

INSPECTION
4.0 **INSPECTION**

The DERP shall maintain a quality-control and inspection program that is satisfactory to and approved by EDTI.

In addition to the DERP’s normal inspection procedures, EDTI reserves the right to:

- Witness the manufacturing, fabrication or any part of the work that involves the subject equipment
- Inspect materials, documents, manufacturing operations and installation procedures
- Witness tests and evaluate results of non-destructive examinations

The DERP shall supply EDTI with a complete set of detailed drawings, which will be used by EDTI to assist in the inspection during the testing of the equipment.
TESTING
5.0 TESTING

This section describes the test procedures and requirements for equipment used to interconnect DER facilities with EDTI’s distribution system. These include type testing, commissioning testing and periodic testing. The procedures listed rely heavily on those described in appropriate Underwriters Laboratory (UL), Institute of Electrical and Electronic Engineers (IEEE) and International Electrotechnical Commission (IEC) documents, most notably:

- UL 1741 Standard for Safety for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems
- IEEE 929 Recommended Practice for Utility Interface of Photovoltaic (PV) Systems

5.1 GENERAL

The DERP shall notify EDTI in writing at least two weeks before the initial energizing and start-up testing of the DERP’s DER equipment. EDTI may witness the testing of any equipment and protective systems associated with the interconnection.

The tests described here are intended to provide assurance that the DERP’s equipment will not adversely affect EDTI’s distribution system and that a DER facility will cease to provide power to EDTI’s distribution system under abnormal conditions.

The following sections also describe the process for certifying equipment. Once a DER unit or device has been certified under this certification process, it may be considered suitable for use as part of a DER facility interconnected with EDTI’s distribution system. Generally, EDTI will not require a DERP to repeat the design review or test the protective functions of equipment that has been certified. It should be noted the certification process is intended to facilitate the DER facility interconnections. Certification is not a prerequisite to interconnect a DER facility. The use of non-certified equipment may be acceptable to EDTI, subject to testing and approval by EDTI as discussed in section 3.2.

These test procedures only apply to the devices and packages associated with the protection of the interconnection between the DER system and EDTI’s facilities. Interconnection protection is usually limited to voltage relays, frequency relays, synchronizing relays, reverse current or power relays, and anti-islanding schemes. The testing of relays or devices associated specifically with the protection or control of the DER equipment is recommended, but not required unless they affect the interconnection protection.

Testing of protection systems shall include procedures to functionally test all protective elements of the system up to and including tripping of the DER and/or point of common coupling. Testing will verify all protective set points and relay/breaker trip timing. The tests and testing procedures shall align with the requirements specified in IEEE 1547.

At the time of production, all interconnecting equipment and digital relays must meet or exceed the requirements of ANSI/IEEE C62.41-2002 or IEEE C37.90.1-2012. If C62.41-2002 is used,
the surge types and parameters shall be applied, as applicable, to the equipment’s intended installation location.

5.2 CERTIFICATION CRITERIA

Equipment tested and approved (or listed) by an accredited, nationally recognized testing laboratory (NRTL) as having met the type-testing requirements described in this document is considered to be certified equipment for purposes of interconnection with EDTI’s distribution system. Certification may apply to either a prepackaged system or an assembly of components that address the necessary functions. Type testing may be done in the manufacturer’s factory, in a test laboratory or in the field. At the discretion of the testing laboratory, field certification may apply only to the particular installation tested. In such cases, some or all of the tests may need to be repeated at other installations.

For non-certified equipment, some or all of the tests described in this document may be required by EDTI for each DER facility installation. The manufacturer, or another laboratory acceptable to EDTI, may perform these tests, and the test results must be submitted for EDTI’s review and approval. Approval by EDTI for equipment used in a particular application does not guarantee EDTI’s approval for use in other applications.

When equipment is certified by a NRTL, the NRTL shall provide to the manufacturer, at a minimum, a certificate with the following information for each device:

   A. Administrative
      • The effective date of certification or applicable serial number (range or first in series), and/or other proof that certification is current
      • Equipment model number(s) of the certified equipment
      • The software version used in the equipment, if applicable
      • Test procedures specified (including date or revision number)
      • Laboratory accreditation (by whom and to what standard)

   B. Technical (as appropriate)
      • Device ratings (kW, kVA, V, amps, etc.)
      • Maximum available fault current in amps
      • In-rush current in amps
      • Trip points, if factory set (trip value and timing)
      • Trip point and timing ranges for adjustable settings
      • Nominal power factor or range if adjustable
• Indication whether the device or system is certified for non-export and the method used (reverse power or underpower)

• Indication whether the device or system is certified as anti-islanding

It is the responsibility of the equipment manufacturer to ensure that certification information is made publicly available by the manufacturer, the testing laboratory or a third party.

5.3 TYPE TESTING

Type testing is performed or witnessed once, by an independent testing laboratory for a specific protection package. Once a package meets the type test criteria described in this section, the design is accepted by EDTI. The type test must also determine whether the protection settings meet the guidelines in this document. All interconnection equipment must include a type test procedure as part of the documentation. If any changes are made to the hardware, software, firmware or verification test procedures, the manufacturer must notify the independent testing laboratory to determine what, if any, parts of the type testing must be repeated. Failure of the manufacturer to notify the independent test laboratory of changes may result in the withdrawal of approval and the disconnection of units installed since the change was made.

5.3.1 Inverters

Static power inverters, at the time of production, must meet or exceed all of the type tests and requirements appropriate for a utility interactive inverter as specified in UL 1741 and IEEE 929. These requirements may also be applied to inverters used with electric energy sources other than photovoltaic systems. All inverters must be anti-islanding as defined by IEEE 929.

Inverter devices must also pass the following additional type tests to:

• Certify anti-islanding functions (section 1.3.16)
• Certify export limit functions (section 1.3.18)
• Determine the maximum in-rush current draw (section 1.3.5)
• Verify the inverter’s ability to synchronize (section 1.3.2)

5.3.2 Synchronous Generators

Synchronous generator devices must pass the following type tests to:

• Certify anti-islanding functions (section 1.3.16)
• Certify export limit functions (section 1.3.18)
• Verify the generator’s ability to synchronize (section 1.3.2)

5.3.3 Induction Generators

Induction generator devices must pass the following type tests to:

• Certify anti-islanding functions (section 1.3.16)
5.3.4 **Anti-Islanding Test**

Interconnection protective devices must pass the anti-islanding test procedure described in section 5.4.1 and IEEE 929.

5.3.5 **Export Limit Test**

Interconnection protective devices must pass an export limit test. An example of a test procedure is included in Appendix VI, 1. Export Limit Test Procedure.

5.3.6 **In-Rush Current Test**

DER equipment that uses EDTI’s distribution system to operate as a motor during start-up must be tested to determine the maximum current drawn during this start-up process. The resulting in-rush current is used to estimate the starting voltage drop. An example of a test procedure is included in Appendix VI, 2. In-Rush Current Test Procedure.

5.3.7 **Synchronization Test**

For synchronous generators and inverters capable of operating as a voltage source, a synchronization test must be performed to verify that the generator synchronizes within the specified voltage/frequency/phase angle requirements as described in section 1.2.2. An example of a test procedure is included in Appendix VI, 3. Synchronization Test Procedure.

5.4 **COMMISSIONING TEST**

A commissioning test of the DERP’s DERs and interconnection facilities will be performed before interconnection. As part of the commissioning process, the DERP shall provide EDTI with all test reports and the relay calibration reports for the DERs and interconnection switchgear.

The commissioning test, where required, will be performed onsite to verify protective settings and functionality as per EDTI relay test procedures. Upon initial parallel operation of a DER facility, or any time interconnection hardware or software is changed and may affect the functions listed below, a commissioning test must be performed by qualified personnel. Qualified personnel include professional engineers and certified technicians or licensed electricians with experience and training in testing protective equipment. The commissioning test must be performed in accordance with the manufacturer’s recommended test procedure to prove that facilities adhere to the requirements of this document. EDTI has the right to witness commissioning tests as described below, or to require written certification by the installer describing which tests were performed and their results. Any exemptions from performing a commissioning test must be agreed upon in writing by EDTI.

Functions to be tested during commissioning, particularly with respect to non-certified equipment, may consist of the following:

- Certify export limit functions (section 1.3.18)
- Determine the maximum in-rush current draw (section 1.3.5)
1. Overvoltage and undervoltage
2. Overfrequency and underfrequency
3. Anti-islanding function (if applicable)
4. Export limit function (if applicable)
5. Inability to energize dead line
6. Time delay on restart after utility source is stable
7. Utility system fault detection (if used)
8. Synchronizing controls (if applicable)
9. Other interconnection protective functions that may be required as part of the Interconnection Operating and Maintenance Agreement

Other checks and tests required include:

10. Verification of final protective settings
11. Trip test
12. On-load test

5.4.1 Certified Equipment

DER facilities that are judged to have little or no potential impact on EDTI’s distribution system need only incorporate certified equipment that, at a minimum, has passed its type tests. For such DER facilities, it is necessary to perform only the following tests:

1. Protection settings that have been changed after factory testing will require field verification. Tests will be performed using secondary injection, applied waveforms, a simulated utility or, if none of the preceding tests are possible and the unit provides discrete readouts of the settings, a settings adjustment test to show that the device trips at the measured (actual) utility voltage or frequency.

2. The anti-islanding function, if provided, will be checked by operating a load-break disconnect switch or circuit breaker to verify that the interconnection equipment ceases to energize its output terminals and does not restart until after the required time delay after the switch is closed.

3. The export limit function will be tested using secondary injection techniques. Alternatively, this function may be tested by adjusting the generating facility output and local loads to verify that the applicable export limit criterion (such as reverse power or minimum power) is met.

An interconnection review study is conducted when a DERP submits a DER interconnection application. The study may impose additional components or additional testing.

5.4.2 Non-Certified Equipment

Non-certified equipment shall be subject to the appropriate tests specified by EDTI. With EDTI’s approval, these tests may be performed in the factory, in the field as part
of commissioning or both. EDTI, at its discretion, may also approve a reduced set of
tests for a particular application or if, for example, EDTI determines that it has sufficient
familiarity with the equipment.

5.4.3 Verification of Settings

If protective function settings have been adjusted as part of the commissioning
process, then following the completion of such testing, the DERP shall confirm that all
devices are set to EDTI-approved settings. This step shall be documented in the relay
operation order certified by a professional engineer.

5.4.4 Trip Tests

Interconnection protective devices (e.g., reverse power relays) that have not previously
been tested as part of the interconnection system with their associated interrupting
devices (e.g., contactor or circuit breaker) shall be trip tested during commissioning.
The trip test shall be adequate to prove that the associated interrupting devices open
when the protective devices operate.

Interlocking circuits between protective devices and between interrupting devices shall
be similarly tested unless they are part of a system that has been tested and approved
during manufacture.

5.4.5 On-Load Tests

Interconnection protective devices that have not previously been tested as part of the
interconnection system with their associated instrument transformers or that are wired
in the field shall be given an on-load test during commissioning. This test will verify
proper wiring, polarity, sensing signals, CT/PT ratios and operation of the measuring
circuits. The on-load test shall be made with the power system energized and
carrying a known level of voltage and current. The magnitude and phase angle of each
alternating-current (AC) voltage and AC current connected to the protective device will
be measured and the results compared to expected values.

For protective devices with built-in metering functions that report current and voltage
magnitudes and phase angles, or magnitudes of current, voltage, and real and reactive
power, the metered values can be compared to the expected values. Otherwise,
calibrated portable ammeters, voltmeters and phase-angle meters shall be used.

5.4.6 Switchgear and Metering

EDTI reserves the right to witness the testing of installed switchgear and metering.
The DERP shall notify EDTI at least 10 working days before any testing.
5.5 PERIODIC TESTING

The periodic testing, calibration and maintenance of DERs and interconnection facilities shall be carried out in accordance with a maintenance schedule agreement between the DERP and EDTI. This includes the protective relaying, controls and automations. The DERP shall maintain periodic test reports or a log for inspection by EDTI. At agreed intervals, the DERP shall submit to EDTI for review the maintenance, test and calibration reports as a condition of continuing the interconnection agreement. EDTI may elect to check the settings and operation of the DERP’s protective relaying under the maintenance schedule agreement, as it deems appropriate.

Any system that depends upon a battery for trip power shall be checked and logged once per month for proper voltage, or monitored continuously.
DATA REQUIREMENTS
## 6.0 DATA REQUIREMENTS

The following drawings and data are required for approval of the project.

<table>
<thead>
<tr>
<th>Drawing/Data</th>
<th>Proposal</th>
<th>Approval</th>
<th>Verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer’s equipment data sheet</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Control schematic</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Single-line diagram indicating proposed protection settings</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Description of protection scheme</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Generator nameplate schedule</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fuse and protective relay coordination study and settings</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Current transformer characteristic curve</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Commissioning report, complete with protection settings</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Plot plan showing location of lockable, “visible” disconnect device</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

* The minimum time requirement for review of information will generally be 10 working days.
7.0 MARKING AND TAGGING
7.0 MARKING AND TAGGING

The nameplate on switchgear shall include the following information:

- Manufacturer’s name
- Manufacturer’s serial number
- A clear “DER Disconnect Switch” label with an approved identification number from EDTI
MAINTENANCE
8.0 MAINTENANCE

The DERP is fully responsible for:

- All routine maintenance of the generator, control and protective equipment and recordkeeping for such maintenance
- Maintenance of the equipment on its side of the point of common coupling to accepted industry standards, in particular the Canadian Electrical Code (CEC) Part 1, Rule 2-300

The DERP shall present to EDTI the planned maintenance procedures and a maintenance schedule for the interconnection protection equipment. Failure to maintain Canadian Electrical Code and other accepted industry standards for facilities and maintenance can result in the disconnection of the generator.

Maintenance on EDTI’s distribution system will be carried out according to EDTI’s distribution maintenance procedures and schedules.

Details on maintenance responsibilities will be outlined in the Interconnection Operating and Maintenance Agreement to be signed by both EDTI and the DERP.
TERMS AND DEFINITIONS
### TERMS AND DEFINITIONS

The following terms and definitions are for your reference for the language used in this document and for use in any correspondence with EDTI.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>active power</td>
<td>The time average of the instantaneous power over one period of the wave, expressed in watts. For sinusoidal quantities in a single-phase circuit, it is the product of the voltage, the current and the cosine of the phase angle between them.</td>
</tr>
<tr>
<td>AECUC</td>
<td>Alberta Electrical and Communication Utility Code. Refer to website: <a href="http://www.safetycodes.ab.ca">www.safetycodes.ab.ca</a>.</td>
</tr>
<tr>
<td>AIES</td>
<td>Alberta Interconnected Electric System. This system encompasses all transmission facilities and all electric distribution systems in Alberta that are interconnected, as defined in the Alberta Electric Utilities Act.</td>
</tr>
<tr>
<td>alternating current (AC)</td>
<td>An electric current that reverses direction at regularly recurring time intervals and has alternating positive and negative values. In North America, the standard for alternating current is 60 complete cycles each second. Such electricity is said to have a frequency of 60 Hz.</td>
</tr>
<tr>
<td>ampere (amp)</td>
<td>The unit of current flow of electricity.</td>
</tr>
<tr>
<td>anti-islanding</td>
<td>Designed to detect and disconnect from a stable unintended “island” with matched load and generation. Reliance solely on undervoltage/overvoltage and frequency trip is not considered sufficient to qualify as anti-islanding.</td>
</tr>
<tr>
<td>apparent power</td>
<td>The product of the root-mean-square current and the root-mean-square voltage, expressed in volt-amperes (VA). This term is used for alternating-current circuits because current flow is not always in phase with voltage, so multiplying volts by amperes does not necessarily give watts. Apparent power is made up of two components, active and reactive power.</td>
</tr>
<tr>
<td>automatic circuit recloser (ACR)</td>
<td>A self-controlled device for automatically interrupting and reclosing an alternating-current circuit with a predetermined sequence of opening and reclosing. EDTI uses these devices for overcurrent protection on some distribution circuits.</td>
</tr>
<tr>
<td>capacity</td>
<td>In the electric power industry, capacity has two meanings: 1) system capacity: the maximum power capability of a system. For example, a utility system might have a rated capacity of 5,000 megawatts. 2) equipment capacity: the rated load-carrying capability of generating equipment or other electrical apparatus, expressed in kilovolt-amperes (kVA) or kilowatts (kW).</td>
</tr>
<tr>
<td>CEC</td>
<td>The Canadian Standards Association’s C22.1 Safety Standard for Electrical Installations Part 1, also known as the Canadian Electrical Code.</td>
</tr>
<tr>
<td>certification test</td>
<td>A test adopted by EDTI that verifies conformance of certain equipment with commission-approved performance standards in order to be classified as certified equipment. Certification tests are normally performed by a nationally recognized testing laboratory such as the CSA or Underwriter’s Laboratory.</td>
</tr>
<tr>
<td>certified equipment</td>
<td>Equipment used in a DER facility that has passed the certification test.</td>
</tr>
<tr>
<td>closed transition</td>
<td>A mode of operation in which the DER is operated in parallel with EDTI’s distribution system for a brief period of time, to ensure that the load is maintained while transferring from the utility to the DER or vice versa.</td>
</tr>
<tr>
<td>commissioning test</td>
<td>A test performed during the commissioning of all or part of a DER facility system to achieve one or more of the following: verify specific aspects of its performance, calibrate its instrumentation, or establish instrument or protective function set points.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>CSA</td>
<td>Canadian Standards Association. Refer to website: <a href="http://www.csa.ca">www.csa.ca</a>.</td>
</tr>
<tr>
<td>current</td>
<td>The flow of electricity in a conductor. Current is measured in amperes.</td>
</tr>
<tr>
<td>direct current (DC)</td>
<td>A unidirectional electric current in which the changes in value are either zero or so small that they may be neglected. The current supplied from a battery is direct current.</td>
</tr>
<tr>
<td>distributed generation (DG)</td>
<td>Electric generation facilities connected to a distribution system through the point of common coupling. Distributed generation is a subset of distributed energy resources.</td>
</tr>
<tr>
<td>distributed energy resources (DER)</td>
<td>Sources of real electric power that are not directly connected to the bulk power transmission system. These include both generators and energy storage technology.</td>
</tr>
<tr>
<td>distribution system</td>
<td>Any facilities that operate at a nominal voltage of 25,000 V or lower and that allow electric power to be delivered to a load, regardless of ownership.</td>
</tr>
<tr>
<td>EDTI</td>
<td>EPCOR Distribution and Transmission Inc., the company that operates the electric distribution system in the city of Edmonton. Refer to website: <a href="http://www.epcor.com">www.epcor.com</a>.</td>
</tr>
<tr>
<td>electrical energy</td>
<td>The quantity of electricity delivered over a period of time. The commonly used unit of electrical energy is the kilowatt hour (kWh).</td>
</tr>
<tr>
<td>electrical power</td>
<td>The rate of delivery of electrical energy and the most frequently used measure of capacity. The commonly used unit of electrical power is the kilowatt (kW).</td>
</tr>
<tr>
<td>electromagnetic interference (EMI)</td>
<td>Any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of a device, equipment or system.</td>
</tr>
<tr>
<td>export limiting</td>
<td>Designed to prevent the transfer of electrical energy above a certain value (the export limit), from the generating facility to EDTI’s distribution system.</td>
</tr>
<tr>
<td>ferroresonance</td>
<td>An oscillatory phenomenon caused by the interaction of system capacitance with the non-linear inductance of a transformer, usually resulting in a high transient or sustained overvoltage.</td>
</tr>
<tr>
<td>frequency</td>
<td>The number of cycles through which an alternating current passes in a second. The North American standard is 60 cycles per second, known as 60 Hz.</td>
</tr>
<tr>
<td>generation</td>
<td>The process of converting solar, thermal, mechanical, chemical or nuclear energy into electric energy.</td>
</tr>
<tr>
<td>grid</td>
<td>A network of electric power lines and connections.</td>
</tr>
<tr>
<td>harmonics</td>
<td>Sinusoidal currents and voltages with frequencies that are integral multiples of the fundamental power line frequency.</td>
</tr>
<tr>
<td>hertz (Hz)</td>
<td>The unit of frequency for alternating current. Formerly called cycles per second. The standard frequency for power supply in North America is 60 Hz.</td>
</tr>
<tr>
<td>hosting capacity</td>
<td>The level of DER connection on a distribution circuit that maintains a safe, reliable and acceptable operation of the distribution circuit.</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers, Inc. Refer to website: <a href="http://www.ieee.org">www.ieee.org</a>.</td>
</tr>
<tr>
<td>independent distributed energy resource provider (IDERP)</td>
<td>A privately owned power generating facility, which may be connected to a utility system to supply electricity for domestic or export markets. Referred to as simply a &quot;distributed energy resource provider (DERP)&quot; in this document.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>induction generator</td>
<td>An induction machine that is driven above its synchronous or zero-slip speed by an external source of mechanical power in order to produce electric power. It does not have a separate excitation system and therefore requires its output terminals to be energized with alternating-current voltage and supplied with reactive power to develop the magnetic flux.</td>
</tr>
<tr>
<td>in-rush current</td>
<td>The maximum current drawn from EDTI by the generator during the start-up process.</td>
</tr>
<tr>
<td>installed capacity</td>
<td>The capacity measured at the output terminals of all the generating units in a station, without deducting station service requirements.</td>
</tr>
<tr>
<td>interconnected system</td>
<td>A system consisting of two or more individual power systems connected together by tie lines.</td>
</tr>
<tr>
<td>interconnection</td>
<td>The physical connection of distributed generation to EDTI’s distribution system so that parallel operation can occur.</td>
</tr>
<tr>
<td>interconnection point</td>
<td>See point of common coupling.</td>
</tr>
<tr>
<td>inverter</td>
<td>A machine, device or system that changes direct-current power to alternating-current power.</td>
</tr>
<tr>
<td>inverter-type voltage-following</td>
<td>Generating equipment that uses power electronic devices to produce a waveform, using the external voltage of the distribution system to control the electronic devices, in such a way that if the external voltage ceases, the electronic devices instantaneously stop producing the waveform.</td>
</tr>
<tr>
<td>island(ing)</td>
<td>A condition where a portion of EDTI’s distribution system is solely energized by one or more DERs, while electrically separated from the rest of the distribution system.</td>
</tr>
<tr>
<td>isolated</td>
<td>A condition where a normally parallel generator becomes disconnected from EDTI’s distribution system, but continues to supply only its own load. Only generators with stand-alone capability are able to operate isolated.</td>
</tr>
<tr>
<td>kilovar (kvar)</td>
<td>1,000 vars. See reactive power.</td>
</tr>
<tr>
<td>kilovolt (kV)</td>
<td>1,000 volts.</td>
</tr>
<tr>
<td>kilovolt-ampere (kVA)</td>
<td>1,000 volt-amperes. See apparent power.</td>
</tr>
<tr>
<td>kilowatt (kW)</td>
<td>The commercial unit of electric power; 1,000 watts. A kilowatt can best be visualized as the total amount of power needed to light 10 100-watt light bulbs.</td>
</tr>
<tr>
<td>kilowatt hour (kWh)</td>
<td>The commercial unit of electric energy; 1,000 watt hours. A kilowatt hour can best be visualized as the amount of electricity consumed by 10 100-watt light bulbs burning for an hour.</td>
</tr>
<tr>
<td>load</td>
<td>The amount of electric power delivered or required at any specified location.</td>
</tr>
<tr>
<td>load factor</td>
<td>The ratio of the average load during a designated period to the peak or maximum load in that same period. Usually expressed as a percentage.</td>
</tr>
<tr>
<td>load forecast</td>
<td>The anticipated amount of electricity required by customers in the future.</td>
</tr>
<tr>
<td>megavar (Mvar)</td>
<td>1,000 kvars.</td>
</tr>
<tr>
<td>megavolt-ampere (MVA)</td>
<td>1,000 kVA.</td>
</tr>
<tr>
<td>megawatt (MW)</td>
<td>A unit of bulk power; 1,000 kilowatts.</td>
</tr>
<tr>
<td>megawatt hour (MWh)</td>
<td>A unit of bulk energy; 1,000 kilowatt hours.</td>
</tr>
<tr>
<td>nationally recognized testing laboratory</td>
<td>A laboratory approved to perform the certification testing requirements for generating facilities.</td>
</tr>
<tr>
<td>(NRTL)</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>non-exporting</td>
<td>Designed to prevent any transfer of electrical energy from the generating facility to EDTI's distribution system.</td>
</tr>
<tr>
<td>overfrequency</td>
<td>The abnormal operating state or system condition that results in a system frequency above the normal 60 Hz.</td>
</tr>
<tr>
<td>overvoltage</td>
<td>The abnormal operating state or system condition that results in a system voltage above the upper limit specified in CSA CAN3-235-83 (R2010)</td>
</tr>
<tr>
<td>parallel (operation)</td>
<td>The operation of a generating unit, while connected to either the Alberta Interconnected Electric System or a smaller separate electric power grid, in parallel with other sources of electric power generation.</td>
</tr>
<tr>
<td>point of common coupling (PCC)</td>
<td>The point where EDTI’s electrical facilities or conductors are connected to the DERP’s facilities or conductors, and where any transfer of electric power between the DERP and EDTI takes place.</td>
</tr>
<tr>
<td>power</td>
<td>The rate of doing work. Electric power is measured in watts.</td>
</tr>
<tr>
<td>power factor</td>
<td>The ratio of active power to apparent power. It is the cosine of the phase angle difference between the current and voltage of a given phase.</td>
</tr>
<tr>
<td>distributed energy resource provider (DERP)</td>
<td>A person or an organization interconnected to EDTI’s distribution system for the purpose of producing electric power from an unregulated generating facility.</td>
</tr>
<tr>
<td>power system</td>
<td>The interconnected facilities of an electrical utility. A power system includes the generation, transmission, distribution, transformation and protective components necessary to provide service.</td>
</tr>
<tr>
<td>reactive power</td>
<td>The square root of the square of the apparent power, minus the square of the active power. Reactive power is developed when there are inductive, capacitive or non-linear elements in the system. It is measured in vars.</td>
</tr>
<tr>
<td>resonance</td>
<td>The enhancement of a circuit’s or system’s response to a periodic excitation, usually resulting in very high currents and voltages.</td>
</tr>
<tr>
<td>root-mean-square (RMS)</td>
<td>The equivalent heating value of a current or voltage waveshape. It is defined mathematically as the square root of the average of the square of the value of the function taken throughout one period. For a sinusoidal waveshape, the RMS value is equal to the peak value divided by 1.414.</td>
</tr>
<tr>
<td>secondary injection testing</td>
<td>A method in which low-level signals obtained from current and voltage signal generators are injected into a power system protective device to test device response.</td>
</tr>
<tr>
<td>simulated utility</td>
<td>An assembly of variable frequency and variable voltage test equipment used to simulate a normal utility source.</td>
</tr>
<tr>
<td>stabilized</td>
<td>Will be used to refer to EDTI’s distribution system, returning to the normal range of voltage and frequency following a disturbance.</td>
</tr>
<tr>
<td>stand-alone (capability)</td>
<td>Distributed generation that can operate by controlling the frequency and voltage of its facility while in islanded or isolated mode.</td>
</tr>
<tr>
<td>synchronous generator</td>
<td>An alternating-current machine in which the rotational speed of normal operation is constant, and when interconnected, is in synchronism with the frequency and in step with the voltage of the electric utility system.</td>
</tr>
<tr>
<td>system controller (SC)</td>
<td>A provincially appointed authority responsible for dispatching load and generation on the Alberta Interconnected Electric System, in real time.</td>
</tr>
<tr>
<td>target (operation indicator)</td>
<td>A supplementary device operated either mechanically or electrically, to indicate visibly that the relay or device has operated or completed its function.</td>
</tr>
<tr>
<td>telemetering</td>
<td>Transmission of measurable quantities using telecommunications techniques.</td>
</tr>
<tr>
<td>total harmonic distortion (THD)</td>
<td>The ratio of the root-mean-square of the harmonic content to the root-mean-square value of the fundamental quantity, expressed as a percentage of the fundamental.</td>
</tr>
<tr>
<td>transformer</td>
<td>An electromagnetic device for changing the voltage of alternating electricity.</td>
</tr>
</tbody>
</table>
### This term ...

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>trip time</td>
<td>The time between the start of the abnormal condition and the interconnection device ceasing to energize the distribution system.</td>
</tr>
<tr>
<td>type test</td>
<td>A test performed on a sample of a particular model of a device to verify specific aspects of its design, construction and performance.</td>
</tr>
<tr>
<td>underfrequency</td>
<td>The abnormal operating state or system condition that results in a system frequency below the normal 60 Hz.</td>
</tr>
<tr>
<td>undervoltage</td>
<td>The abnormal operating state or system condition that results in a system voltage below the lower limit specified in CSA CAN3-235-83 (R2010).</td>
</tr>
<tr>
<td>visible-break disconnect</td>
<td>A disconnect switch or withdrawable circuit breaker that can simultaneously disconnect under full load the generator and all protective devices and control apparatus from the circuits supplied by the generator. The switch or breaker shall be provided with the means for adequate visible inspection of all contacts in the open position, and the blades or moving contacts shall be connected to the generator side.</td>
</tr>
<tr>
<td>voltage</td>
<td>The electrical force or potential that causes a current to flow in a circuit (just as pressure causes water to flow in a pipe). Voltage is measured in volts (V) or kilovolts (kV). 1 kV = 1,000 V.</td>
</tr>
<tr>
<td>voltage flicker</td>
<td>A condition of fluctuating voltage on a power system that can lead to noticeable fluctuations in the output of lighting systems.</td>
</tr>
<tr>
<td>watt</td>
<td>The scientific unit of electric power. A typical light bulb is rated 25, 40, 60 or 100 watts. One horsepower is 746 watts.</td>
</tr>
</tbody>
</table>
APPENDICES
## APPENDIX 1  INTERCONNECTION REVIEW STUDY OUTLINE

<table>
<thead>
<tr>
<th>No.</th>
<th>Item to be checked</th>
<th>Condition of study/evidence</th>
<th>Reference section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remaining capacity on the bus to be connected</td>
<td>All DERs connected and to be connected to the bus</td>
<td>1.1.9</td>
</tr>
<tr>
<td>2</td>
<td>Circuit steady-state voltage</td>
<td>At minimum and maximum circuit load, at minimum and maximum generation for all DER’s power factor range</td>
<td>1.1.3</td>
</tr>
<tr>
<td>3</td>
<td>Circuit voltage</td>
<td>Maximum generation at minimum and maximum circuit load</td>
<td>1.2.5</td>
</tr>
<tr>
<td>5</td>
<td>unbalance</td>
<td>Maximum generation at minimum and maximum circuit load</td>
<td>1.2.5</td>
</tr>
<tr>
<td>6</td>
<td>Power factor</td>
<td>Maximum output</td>
<td>1.2.3</td>
</tr>
<tr>
<td>7</td>
<td>Equipment thermal loading – circuit and substation</td>
<td>Maximum generation and minimum feeder load</td>
<td>EDTI’s Distribution Planning Criteria. Contact <a href="mailto:distgen@epcor.com">distgen@epcor.com</a> for more information.</td>
</tr>
<tr>
<td>8</td>
<td>Impact of DER fault contributions on circuit substation equipment ratings</td>
<td>Maximum fault conditions and maximum generation</td>
<td>1.3.10 and 1.3.11</td>
</tr>
<tr>
<td>9</td>
<td>Voltage regulating and metering devices on distribution system</td>
<td>Minimum circuit load and maximum generation</td>
<td>1.2.3 and 2.5</td>
</tr>
<tr>
<td>10</td>
<td>Synchronization</td>
<td>Check existence</td>
<td>1.2.2</td>
</tr>
<tr>
<td>11</td>
<td>Reclosing</td>
<td>DER to be turned off in less than 0.6 s</td>
<td>1.1.8</td>
</tr>
<tr>
<td>12</td>
<td>Transfer trip</td>
<td>Required for DER rating equal to or greater than 1,000 kW</td>
<td>1.3.17</td>
</tr>
<tr>
<td>13</td>
<td>Anti-islanding</td>
<td>Passive and active anti-islanding functions required</td>
<td>1w.3.16</td>
</tr>
</tbody>
</table>
APPENDIX 2  SINGLE-LINE DIAGRAM FOR DELTA-WYE SECONDARY INTERCONNECTION

NOTE: ONLY INTERCONNECTION PROTECTION DEVICES ARE SHOWN. GENERATOR PROTECTION IS NOT SHOWN.
### APPENDIX 3  SINGLE LINE DIAGRAM FOR WYE-WYE SECONDARY INTERCONNECTION

**Note:** Only interconnection protection devices are shown. Generator protection is not shown.

**LEGEND**
- M: Metering
- Fuse
- Neutral Grounding Resistor (NGR)
- Circuit Breaker
- Manual Air Break
- Transformer
- CT
- PT

**PROTECTION LEGEND**
- 25: Synch-Check
- 27: Undervoltage
- 32: Directional Power
- 50/51: Inst./Timed Overcurrent
- 50/50N: Inst./Timed Neutral Overcurrent
- 59: Overvoltage
- 59N: Neutral Overvoltage
- 81O/U: Over & Under Frequency
- 86: Lockout Relay

**REMARKS:**
1. Exact location of the switch is to be mutually agreed upon by EDTI and the Power Producer.
2. FOR EXPORT ONLY. For synchronous generators or generators susceptible to self-excitation (induction and static power converters).
3. FOR NON-EXPORT or EXPORT LIMITED ONLY. Relay must sense both real and reactive power.
4. Number and location of the metering points by commercial parameters.

**Diagram:**
- Single line diagram for Wye-Wye secondary interconnection through Wye-Wye transformer.

**By:**
- Date: 04/04/2000
- Checked: [Signature]
- Scale: 1/72
APPENDIX 4  SINGLE LINE DIAGRAM FOR PRIMARY INTERCONNECTION

LEGEND
- Metering
- Fuse
- Neutral Grounding Resistor (NGR)
- Circuit Breaker
- Manual Air Break
- Transformer
- CT
- PT

PROTECTION LEGEND
25 – Synch-Check
27 – Undervoltage
32 – Directional Power
50/51 – Inst./Timed Overcurrent
50/50N – Inst./Timed Neutral Overcurrent
59 – Overvoltage
59N – Neutral Overvoltage
810/U – Over & Under Frequency
86 – Lockout Relay

NOTE: ONLY INTERCONNECTION PROTECTION DEVICES ARE SHOWN. GENERATOR PROTECTION IS NOT SHOWN.

REMARKS:
1. Exact location of the switch is to be mutually agreed upon by EDI and the Power Producer.
2. FOR EXPORT ONLY. For synchronous generators or generators susceptible to self-excitation (induction and static power converters).
3. FOR NON-EXPORT or EXPORT LIMITED ONLY. Relay must sense both real and reactive power.
4. Number and location of the metering points by commercial parameters.

EPCOR

SINGLE LINE DIAGRAM FOR DG PRIMARY INTERCONNECTION
## APPENDIX 5  SCHEDULE OF ACCURACIES FOR METERING EQUIPMENT

Schedule of accuracies for metering equipment approved under section 9(1) of the electricity and gas inspection act

<table>
<thead>
<tr>
<th>Metering point capacity (MVA)</th>
<th>Watt hour meter accuracy class</th>
<th>Var hour meter accuracy class</th>
<th>Measurement transformers accuracy class</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 and above</td>
<td>0.2%</td>
<td>0.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Below 10</td>
<td>0.5%</td>
<td>1.0%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

Notes:
The columns apply to requirements set out in this guideline under Metering sections 2.2 and 2.3.

If an alternate measurement is used to determine reactive energy, the accuracy class of the alternate measurement must be equal to or better than the accuracy class set out for reactive energy.
APPENDIX 6  EXAMPLE TEST PROCEDURES

1. EXPORT LIMIT TEST PROCEDURE

The export limit test is intended to verify the operation of relays, controllers and inverters designed to limit the export of power and certify the equipment as meeting the requirements of an export-limited DER facility. Tests are provided for digital relay packages and for controllers and inverters that include the intended function.

A. Reverse Power Relay Test

This version of the export limit test procedure is intended for stand-alone reverse power and underpower relay packages provided to meet the requirements of an export-limited distributed generation facility. It should be understood that in the reverse power application, the relay will provide a trip output with power in the export direction (toward the EDTI distribution system).

Step 1: Power Flow Test at Minimum, Midpoint and Maximum Pickup Level Settings

Determine the appropriate secondary pickup current for the desired export power flow of 0.5 secondary watts (the agreed-upon minimum pickup setting; assumes 5 amp and 120 V CT/PT secondary). Apply nominal voltage with minimum current setting at zero degrees in the trip direction. Increase the current to pickup level. Observe the relay trip’s (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat this test at the midpoint and maximum settings. Repeat at phase angles of 90, 180 and 270 degrees and verify that the relay does not operate (measured watts will be zero or negative).

Step 2: Leading Power Factor Test

Apply rated voltage to the relay with a minimum pickup current setting (calculated value for system application) and apply a leading power factor load current in the non-trip direction (current lagging voltage by 135 degrees). Increase the current to the relay rated current and verify that the relay does not operate. For relays with adjustable settings, this test should be repeated at the minimum, midpoint and maximum settings.

Step 3: Minimum Power Factor Test

At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Increase the current level to pickup (about 10 times higher than at 0 degrees) and verify that the relay operates. Repeat for phase angles of 90, 180 and 270 degrees and verify that the relay does not operate.

Step 4: Negative-Sequence Voltage Test

Using the pickup settings determined in Step 1, apply rated relay voltage and current at 180 degrees from tripping direction, to simulate normal load conditions (for three-phase relays, use Ia at 180, Ib at 60 and Ic at 300 degrees). Remove phase-one voltage and observe that the relay does not operate. Repeat for phases two and three.
Step 5: **Load Current Test**

Using the pickup settings determined in Step 1, apply rated voltage and current at 180 degrees from the tripping direction, to simulate normal load conditions (use Ia at 180, Ib at 300 and Ic at 60 degrees). Observe that the relay does not operate.

Step 6: **Unbalanced Fault Test**

Using the pickup settings determined in Step 1, apply rated voltage and 2 times rated current, to simulate an unbalanced fault in the non-trip direction (use Va at 0 degrees, Vb and Vc at 180 degrees, Ia at 180 degrees, Ib at 0 degrees and Ic at 180 degrees). Observe that the relay, especially single-phase, does not operate.

Step 7: **Time-Delay Settings Test**

Apply Step 1 settings and set the time delay to the minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the timer stops when the relay trips. Repeat at midpoint and maximum delay settings.

Step 8: **Dielectric Test**

Perform the test described in IEC 414 using 2 kV RMS for 1 minute.

Step 9: **Surge Withstand**

Perform the surge withstand test described in IEEE C37.90.1.

B. **Underpower Relay Test**

In the underpower application, the relay will provide a trip output when import power (toward the producer’s generating facility) drops below the specified power level.

*Note: For an underpower relay, pickup is defined as the highest power level at which the relay indicates that the power is less than the approved setting.*

Step 1: **Power Flow Test at Minimum, Midpoint and Maximum Pickup Level Settings**

Determine the appropriate secondary pickup current for the desired power flow pickup level of 5% of peak load (the agreed-upon minimum pickup setting). Apply rated voltage and current setting at 0 degrees in the direction of normal load current. Decrease the current to pickup level. Observe the relay’s (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat the test at the midpoint and maximum settings. Repeat at phase angles of 90, 180 and 270 degrees and verify that the relay operates properly.

Step 2: **Leading Power Factor Test**

Using the pickup current setting determined in Step 1, apply rated voltage and rated leading power factor load current in the normal load direction (current leading voltage by 45 degrees). Decrease the current to 145% of the pickup level determined in Step 1 and verify that the relay does not operate. For relays with adjustable settings, repeat the test at the minimum, midpoint and maximum settings.
Step 3: Minimum Power Factor Test

At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Decrease the current level to pickup (about 10% of the value at 0 degrees) and verify that the relay operates. Repeat for angles 90, 180 and 270 degrees and verify that the relay operates for any current less than rated current.

Step 4: Negative-Sequence Voltage Test

Using the pickup settings determined in Step 1, apply rated relay voltage and 25% of rated current in the normal load direction, to simulate light load conditions. Remove phase-one voltage and observe that the relay does not operate; repeat for phases two and three.

Step 5: Unbalanced Fault Test

Using the pickup settings determined in Step 1, apply rated voltage and two times rated current, to simulate an unbalanced fault in the normal load direction (use Va at 0 degrees, Vb and Vc at 180 degrees, Ia at 0 degrees, Ib at 180 degrees and Ic at 0 degrees). Observe that the relay, especially single phase, operates properly.

Step 6: Time-Delay Settings Test

Apply Step 1 settings and set the time delay to the minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the timer stops when the relay trips. Repeat at midpoint and maximum delay settings.

Step 7: Dielectric Test

Perform the test described in IEC 414 using 2 kV RMS for 1 minute.

Step 8: Surge Withstand

Perform the surge withstand test described in IEEE C37.90.1.

C. Functional Tests for Inverters and Controllers

Inverters and controllers designed to provide reverse or underpower functions shall be tested to certify the intended operation of this function. Two methods are provided:

Method 1: If the controller uses external current/voltage measurement to determine the reverse or underpower condition, then the controller shall be functionally tested by applying appropriate secondary currents and potentials as described above in 1. A) Reverse Power Relay Test.

Method 2: If external secondary current or potential signals are not used, then unit-specific tests must be conducted to verify that power cannot be exported across the point of common coupling for a period exceeding two seconds. These tests may be factory tests, if the measurement and control points are part of a single unit, or may be provided for in the field.
2. **IN-RUSH CURRENT TEST PROCEDURE**¹⁸

This test will determine the maximum in-rush current drawn by the unit. Two methods are provided:

*Locked-rotor method*: Use the test procedure defined in NEMA MG 1 (manufacturer’s data is acceptable if available).

*Start-up method*: Install and set up the generating facility equipment as specified by the manufacturer. Using a calibrated oscilloscope or data-acquisition equipment with appropriate speed and accuracy, measure the current draw at the point of common coupling as the generating facility starts up and comes into parallel with EDTI’s distribution system. Start-up shall follow the normal manufacturer-specified procedure. Sufficient time and current resolution and accuracy shall be used to capture the maximum current draw within 5%. In-rush current is defined as the maximum current draw from EDTI during the start-up process, using a 10-cycle moving average. During the test, the utility source, real or simulated, must be capable of maintaining voltage within +/–5% of rated at the connection to the unit under test. Repeat this test five times. Report the highest 10-cycle current as the in-rush current. A graphical representation of the time-current characteristic along with the certified in-rush current must be included in the test report and made available to EDTI.

3. **SYNCHRONIZATION TEST PROCEDURE**

This test verifies that the unit synchronizes within the specified voltage/frequency/phase angle requirements.

The test will start with only one of the three parameters: 1) voltage difference between the generating facility and EDTI’s distribution system, 2) frequency difference or 3) phase angle outside of the synchronization specification.

Initiate the synchronization routine and verify that the generating facility is brought within specification prior to synchronization. Repeat the test five times for each of the above three parameters. For manual synchronization with synch-check relay or manual control with auto-synchronization relay, the test must verify that paralleling does not occur until the parameters are brought within specifications.

---

APPENDIX 7  REFERENCE NOTES

BIBLIOGRAPHY

Note 1:


Note 2:


Note 3:


Note 4:

APPENDIX 8  APPLICABLE CODES AND STANDARDS

When the stated version of the following standards is superseded by an approved revision, then that revision shall apply.

The DER interconnection shall conform to this guideline and to the applicable sections of the following codes and standards. Specific types of interconnection schemes, DER technologies and EDTI's distribution systems may have additional requirements, standards, recommended practices or guideline documents external to this guideline. The applicability and hierarchy of those, with respect to the requirements herein, are beyond the scope of this guideline. This list of standards is therefore not to be regarded as all-inclusive.

**Power Quality Standards**

- CSA Standard CAN3-C235-83 (R2010) Preferred Voltage Levels for AC Systems, 0 to 50 000 V
- IEEE Std 519-2014 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- IEEE Std 1159-2009 IEEE Recommended Practice for Monitoring Electric Power Quality
- IEEE Std 1250-2011 IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

In addition to the power quality standards, the following standards are applicable to the interconnection of distributed resources on EDTI’s distribution system:

- Alberta Electrical and Communication Utility Code (formerly the Alberta Electrical and Communication Utility System Regulation 44/1976 or future amendments)
- Canadian Electrical Code, CSA-C22.1-2015
- Can/CSA-C22.2 No. 31-M89 (R2000) Switchgear Assemblies
- Can/CSA-C22.2 No. 107.1-01 (R2011) General Use Power Supplies
- Can/CSA-C22.2 No. 61010.1-1-12 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use – Part 1: General Requirements
- Can/CSA-C22.2 No. 144-M91 (R2015) Ground Fault Circuit Interrupters
- Can/CSA-C22.2 No. 201-M1984 (R2014) Metal-Enclosed High Voltage Busways
- Can/CSA-C22.2 No. 229-M1988 (R2014) Switching and Metering Centres
- IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
- IEEE Std 100-1996 IEEE Standard Dictionary of Electrical and Electronics Terms
• IEEE Std 242-2001 IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
• IEEE Std 929-2000 IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
• C12.20-2010 American National Standard for Electricity Meters 0.2% and 0.5% Accuracy Classes
• C37.04-1999 IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/DoD)
• C37.06-2009 American National Standard for Switchgear – AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities
• C37.010-1999 (R2005) IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
• C37.011-2011 IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
• C37.012-1979 (R2014) IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
• C37.013-1997 (R2008) IEEE Standard for AC High-Voltage Generator Circuits Breaker Rated on a Symmetrical Current Basis
• C37.015-2009 IEEE Application Guide for Shunt Reactor Switching
• C37.1-2007 IEEE Standard for SCADA and Automation Systems
• C37.2-1996 IEEE Standard Electrical Power System Device Function Numbers
• C37.11-2017 IEEE Standard Requirements for Electrical Control for AC High-Voltage (> 1000 V) Circuit Breakers
• C37.13-2015 IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
• C37.14-2015 IEEE Standard for Low-Voltage DC (3200 V and below) Power Circuit Breakers Used in Enclosures
• C37.16-2009 IEEE Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC (3200 V and below) Power Circuit Breakers
• C37.20.1-2015 IEEE Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breakers Switchgear
• C37.20.2-2015 IEEE Standard for Metal-Clad Switchgear
• C37.20.3-2013 ANSI/IEEE Standard for Metal-Enclosed Interrupter Switchgear (1 kV–38 kV)
• C37.20.6-2015 IEEE Standard for 4.76 to 38 kV Rated Grounding and Testing Devices Used in Enclosures
• C37.23-2015 IEEE Standard for Metal-Enclosed Bus
• C37.30-1997 IEEE Standard Requirements for High-Voltage Switches
• C37.34-1994 IEEE Standard Test Code for High-Voltage Air Switches
• C37.35-1995 IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches
• C37.36b-1990 IEEE Guide to Current Interruption with Horn-Gap Air Switches
• C37.38-1989 IEEE Standard for Gas-Insulated, Metal-Enclosed Disconnecting, Interrupter, and Grounding Switches
• C37.42-2009 IEEE Standard Specifications for High-Voltage (> 1000 V) Expulsion-Type Distribution-Class Fuses, Fuse and Disconnecting Cutouts, Fuse Disconnecting Switches, and Fuse Links, and Accessories Used with These Devices
• C37.50-1989 American National Standard Test Procedures for Low-Voltage AC Circuit Breakers Used in Enclosures
• C37.51-1989 American National Standard Conformance Test Procedure for Metal Enclosed Low-Voltage AC Power Circuit-Breaker Switchgear Assemblies
• C37.66-2005 IEEE Standard for Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV)
• C37.81-1989 (R2009) IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies
• C37.90.2-2004 (R2010) IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
• C37.95-2014 IEEE Guide for Protective Relaying of Utility Consumer Interconnections
• C37.98-2013 IEEE Standard for Seismic Qualification Testing of Protective Relays and Auxiliaries for Nuclear Facilities
• C57.12.00-2015 IEEE Standard General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers
• C57.13-2016 IEEE Standard Requirements for Instrument Transformers
• C57.13.1-2016 IEEE Guide for Field Testing of Relaying Current Transformers
• C57.13.2-2005 IEEE Standard Conformance Test Procedures for Instrument Transformers
• C57.13.3-2014 IEEE Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases
• C57.19.100-2012 IEEE Guide for Application of Power Apparatus Bushings
• C57.98-2011 IEEE Guide for Transformer Impulse Tests
• C57.110-2008 IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Non-sinusoidal Load Currents


• C62.11-1999 IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (< 1 kV)


• C62.45-2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits


• C62.92.3-2012 IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part III – Generator Auxiliary Systems

• C62.92.4-2014 IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part IV – Distribution

• IEC 414-1981 Safety Requirements for Indicating and Recording Electrical Measuring Instruments and Their Accessories

• UL 1008 Transfer Switch Equipment

• UL 1741-2010 Standard for Safety for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems

• NEMA Standards Publication No. CC 1 – Electric Power Connectors for Substations NEMA Standards Publication No. LA 1 – Surge Arresters

• NEMA Standards Publication No. MG 1 – Motors and Generators