Distributed Resource
Technical Interconnection Guideline
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Prepared by the Northwest Territories Power Corporation

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Revision History

REVISION	RELEASE DATA	DESCRIPTION

SUMMARY

The Distributed Resource Technical Interconnection Guideline outlines technical requirements for the interconnection of a Distributed Resource (DR) to the NTPC 25 kV and lower Distribution System. The document is not intended to use as a design guideline.

Guidance is provided on the power quality requirements of a DR and restrictions of detrimental impacts to the Distribution System. The guideline provides indication of system impact studies to be undertaken to ensure that the safety, reliability and efficiency of the Distribution System is not compromised. Required practices in the areas of operation, protection & control, and metering that must be in-line with and compatible to NTPC standards are described.

The following standard references form the basis of this guideline:

CSA C22.3 No. 9:20 Interconnection of Distributed Energy Resources and Electricity Supply Systems.

IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resource with Associated Electric Power Systems Interfaces

The guideline structure is as follows:

Section 2 defines the terms and references used in this guideline.

Section 3 sets out cautions respecting the limitation of use of this guideline.

Section 4 indicates the standard Distribution System operating parameters.

Section 5 describes interconnection requirements

Section 6 addresses construction requirements.

Section 7 provides metering requirements.

Section 8 addresses inspection and equipment testing matters.

Section 9 provides the data requirements for approval of DR projects.

Section 10 addresses equipment marking and tagging.

Section 11 specifies the maintenance requirements.

Section 12 contains tables which list interconnection protection requirements.

Appendices 1-4 set out (1) applicable Codes and Standards, (2) single line drawings illustrating typical interconnection arrangements, (3) metering accuracy tables and (4) reference notes.

1.0 INTRODUCTION

1.1 Purpose

The Distributed Resource Technical Interconnection Guideline (**DRTIG**) provides guidance for the addition of a DR (distributed resource) to the existing NTPC electrical distribution system.

In this document, DR includes both generation and energy storage technology and which may be constructed, owned, and operated by an IPP (Independent Power Producer). The DR may also be utility owned and operated or through other contractual conditions.

This document applies to all electric energy generator energy sources, energy storage, and energy conversion technologies including synchronous, asynchronous machines, and those connected through inverter or static power technology.

The **DRTIG** functions to:

1. Provide technical guidelines for interconnection of a DR operating at a voltage of 25 kV or lower to the NTPC Wires Owner's distribution system facilities, and

2. Provides information to assist in determining the operational and technical requirements for successful integration within the distribution system.

The guideline provides the requirements across a broad spectrum of matters relevant to the performance, protection and control, operation, testing, safety and maintenance of a DR to distribution system interconnection. This guideline has been developed with reference to CSA Standard C22.3 No. 9-2020 'Interconnection of Distributed Energy Resources and Electricity Supply Systems', the suite of IEEE 1547 Standards, as well as utility practices in other jurisdictions.

The Guideline has the following limitations in its use:

1. The Guideline does not constitute and is not intended to be a comprehensive guide or handbook for designing, constructing, testing or operating a DR. Persons considering the development of a DR should engage the services of qualified individuals to provide electrical design and consulting services. The Wires Owner shall, upon DR project application, review the interconnection requirements indicated within this guide, indicate acceptance and/or any additional technical, maintenance, or operational requirements.

2. Interconnection to NTPC voltage systems above 25 kV is not covered by this document.

3. It shall only apply to DR facilities interconnected either directly or indirectly to the NTPC DS. Facilities operating within and supplying power to an intentionally isolated power grid or island are not considered.

4. It does not constitute an offer to, or infer an interest in, purchasing capacity and energy from DR projects.

5. The Guideline does not consider any commercial terms or arrangements including fees or tariffs, power delivery contract terms, capacity or other costs associated with DR project interconnection, operation, or maintenance. These and related items must be discussed individually and agreed upon with the relevant Wires Owner.

2.0 DEFINITIONS

Within this document the following definitions shall apply:

Alternating Current or **AC**

An electric current that reverses direction at regularly recurring intervals of time and has alternating positive and negative values.

Anti-Islanding

Protection that disconnects or prevents the DR from energizing the Wires Owner distribution system (DS) should the same DS or portion of become separated from the rest of the utility grid or be de-energized. The DR must have protection to separate itself upon detection of distribution system problems and therefore avoid the creation of an islanded Wires Owner system supplied solely by the DR. Reliance solely on under/over voltage and frequency protection shall not be considered as adequate anti-Islanding protection.

ANSI

American National Standards Institute.

CSA

Canadian Standards Association.

Direct Current or DC

A unidirectional electric current in which the changes in value are either zero or so small that they may be neglected.

Distributed Generation or DG

Electric generation facilities connected to a Distribution system through the PCC. DG is a subset of DR.

Distributed Resource or DR

All sources of real electric power operating in parallel with the NTPC Distribution System. This includes generation and energy storage systems such as electric generators, photo voltaic, wind turbines, battery energy storage systems (**BESS**), and fuel cells.

Distribution System or DS

Facilities and equipment operating at a nominal voltage of 25,000 volts or lower used to transmit power to a load regardless of ownership.

DR Owner

Anyone interconnected to the Wires Owner's system for the purpose of generating electric power.

Hertz or Hz

The unit of frequency for alternating current.

IEEE

Institute of Electrical and Electronic Engineers.

Impact Studies

A study or group of studies/ analyses that identify the effect on the electric power system should the DR be interconnected. These studies identify resulting or required power system changes in operation, ratings, reliability and identify all potential deleterious effects.

IPP

Independent power producer

Island(ing)

A condition in which a portion of the Wires Owner's system is energized by one or more DR Owner generators through their PCC(s) while electrically separated from the rest of the Wires Owner's system. Island operation of a DR creates a safety hazard for Owner employees and can create an abnormal operating condition for customers. Protective relaying to avoid islanding is an NTPC requirement for the DR Owner.

NTPC

North West Territories Power Corporation

OCR

Oil circuit re-closure.

Operation Indicator (Target)

A supplementary device operated either mechanically or electrically, to indicate visibly that the relay or device has operated or completed its function.

Parallel Operation

With reference to the Wires Owner, any electrical connection between the Wires Owner and the DR Owner's generation equipment.

Point of Common Coupling or PCC

The point where the electrical facilities or conductors of the Wires Owner are connected to the DR Owner's facilities or conductors, and where any transfer of electric power between the DR Owner and the Wires Owner takes place.

Primary DS

The portion of the DS between the main distribution substation and the distribution transformers. This system consists of the primary feeders from the main distribution substation.

Secondary DS

The portion of the DS between the distribution transformers and end user metering. At the user level, this system is low voltage 120/240 VAC.

Stabilized

The state of the DS after voltage and frequency have returned to normal range for a period of at least five minutes (or another period of time as coordinated with the Wires Owner) following a disturbance.

Telemetering

The transmission of measurable quantities using telecommunications techniques.

Trip Time

In the context of this guideline, total time elapsed between the start of the abnormal condition and the main interconnection interrupting device ceasing to continue energization of the Wires Owner's DS.

Visible-Break Disconnect

A disconnect switch or circuit breaker by means of which the generator and all protective devices and control apparatus can be simultaneously disconnected under full load entirely from the circuits supplied by the generator. The switch 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.

Voltage

The electrical force or potential that causes a current to flow in a circuit measured in Volts (V) or kiloVolts (kV). 1 kV = 1000 V.

Wires

Electric utility DS

Wires Owner

Electric utility (typically NTPC) which owns the distribution system

3.0 LIMITATIONS

Installation of a DR on radial primary and secondary DSs at or below 25 kV is the emphasis of this document. Requirements shall be met at the Point of Common Coupling (PCC), although the location of the protective devices may not necessarily be at that point.

For all DR technologies, the minimum criteria, guidance and requirements in this guideline are applicable to interconnections made to primary distribution system voltages through existing or new infrastructure and secondary voltages of a Distribution System.

Additional requirements may have to be met by both the DR Owner and the Wires Owner to ensure that the final interconnection design meets all local and national standards and codes, and that the design is safe for the intended application.

Unless agreed upon elsewhere, the Wires Owner shall not be liable for any damage, injury, loss, costs or claims suffered or incurred by the DR Owner, its agents or employees as a result of this standard.

This guideline ***does not***:

- Absolve the DR Owner of responsibility to protect their equipment, the Wires Owner's equipment, and personal and public safety

- Address other liability provisions provided for elsewhere, such as in commercial, interconnection and operating agreements between the DR Owner and the Wires Owner, or the Wires Owner's tariffs.

The DR Owner shall be responsible for making required changes to the DR Owner's facilities, as required, to meet new or revised standards or due to system changes. In addition, when advised by the Wires Owner, the DR Owner will make changes requested by the Wires Owner to the DR Owner's facilities. The cost of any required changes shall be borne by the DR Owner.

4.0 NTPC DISTRIBUTION SYSTEM

Note: As described, NTPC references and utilizes industry standards related to system operation, voltage levels, etc. It shall be understood that normally or at times of system disturbance these levels will not or cannot be achieved. It is the responsibility of the DR applicant to investigate the NTPC operating condition during normal and disturbance periods and take into account these conditions during the interconnection application process.

4.1 System Frequency

The NTPC interconnected alternating current system operates at a nominal frequency of 60 Hertz (Hz). Frequency deviations typically range from 59.0 Hz to 61.0 Hz including during modest disturbances. In these ranges the Northwest Territories interconnected system shall remain intact.

4.2 Voltage Levels

NTPC references CSA Standard CAN3 C235-83 – 'Preferred Voltage Levels for AC Systems 0 to 50,000 V' as the guideline for preferred voltage levels and ranges. On the NTPC DS, actual voltage ranges may be outside of the preferred values. The steady state voltage is typically maintained in a range of +/- 7%.

4.3 System Grounding

Distribution facilities are typically operated as effectively (solidly) grounded and wye-connected at the source substation bus. Other configurations are occasionally found. DS grounding must conform to the *Alberta Electrical and Communication Utility Code*, 5th Edition, 2016, declared in force pursuant to the *Electrical Code Regulation*, Alta. Reg. 209/2006, as amended or replaced.

4.4 Voltage Unbalance

Phase to phase voltage unbalance can be expected on the primary DS. During normal steady state operation, phase to phase voltage unbalance is normally less than 3%. In some remote locations, unbalances may be higher. The DR Owner should consult with the Wires Owner to obtain site specific details.

As defined by CSA and IEEE, voltage unbalance (%) is:

$$\frac{100 \times \text{negative sequence voltage of the fundamental frequency component}}{\text{positive sequence voltage of the fundamental frequency component}}$$

4.5 Power Quality

NTPC operates to limit to 3% of the fundamental frequency for individual harmonic frequencies and 5% voltage total harmonic distortion on the Wires Owner's side of the PCC. IEEE Std. 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems has been accepted by industry and DR should comply with its requirements. Further details on other industrial standards has been mentioned in following "Power Quality " section of this guidelines that should be referred by DR.

5.0 INTERCONNECTION AND PROTECTION REQUIREMENTS

Achieving and maintaining a technically sound and robust interconnection between a DR and the NTPC distribution system will require diligence on the part of everyone involved in the interconnection, including designers, manufacturers, users, owners and operators of both the DR and the distribution system.

Addition of the DR to the NTPC distribution system may result in a change to the existing distribution system configuration, however:

- *the DR addition shall not compromise the operation or reliability of the electric system and in this regard shall meet the terms and clauses identified in the Connection/ Terms of Service Agreement.*

Any DR Owner may operate 60 Hz single or three phase generating equipment in parallel with the Wires Owner's System provided the DR system:

- *is in accordance with the documented interconnection and operating agreements with the Wires Owner, and*
- *subject to the equipment and DR Owner meeting or exceeding the requirements of this guideline and the Wires Owner's approval, and*
- *the DR Owner's generation and interconnection installation meeting all applicable national, provincial and local construction and safety codes.*

As part of the interconnection process, the DR Owner will ensure that his interconnection to the Wires Owner system will not result in DS conditions that are:

- *unsafe, adversely affect existing or future customers or exceed originally planned for conditions.*

The DR Owner shall be required to perform system impact studies per the requirements of the Wires Owner. These studies will include the following:

- *Impacts to existing system operation, protection, and equipment, and DS changes required for interconnection; DS/ DR changes or requirements for system restoration*
- *Potential impacts to other connected or contemplated distributed resources*
- *Load flow related studies and the effect of sudden load/ DR loss*
- *DS protection, arc flash and short circuit studies that indicate the effects and necessary changes resulting by incorporating the DR into the DS and this considered under all DS operating scenarios (loading, loss of load).*

This should also include any changes that may be required on existing protection settings because of fault current contribution from DR and/or any reverse power flow condition that may arise etc.

- *Changes to system voltage regulation; effects to existing voltage support systems and their control*
- *Power quality and the relation to DR dispatch and unscheduled or changes in output capacity*
- *Changes to steady state or transient voltage conditions*

The DR Owner shall provide operating, metering, and protection and control practices in line with this Interconnection Guideline and related or otherwise necessary Codes, Standards, and Guidelines. The DR Owner, unless otherwise agreed upon, shall be responsible for all required analyses ensuring compatibility with NTPC standard, operating, metering, protection and control practices.

Sections 5 and 7 define the system technical requirements. The DR Owner's equipment must be able to operate within the ranges specified in Section 4.

These requirements promote safe operation and minimize the impact on the electrical equipment in the Wires Owner's system and its other customers.

The Distributed Resource Technical Interconnection Guideline indicates *Interconnection* requirements and is not intended to list or specify specific protection for the DR Owner's generation equipment. It is the responsibility of the DR Owner to provide such protection.

The DR Owner is responsible for protecting the DR Owner's generating equipment in such a manner that DS outages, short circuits or other disturbances, including excessive zero sequence currents and ferroresonant over voltages, do not damage the DR Owner's generating equipment. The DR Owner's protective equipment shall also prevent excessive or unnecessary tripping that would affect the Wires Owner's system reliability and power quality to other customers as required in this guideline.

The DR Owner is required to install, operate and maintain in good order and repair at all times in conformity with good electrical practice the facilities required by this guideline for the safe parallel operation with the Wires Owner's system. Refer to Tables 1, 2 and 3 and Appendix B for summary tables & single line diagrams showing typical interconnection protection requirements.

5.1 DR Facility Power Quality Requirements for Interconnection

5.1.1 Power Quality

It is the DR Owner’s responsibility to ensure that the power quality of the DS has been maintained (not materially degraded below acceptable levels) after connection to the DS. Power quality shall be maintained to within the Wires Owner's standards of requirement for power quality. The quality performance levels deemed acceptable to NTPC shall be maintained under normal and upset condition operating modes of the DR.

At the discretion of NTPC, further limitation and mitigation requirements may be stipulated for and include voltage notching, voltage unbalance limitations (Section 5.2.5), voltage crest factor (amplitude and duration), and voltage sagging on interconnection. The DR design shall not cause telephone interference.

The following industry standards shall be utilized to provide guidance as to appropriate power quality performance:

CSA C22.3 No. 9:20 Interconnection of Distributed Energy Resources and Electricity Supply Systems.

CAN/CSA-C61000-3-6-09 (R2018) Electromagnetic Compatibility (EMC) - Part 3-6: Limits - Assessment of Emission Limits for the Connection of Distorting installations to MV, HV and EHV power systems

CAN/CSA-C61000-3-7:09 (R2014) Electromagnetic Compatibility (EMC) – Part 3-7: Limits – Assessment of Emission Limits for the Connection of Fluctuating Installations to MV, HV and EHV Power Systems

CAN/CSA-IEC 61000-4-7:13 (R2017) Electromagnetic Compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and Inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto

IEC 61000-4-15 – Testing and Measurement Techniques – Flickermeter - Functional and Design Specifications

IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resource with Associated Electric Power Systems Interfaces

IEEE Std. 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

(a) Voltage Fluctuations

Flicker

1. Under operation or during disconnection, the DR shall not create objectionable flicker to other DS customers. The DR Owner is required to ensure that the operation of the DR Owner's facility will not cause voltage variations on the Wires Owner's system that could result in excessive lamp flicker for the Wires Owner's customers. If the DR Owner's facility utilizes a prime mover that has a fluctuating power output (e.g., wind power, slow speed reciprocating engine, etc.), the DR Owner must ensure that the fluctuations in power output do not cause voltage variations, which exceed the Wires Owner's acceptable limits.

2. To ensure that flicker requirements are met, the DR operator may require provision of loss of synchronism protection or staggered energization of multiple unit generator systems.

3. Flicker contributions of the DR measured at the PCC shall conform to the flicker requirements of CAN/CSA C61000-3-7. The Wires Owner may request flicker measurements be conducted by the DR Owner should customer complaints be received in the nearby area(s). If so requested, the flicker measurement device shall conform to CAN/CSA-C61000-4-15.

Rapid Voltage Changes

When the PCC is at 1 kV to 25 kV, the DR shall not cause step or ramp voltage changes to the nominal DS RMS voltage exceeding the following:

3% of Vnominal and exceeding 3% per second averaged in a period of 1 second (source: IEEE Std 1547-2018)

(b) Harmonics

The DR shall not inject harmonic currents such that will cause objectionable voltage distortion on the DS and shall follow the voltage distortion limit requirements of CAN/CSA C61000-3-06.

The objective of the current distortion limit is to limit this injection from individual customers. This is to ensure that they do not cause unacceptable voltage distortion levels to normal system characteristics.

The voltage distortion shall then be limited to 3% of the fundamental frequency for individual harmonic frequencies and 5% voltage total harmonic distortion on the Wires Owner's side of the PCC.

NTPC, at the DR's expense, shall conduct a Power Quality Assessment of the DS in the immediate vicinity of the interconnection using a measurement technique compliant with CAN/CSA-IEC 61000-4-7.

As part of this assessment, the measurements at the DR PCC shall be taken over a minimum one week period during DR typical operation.

(c) Limitation of DC Injection

The DR shall not inject DC current greater than 0.5% of the DR's full rated output current as measured at the PCC.

(d) Voltage and Current Unbalance

Refer to Section 5.2.5 for DR voltage contribution limits to the PCC. Additionally, the DR shall be capable of operating under the existing voltage unbalance conditions of the DS and during system disturbances and be capable of withstanding elevated unbalanced voltages and high negative sequence currents for short periods of time. The DR shall have adequate protection in this regard.

5.1.2 Fault Levels

Fault X/R ratios, levels and maximum allowable fault levels, vary significantly through a DS and must be considered in the design of the interconnection and for the DR equipment ratings. The interconnection fault study shall consider any effects to the existing interconnected DS-DR power system.

5.1.3 Fault and Line Clearing

To maintain the reliability of the DS, the Wires Owner may use automatic re-closing. The DR Owner must take into consideration line re-closing when designing generator protection schemes. This is to ensure that the generator is disconnected from the DS prior to automatic re-close of breakers. The DR Owner may reconnect when the DS voltage and frequency return to normal range and is stabilized. To enhance reliability and safety and with the Wires Owner's approval, the DR Owner may employ a modified relay scheme with tripping or blocking using communications equipment between the DR Owner's and the Wires Owner's facilities(please see Hydro One TIR and discuss if DGEO, LSBS etc. signals required to be added here)

5.2 DR Generating Facility Requirements

5.2.1 Mitigation of Adverse Effects

Adding a generating facility can adversely affect the electric service to existing or future electric customers. The DR Owner shall work with the Wires Owner to mitigate any adverse effects.

If the generating facility is affecting customers adversely, the Wires Owner may disconnect it until such time as the concern has been rectified. The DR Owner will be responsible for any costs incurred as a result of these actions.

5.2.2 Synchronism

Any generating facility that can create a voltage while separate from the electric system must have synchronization facilities including synch-check relaying to allow its connection to the electric system.

Inverter-type, voltage-following equipment that cannot generate a voltage while separate from the electric system does not require synchronization facilities. Nor do induction generators that act as motors during start-up, drawing power from the electric system before they themselves generate power.

The DR Owner has the responsibility to synchronize and maintain synchronization to the Wires Owner's system. The Wires Owner cannot synchronize to the generating facility. A proposed synchronizing scheme must be submitted by the DR Owner and outlined in interconnection and operating agreements with the Wires Owner.

Distribution and transmission facilities typically allow for automatic re-closing of electrical circuits after a variable time delay. The DR Owner is responsible for protecting their own facility from the impacts of such re-closing.

Generators can automatically restart following automatic re-closing of distribution facility electrical equipment if agreed to by the Wires Owner. Generators that automatically restart must have time delay on restart adjustable as agreed to by the Wires Owner. The Wires Owner will coordinate the settings of generator restart time-delays so that generators on any individual feeders restart in staggered order.

5.2.3 Voltage Regulation and Power Factor

The DR Owner shall be responsible for ensuring that the voltage levels at the PCC are maintained within the guidelines prescribed by the Wires Owner and/or at least not exceeding or falling below to the voltage levels, during feeder peak load conditions and feeder minimum loading conditions, prior to the interconnection.

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

Induction generators do not have voltage or reactive power control and consume reactive power. In this case, the generator must provide reactive compensation to correct the power factor to ±0.90 at the PCC, unless other terms are negotiated with the Wires Owner.

Inverter-type generating equipment can control the power factor over a wide range, typically ±0.75. An inverter type generator connected to the distribution facility must be capable of adjusting the power factor in the range of +/- 0.9. The DR Owner may operate outside that range by agreement with the Wires Owner.

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

In order to coordinate with its existing voltage control devices, the Wires Owner may require that the generator operate in a power factor control mode (i.e., within a constant power factor set-point range). The voltage/power factor regulator shall be capable of controlling the power factor of the generator between +0.90 and -0.90. The Wires Owner shall determine the actual set point between these limits.

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

5.2.4 Speed Regulation and Frequency Control

A DG must remain synchronously connected for frequency excursions as identified in this guideline and the table below:

Table 1: DG Frequency Performance

Under Frequency Limit	Over Frequency Limit	Minimum Time
60.0-59.0 Hz	60.0-61.0 Hz	N/A (continuous operating range
58.9-58.5 Hz	61.1-61.5 Hz	3 minutes
58.4-57.9 Hz	61.6-61.7 Hz	30 seconds
57.8-57.4 Hz	-	7.5 seconds
57.3-56.9 Hz	-	45 cycles
56.8-56.5 Hz	-	7.2 cycles
less than 56.4 Hz	greater than 61.7 Hz	Instantaneous trip

For generators connected to the Wires Owner, Islanded operations are not allowed (see Section 5.3.10). Generators that serve remote isolated systems must be capable of controlling the frequency of the system to between 59.0 Hz to

61.0 Hz for normal operation. Under certain operating conditions, frequency tolerances may need to be operated within a smaller bandwidth.

The frequency of the electric system is controlled by all synchronous generator governor systems that connect to the electric system. Such governor systems respond automatically to changes in system frequency to prevent further deviation.

Synchronous generators and other generators with stand-alone capability and significant capacity in relation to the current system's installed capacity must have a speed droop governor.

The droop setting of the governor shall be 5% and the governor system must be operated at all times so that it is free to respond to system frequency changes. If a 5% setting is not possible, the DR Owner must obtain approval from the Wires Owner for an alternate droop setting.

Unless defined otherwise by the Wires Owner/ NTPC:

- all units 1 MW and greater shall be equipped with governors capable of operating in droop mode.
- units less than 1 MVA shall operate in base load mode

The utility will indicate the required frequency and control requirements on a per project basis.

5.2.5 Voltage Unbalance

At the PCC, any three-phase DR facility generation contribution shall not cause a voltage unbalance exceeding 1% (as measured both with no load and with balanced three-phase loading) or a current unbalance exceeding 5%.

Single-phase generators must not adversely unbalance the nearest three-phase system. When they are connected in multiple units, an equal amount of generation capacity must be applied to each phase of a three-phase circuit, and the group of generators must maintain balance when one unit trips or begins generating before or after the others. A single one-phase generator may be connected alone only if it does not cause voltage unbalance on the DS in excess of 2%.

As existing unbalance at the PCC may be close to the limits imposed by the Wires Owner, increases in unbalance caused by DR interconnection will be individually reviewed and considered.

5.2.6 Resonance and Self Excitation of Induction Generators

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

- ferro-resonance in the transformer (Appendix D, [A1], [A2], [A3], [A4]);
- sub-synchronous resonance due to the presence of series capacitor banks (Appendix D, [A5], [A6]); and
- harmonic resonance with other customers' equipment due to the addition of capacitor banks to the DS (Appendix D, [A7], [A8], [A9]).

In the event that an induction generator is used by the DR Owner, 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 (Appendix D, [A10]).

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

5.3 Interconnection

5.3.1 Safety

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

5.3.2 Point of Common Coupling

The Point of Common Coupling or PCC is the point where the Wires Owner's electrical facilities or conductors are connected to the DR Owner's facilities or conductors, and where any transfer of electric power between the DR Owner and the Wires Owner takes place. The PCC will be identified in the design and on the single line diagram. The Wires Owner will coordinate design, construction, maintenance and operation of the facilities on the distribution side of the PCC. The DR Owner is responsible for the design, construction, maintenance and operation of the facilities on the generation side of the PCC.

In specific cases, either the Wires Owner or the DR Owner may own equipment located on the other party's side of the PCC. For example, the Wires Owner may own and operate communications, supervisory, or metering equipment, which is located on the DR Owner's side of the PCC.

The DR Owner must provide a site with the necessary space for the Wires Owner to install current transformers, potential transformers, switching equipment, meters and any other controls or communications equipment required to interconnect with the generating facility. The site is to be approved by the Wires Owner and a 120-volt AC power service is to be available at no cost for the use of portable tools.

The DR Owner is responsible for paying any incremental costs to the transmission/DSs caused by the generator. The Wires Owner will carry out the engineering, design and construction required for its system; and charges these costs back to the DR Owner. The Wires Owner will recover ongoing O&M costs required on the distribution feeder side.

5.3.3 Point of Disconnection

The disconnect switch can be on the high or low voltage side of the interconnection transformer if required. When the interconnection involves three phase generators the disconnect switch must be gang operated to simultaneously isolate all three phases.

High Voltage - Disconnect Switch

The disconnect switch on the Wires Owner's side of the interconnection transformer (e.g., 25 kV nominal air-break) will be installed, owned and maintained by the Wires Owner.

Low Voltage - Disconnect Switch

A manual visible disconnect switch is required so that the power system can be isolated in order to work on the facilities. Appendix B illustrates sample configurations. The DR Owner is responsible for the disconnect switch installation. All low voltage disconnect switches shall:

- be adequately rated to break the connected generation load;
- be within 5 meters (horizontal) of the interconnection point, or wire owner approved location;
- have contact operation verifiable by direct visible means;
- be readily accessible to the Wires Owner operating personnel;
- 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 with safety to the operator with a fault on the system;
- be capable of being energized from both sides;
- plainly indicate whether in the “open” or “closed” position;
- be labeled with a Wires Owner switch number;
- meet applicable CSA Part II standards;
- be installed to meet all applicable codes;
- provide safe isolation for the Wires Owner’s personnel from the generators and all other possible customer sources of power; and
- be annually inspected and maintained.

The disconnect switch on the generation side of the interconnection transformer will be owned and maintained by the DR Owner.

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

There may be other means of meeting this requirement. The Wires Owner must approve any other means.

The DR Owner shall follow the Wires Owner’s switching, work protection procedures in which the Wires Owner shall instruct the DR Owner.

5.3.4 Phasing

Phasing is not standardized across the DSs. Therefore, the phase sequence and the direction of rotation must be coordinated between the Wires Owner and the DR Owner.

5.3.5 Interconnection Grounding

Grounding configurations shall be designed to provide:

- solidly grounded distribution facilities; and
- suitable fault detection to isolate all sources of fault contribution, including the generator, from a faulted line or distribution element; and

- a circuit to block the transmission of harmonic currents and voltages; and
- protection of the low voltage side from high fault current damage.

The preferred configuration is delta connection on the generator side of the transformer and a grounded Wye configuration on the Wires Owner's side of the transformer. If this configuration is not possible, the configuration chosen must still address the above concerns. The winding configuration for DR Owner interconnection transformers should be reviewed and approved by the Wires Owner.

5.3.6 Interrupting Device Ratings

The design of the DR must consider the fault contributions from both the DS and the generating facility itself, to ensure that all circuit fault interrupters are adequately sized. The Wires Owner will inform the DR Owner of the present and anticipated future fault contribution from the interconnected electric system. The DR will document any/all upgrades/modification required in existing DS due to increase fault current and will intimate Wires owner. The cost to do these modifications to accommodate DR may be incurred to DR.

5.3.7 Phase and Ground Fault Protection

The DR Owner must install protective devices to detect and promptly isolate the generating facility for faults occurring either in the generating facility itself or on the DS. "Virtual devices" (i.e., computer or programmable-logic-controller systems) are acceptable provided that they meet standard utility practice for system protection and they have been type tested and approved by an independent testing laboratory.

The DR's protective devices must fully coordinate with protective relays on the electric system unless otherwise agreed by the Wires Owner. The DR Owner must calculate the protective device settings and submit the relay characteristics and settings to the Wires Owner for review and approval.

The DR must be able to detect the following situations and isolate itself from the DS for:

- loss of any phase(s);
- a short circuit between any phase(s) and ground; and
- a short circuit between phase(s).

5.3.8 Over-voltage and Under-voltage Protection

The DR Owner will operate its generating equipment in such manner that the voltage levels on the Wires Owner’s system are in the same range as if the generating equipment were not connected to the Wires Owner’s system.

The DR Owner must install necessary relays to trip the circuit breaker when the voltage, measured phase to ground, is outside predetermined limits. Under-voltage relays should be adjustable and should have a settable time delay to prevent unnecessary tripping of the generator on external faults. Over voltage relays should be adjustable and may be instantaneous.

The DR Owner’s interconnection protection device shall cause the generator to cease to energize the Wires Owner’s DS within the trip time specified in the table below.

Table 2: Protection Response to Abnormal Voltages

Voltage (based on 120 VAC, RMS)	**Trip Time**
$V \le 60$ ($V \le 50\%$)	Instantaneous
$60 < V < 108$ ($50\% < V < 90\%$)	120 cycles
$108 < V < 127$ ($90\% < V < 106\%$)	Normal Operation
$127 < V < 144$ ($106\% < V < 120\%$)	30 Cycles
$V \ge 144$ ($V \ge 120\%$)	Instantaneous

The DR Owner may reconnect when the Wires Owner’s system voltage and frequency return to normal range and is stabilized as permitted in the interconnection and operating agreements. These set points are for DR getting connected to 120V DS secondary and <10 kW. For higher voltages and higher capacity DR, refer to “Voltage Unbalance” section of this guide and other applicable standards. The settings file should be submitted to Wire Owner for review and approval. More stringent settings or clearing times may be specified after reviewing/evaluating connection impact study submitted by DR to Wire Owner.

5.3.9 Over Frequency and Under Frequency Protection

The DR Owner must install frequency selective relays to separate the DR from the DS in cases of extreme variations in frequency.

Under frequency and over frequency relaying that automatically disconnects generators from the DS shall be time delayed in accordance with the Wires Owner requirements specified in Section 5.2.4. The DR Owner may reconnect when the DS voltage and frequency return to normal range and is stabilized as permitted in interconnection and operating agreements.

5.3.10 Anti-Islanding

The DR Owner's generator shall be equipped with protective hardware and software designed to prevent the generator from being connected to a de-energized circuit owned by the Wires Owner.

At the discretion of the Wires Owner, the DR Owner will install under-frequency tripping at 59.0 Hz and over frequency tripping at 61.0 Hz at a time delay as permitted in interconnection and operating agreements.

In most cases, the DR will routinely operate as a part of the interconnected system. A problem on the system could lead to the generator becoming Islanded (i.e., the sole producer of power to one or more of the Wires Owner's customers). In turn, this could lead to damages to those customers caused by irregularities in power quality. To prevent this, the DR Owner must use tele-protection signals from the DS or other reliable means to separate the DG from the DS upon Islanding. The DR Owner is responsible for damages caused as a result of failure to safely separate during an Islanding event.

For situations where there could be a reasonable match between the DR Owner generation and Islanded load, conventional methods may not be effective in detecting Islanded operation. In this event the Wires Owner will require the addition of transfer trip communication facilities to remotely trip off the DR Owner generation upon opening of the distribution feeder main circuit breaker or circuit re-closer.

5.3.11 Telemetering and Targeting

Where a DR could adversely affect the power system, the DR Owner must have systems in place to inform the Wires Owner of what protective operations occurred and failed to occur. An example of an adverse effect would be the DR Owner's generator providing inflow into a fault.

Additionally, the DR Owner shall ensure to the Wires Owners satisfaction that the facility is equipped to measure, record and report on performance related events to demonstrate compliance with the applicable sections of this interconnection guideline. In summary, the DR at the discretion and requirements of NTPC shall provide the following or additional signals to NTPC:

- Connection or circuit breaker status,
- Voltage at point of interest, typically PCC,
- Real and reactive power output in kW and kVAR (verified by Measurement of Canada utility grade metering for power purchase agreements as necessary),

- Load tap changer (LTC) position of the interconnecting transformer (if so equipped),

- Communication and RTU failure alarm(s), and

- Interconnection Intelligent Electronic Device (IED)/ relay failed status, IEDs shall be equipped and configured with event monitoring and recording,

The communication equipment requirements, redundancy aspects, and protocols will be provided by NTPC. Signals shall be referenced to the stipulated satellite-synchronized clock (or other reference) required by NTPC as part of the DR facility. NTPC will indicate any historical record keeping requirements (equipment and signals).

5.3.12 Requirements for Transfer Trip

All DR generators connected to the DS shall be equipped with transfer trip protection to ensure that these machines do not Island in the event of substation breaker or intermediate oil circuit re-closure ("OCR") operation. General requirements are:

- generator separation within 0.6 seconds of breaker or OCR operation;

- fail safe lock out within 6 seconds of communication loss; and

- the DR Owner has responsibility for detecting and tripping in the event of communication loss.

Transfer tripping requirements are also applicable to induction generators, unless the DR Owner can demonstrate to the satisfaction of the Wires Owner that there is no potential for self- excitation.

5.3.13 Special Interconnection Protection

In some cases, it will be necessary to provide for special generator-specific protection and controls, such as out-of-step or loss of synchronism.

The DR Owner needs to be aware that unbalance conditions can occur in the DS, especially under system fault conditions, and the design of the interconnection facilities should take this into account.

For star-delta interconnection transformers, the unbalance fault current could damage the generator interconnection transformer under certain fault conditions, as a result of the circulating current, which occurs in the delta winding of the interconnection transformer in an attempt to balance the fault current. The design may therefore require protection for the transformer to address this potential issue.

5.3.14 Protection from Abnormal Conditions

The DR Owner's interconnection facilities shall be adequately protected from or able to withstand abnormal conditions on the Wires Owner's DS. This may include, but is not limited to:

- frequency excursions due to disturbances on the Wires Owner's DS;
- partial or complete loss of load as a result of disturbances on the Wires Owner's DS;
- transient over-voltage as a result of lightning or switching events; and
- over-voltage due to resonance conditions, healthy phase voltage rise during faults, self-excitation and loss of load.

The DR Owner's facility must be self-protecting to prevent damage as a result of the normal or abnormal operation of the Wires Owner's DS. The DR Owner is accountable for the execution of studies to identify potential abnormal conditions and the cost of mitigating the effects of abnormal conditions.

5.3.15 Self-Excitation

Self-excitation of a DR generator can occur if the generator plus a portion of the Wires Owner's system become isolated from the rest of the Wires Owner's system, resulting in an Island. In an Island condition, self-excitation of the generator resulting from line capacitance or capacitors on the Wires Owner's system exceeds the capability of the generator and its excitation/voltage regulator system to control the voltage.

Unless the DR Owner can demonstrate through the execution of analytical studies, that there is no risk of self-excitation of the generator, the DR Owner must ensure, to the Wires Owner's satisfaction that:

- the DR Owner's facility has protection systems to detect a self-excitation condition.
- the interrupting device provided by the DR Owner is capable of switching the anticipated leading power factor current at the anticipated elevated voltages; and
- isolation of the DR Owner will occur quickly enough to preclude damage to other customers or the Wires Owner's system from the abnormal voltages that may occur.

5.3.16 Inadvertent Energization of the Wires Owner's Facilities

The DR's generator shall not energize the Wires Owner facilities when the Wires Owner's facilities are de-energized.

5.3.17 Protection from Electromagnetic Interference (EMI)

The DR facility and interconnection design and construction shall be such that the influence of electromagnetic interference shall not result in false changes in state, failure or other interconnection system mis-operation. The DR facility must demonstrate compliance to withstand EMI environments in accordance with:

- IEEE C37.90.2 - 2004 IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers; or

- CAN/CSA-CEI/IEC 61000-4-3:07 (R2020) Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio - Frequency, Electromagnetic Field Immunity Test (Adopted CEI/IEC 61000-4-3:2006, third edition, 2006-02) using Level X, 35 V/m, in accordance with IEEE C37.90.2

5.3.18 Surge Withstand Performance

The interconnection system shall have the capability to withstand voltage and current surges in accordance with the environments described in:

- IEEE C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; or

- IEEE C37.90.1-2012 - IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

5.3.19 Synchronization

Interconnection shall be prevented when the DR's synchronous generator and/or powers system is operating outside of the following limits:

Table 3: Synchronization Parameters

Aggregate Rates of Generation (kVA)	Frequency difference (Hz)	Voltage Difference (%)	Phase Angle Difference (degrees)
0-500	0.3	10	20
>500-1500	0.2	5	15
>1500	0.1	3	10

5.4 Typical Interconnection Requirements

While the typical interconnection requirements for safely operating the DR Owner's equipment in parallel with the Wires Owner's System are specified below, specific interconnection locations and conditions may require more restrictive protective settings or hardware especially when exporting power to the Wires Owner's DS. The Wires Owner shall make these deviations known to the DR Owner as soon as possible, subject to review on an individual basis.

Protective relays, electric conversion devices, or other devices may comply with this guideline by the DR Owner demonstrating that such devices can accomplish the required protective function specified as applicable in Section 12, Tables 1, 2 or 3.

5.4.1 Single-Phase Generators

Section 12, Table 1 shows 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 CSA 22.2 107.1.

5.4.2 Three-Phase Synchronous Generators

Section 12, Table 2 shows the protective functions required to meet this guideline.

The DR Owner's generator circuit breakers shall be three-phase devices with electronic or electromechanical control. The DR Owner is solely responsible for properly synchronizing its generator with the Wires Owner's system. The DR Owner is also responsible for ensuring that the interconnection protection device settings coordinate with the Wires Owner's protective device settings.

5.4.3 Three-Phase Induction Generators and Inverter Systems

Section 12, Table 2 shows the protective functions versus generator size required to meet this guideline.

Induction generation may be connected and brought up to synchronous speed (as an induction motor) if it can be demonstrated that the initial voltage drop measured on the Wires Owner's side at the PCC is within the flicker limits. Otherwise, the DR Owner may be required to install hardware or other techniques to bring voltage fluctuations to acceptable levels.

Inverter type generators must meet the applicable criteria in IEEE 929 and be certified to UL 1741 and CSA 22.2 107.1. This also applies to induction generators and self-commutation inverters.

Line-commutated inverters do not require synchronizing equipment. Self-commutated inverters (whether of the utility-interactive type or stand-alone type) shall be used in parallel with the Wires Owner's system only with synchronizing equipment. Direct current generation shall not be directly paralleled with the Wires Owner's system.

5.4.4 Generators Paralleling for 6 cycles or less (Closed Transition Switching)

Section 12, Table 3 shows the protective functions required by this guideline for generators, which parallel with the Wires Owner for 6 cycles or less.

Generators meeting this requirement shall apply for Parallel Operation, shall enter into interconnection and operating agreements with the Wires Owner and shall otherwise meet the requirements of this guideline.

5.4.5 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 design of protection should be done by a qualified engineer, or a competent technical person, working with the Wires Owner's engineers to ensure that the self-diagnostic check feature be integrated into the overall protection system for the safe and reliable operation of the power system.

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

Older electro-mechanical relays do not generally come with such self-diagnostic features. Design of protection and control systems in this case should generally be of a fail-safe nature to maintain the integrity of the protection system under protection system malfunction conditions.

5.4.6 Maximum Generator Power to be Exported

Where the DR capacity exceeds the load carrying capacity of the generator interconnection at the PCC or exceeds the capacity of the Wire Owner's DS connected to the generator, the DR shall install protection to limit the amount of export power to the rated capacity of the DS or the contracted export amount, whichever is less. The maximum limit on the amount of power to be exported shall be set out in an interconnection and operating agreement.

5.5 Interconnection Protection Approval

The DR Owner shall provide to the Wires Owner complete documentation on the proposed interconnection protection for review against the requirements of this guideline and potential impacts on the Wires Owner's system.

The documentation should include:

- a completed application form;
- an overall description on how the protection will function;
- a detailed single line diagram;
- the protection components details (manufacturer, model);
- the protection component settings (trigger levels and time values); and
- the disconnect switch details (i.e., manufacturer, model and associated certification.

The DR Owner shall revise and re-submit the protection information for any proposed modification.

6.0 CONSTRUCTION REQUIREMENTS

6.1 General

The DR Owner's facility shall be constructed and installed to meet all applicable regulations. All permitting and safety codes compliance must be completed and copies of inspection reports provided to the Wires Owner prior to energizing the PCC.

All single line diagrams (original or electronic versions) provided to the Wires Owner shall be drawn in accordance with IEEE standards and conventions and shall be stamped by a professional engineer assuming responsibility for the design.

7.0 METERING

7.1 General

Metering shall comply with Measurement Canada requirements and shall:

- be suitable for use in the environmental conditions reasonably expected to occur at the installation site over the course of a typical year;

- be appropriate for the power system characteristics reasonably expected to exist at the installation site under all power system conditions and events; and

- be approved by the Wires Owner.

The primary side of the interconnection transformer, which is the side connected to the DS, is the metering billing point for the DR Owner's generation export conditions. The low side of the interconnection transformer, which is the side connected to the DR Owner's facilities, is the metering billing point for the DR Owner's import conditions. On all installations where the metering equipment is installed on the low side of the interconnecting transformer, transformer loss compensation shall be installed in the meter for generation export conditions.

7.2 Meter Requirements

The meter must:

- be Measurement Canada approved under subsections 9(1), 9(2) 9(3) of the *Electricity and Gas Inspection Act*, as amended or replaced.

- be verified and sealed in accordance with the *Electricity and Gas Inspections Act*, as amended or replaced, subject to the terms and conditions of any applicable dispensation(s);

- be a bi-directional four quadrant meter.

- include an interval time-stamping clock, if the meter provides the interval data time-stamping function, capable of maintaining the interval boundaries within 60 seconds of the hour and every quarter hour thereafter according to Mountain Standard Time or Mountain Daylight Time whichever is then in effect in the Northwest Territories.

- measure all quantities required to determine active energy and reactive energy transferred in the required directions at the metering point;

- provide a separate register to maintain the continuously cumulative readings of the active energy and reactive energy transferred in the required directions at the metering point.

- retain readings and, if applicable, all clock functions for at least fourteen (14) days in the absence of line power.

- have an accuracy class rating for active energy measurement that equals or exceeds the values specified in Appendix C, Schedule 1, for non-dispensed metering equipment and Appendix C, Schedule 2 for dispensed metering equipment.

- have an accuracy class rating for reactive energy measurement that equals or exceeds the values specified in Appendix C, Schedule 1 for non-dispensed metering equipment and Appendix C, Schedule 2 for dispensed metering equipment; and

- if the meter is internally compensated for line or transformer losses, shall have "LOSS COMPENSATED" indelibly marked in red on the nameplate.

7.3 Measurement Transformers

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

- be Measurement Canada approved under subsections 9(1), 9(2) or 9(3) of the *Electricity and Gas Inspection Act*, as amended or replaced;

- be burdened to a degree that does not compromise the accuracy required by this Guideline; and

- have an accuracy class rating that equals or exceeds the values specified in Appendix C, Schedule 1 for non-dispensed metering equipment.

7.4 Remote Communications Equipment

Remote communications equipment may or may not be an integral part of the meter or the recorder but must incorporate protocol schemes suitable for the type/nature of the communications media/path that will prevent the corruption of data during interval data transmission.

7.5 Quadrants to be Measured

DR Owners exporting power onto the DS shall be equipped with bi-directional meters with four quadrant measurement capability. Six channels are required for four quadrant meters to separately record active power, leading power and lagging reactive power in both the export and the import directions. Where export of power is not required, unidirectional two quadrant metering with three channels is required to separately record active power, leading power and lagging reactive power. A reverse power relay shall also be installed to ensure blocking of any power exports.

7.6 Safety Requirements

The installation shall conform to the requirements of:

- Measurement Canada Standard Drawings;

- CSA Standard - C22.2; and

- IEEE C57.13.3-2014 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

8.0 INSPECTION AND TESTING

The DR Owner shall maintain a quality control and inspection program satisfactory to and approved by the Wires Owner.

In addition to the DR Owner's normal inspection procedures, the Wires Owner reserves the right to witness the manufacturing, fabrication or any part of work which concerns the subject equipment, to inspect materials, documents and manufacturing operations and installation procedures, to witness tests and to evaluate results of non-destructive examinations. The DR Owner shall supply the Wires Owner with a complete set of detailed drawings, which will be used by the Wires Owner to assist in the inspection during the testing of the equipment.

8.1 General

The DR Owner shall notify the Wires Owner in writing at least 2 weeks before the initial energizing and start-up testing of the DR equipment and the Wires Owner may witness the testing of any equipment and protective systems associated with the interconnection. The tests and testing procedures shall generally align with the requirements specified in IEEE 1547.

This section is divided into “type testing” and “verification testing”. Type testing is performed or witnessed a single time 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 the Wires Owner. 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 withdrawal of approval and disconnection of units installed since the change was made. Verification testing is site-specific, periodic testing to assure continued acceptable performance.

These test procedures apply only to devices and packages associated with protection of the interface between the generating system and the Wires Owner’s facilities. Interface protection is usually limited to voltage relays, frequency relays, synchronizing relays, reverse current or power relays, and Anti-Islanding schemes. Testing of relays or devices associated specifically with protection or control of generating equipment is recommended, but not required unless they impact the interface protection.

Testing of protection systems shall include procedures to functionally test all protective elements of the system up to and including tripping of the generator and/or interconnection point. Testing will verify all protective set points and relay/breaker trip timing.

At the time of production, all interconnecting equipment and discrete relays shall meet or exceed the requirements of IEEE C62.41 - 1991 Recommended Practices on Surge Voltages in Low Voltage AC Power Circuits or C37.90.1-2012, IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus. If ANSI /IEEE C62.41-1991 is used, the surge types and parameters shall be applied, as applicable, to the equipment's intended insulation location.

The manufacturer's verification test and the appropriate dielectric test specified in UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources shall also be met.

8.2 Type Testing

All interface equipment must include a type test procedure as part of the documentation. The type test must determine if the protection settings meet these guidelines.

Prior to testing, all batteries shall be disconnected or removed for a minimum of ten (10) minutes. This test is to verify the system has a non-volatile memory and that the protection settings are not lost. A test shall also be performed to determine that failure of any battery used to supply trip power will result in an automatic shutdown.

All inverters shall be non-Islanding as defined by IEEE 929. Inverters shall at the time of production meet or exceed the requirements of IEEE 929 and UL 1741.

8.3 Verification Testing

Prior to parallel operation of a generating system, or any time interface hardware or software is changed; a verification test must be performed. A licensed professional engineer or otherwise qualified individual must perform verification testing in accordance with the manufacturer's published test procedure. Qualified individuals include professional engineers, factory trained and certified technicians, and licensed electricians with experience in testing protective equipment. The Wires Owner reserves the right to witness verification testing or require written certification that the testing was performed.

Verification testing shall be performed annually. All verification tests prescribed by the manufacturer or developed by the DR Owner, which are agreed to by the Wires Owner shall be performed. The DR Owner shall maintain verification test reports for inspection by the Wires Owner.

Inverter generator operation shall be verified annually by operating the load break disconnect switch and verifying that the DR Owner's facility automatically shuts down and does not restart for five minutes after the switch is closed as permitted in interconnection and operating agreements.

Any system that depends upon a battery for trip power shall be checked and logged once per month for proper voltage. Once every four years the battery must be either replaced or a discharge test performed and passed.

8.3.1 Protective Function Tests

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

The non-Islanding function, if provided, shall be checked by operating a load break switch to verify that the interconnection equipment ceases to energize its output terminals and does not restart for the required time delay after the switch is closed.

A reverse-power or minimum power function, if used to meet the interconnection requirements, shall be tested using secondary injection techniques. Alternatively this function can be tested by means of a local load trip test or by adjusting the DR output and local loads to verify that the applicable non-export criterion (i.e., reverse power or minimum power) is met.

8.3.2 Verification of Final Protective Settings Test

If protective function settings have been adjusted as part of the commissioning process, then, at the completion of such testing, the DR Owner shall confirm all devices are set to the Wires Owner’s approved settings.

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 in-service test during commissioning.

This test shall verify proper wiring, polarity, sensing signals, CT/VT ratios, and proper operation of the measuring circuits.

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. Alternatively, calibrated portable ammeters, voltmeters, and phase-angle meters may be used.

8.3.3 Hardware or Software Changes

Whenever interconnection system hardware or software is changed, the functions listed below may be affected. A retest shall be made of the potentially affected functions:

- over-voltage and under-voltage
- over-frequency and under-frequency
- non-islanding function (if applicable)
- reverse or minimum power function (if applicable)
- inability to energize dead line
- time delay restart after the Wires Owner's outage.
- fault detection, if used; and
- synchronizing controls (if applicable).

To ensure that commissioning tests are performed correctly, it may be appropriate for the Wires Owner to witness the tests and receive written certification of the test results.

8.4 Switchgear and Metering

The Wires Owner reserves the right to witness the testing of installed switchgear, and metering. The DR Owner shall notify the Wires Owner at least ten days prior to any testing.

9.0 PROJECT DATA REQUIREMENTS

The following lists the drawings and data required for the approval of the project:

Drawing/Data	Proposal	Approval*	Verified
Manufacturer' s Equipment Data Sheet			X
Control schematic		X	X
Single Line Diagram indicating proposed protection settings	X	X	X
Description of Protection Scheme	X	X	X
Generator Nameplate schedule		X	X

Fuse and protective relay coordination study & settings		X	X
Current transformer characteristic curve		X	X
Commissioning Report c/w Protection Settings			X
Plot plan showing location of lockable "visible" disconnect device	X	X	X

*The minimum time requirement for review of information will generally be in the order of 10 working days.

10.0 MARKING AND TAGGING

The nameplate on switchgear shall include the following information:

- manufacturer’s name;
- manufacturer’s serial number; and
- the disconnect switch shall be clearly marked “DG Disconnect Switch” and tagged with approved identification number from the Wires Owner.

11.0 MAINTENANCE

The DR Owner has full responsibility for routine maintenance of the DR Owner’s generator, control and protective equipment and the keeping of records for such maintenance.

All of the equipment from the generator up to and including the visible point of isolation is the responsibility of the DR Owner. The DR Owner is responsible to maintain the equipment to accepted industry standards.

The DR Owner shall present the planned maintenance procedures and a maintenance schedule for the interconnection protection equipment to the Wires Owner.

Failure to maintain CEC and industry acceptable facilities and maintenance standards can result in disconnection of the generator. The DR Owner shall provide to the Wires Owner annual inspection, shutdown and maintenance reports.

12.0 TABLES

Table 1

Protection for Single-Phase Generators

Interconnection Control, Protection and Safety Equipment		
	Single-Phase Connected to Secondary System	**Inverter**
Interconnect Disconnect Device	X	
Generator Disconnect Device	X	
Undervoltage Trip	X	
Overvoltage Trip	X	
Over & Under Frequency Trip	X	
Overcurrent	X	
Synchronizing Control	Manual or Automatic	
Synch-Check (At PCC)	X	
Anti-Islanding Protection		X

"X" denotes a requirement for this Guideline.

Notes:

1. Exporting to the Wires Owner system may require additional operational/protection devices and will require coordination of operations with the Wires Owner.

2. For synchronous and other types of generators with stand alone capability.

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

Table 2

Protection for Three Phase Generators

Interconnection Control, Protection and Safety Equipment Three-Phase Connected to Primary or Secondary System

		Generator Size Classification		
Device Number	**Device**	**<50 kW**	**50-499 kW**	**500-2,000 kW**
	Interconnect Disconnect Device	X	X	X
	Generator Disconnect Device	X	X	X
	Synchronizing Control[1] Manual (M) or Automatic (A)	M or A	M or A	A
25	Synch-Check[1] (At PCC)	X	X	X
	Automatic Voltage Regulation (AVR)[1]		X	X
27	Undervoltage	X	X	X
59	Overvoltage	X	X	X
59N	Neutral Overvoltage[2]	X[3]	X	X
50/51	Instantaneous/Timed Overcurrent	X[4]	X[4]	X[4]
50/51N	Instantaneous/Timed Neutral Overcurrent	X[3]	X	X
81	Over & Under Frequency	X	X	X
32	Directional Power	X[5]	X[5]	X[5]
TT	Transfer Trip or Equivalent Relay		X[6]	X[6]
	Telemetry Data Communication			X[7]
	Anti-Islanding for Inverters (IEEE Std. 929, UL 1741)	X	X	X

"X" denotes a requirement for this guideline.

All devices are three-phase unless otherwise specified.

Notes:

For synchronous and other types of generators with stand alone capability:

1. Only required for generators that have their interconnection transformer's primary winding ungrounded. Used in conjunction with three PT's in broken delta configuration rated for line to line voltage. For detecting ground faults on the DS.

2. May not be required if the generator is an inverter type voltage-following system of less than 50 kW aggregate. In this case, the Wires Owner will inform the DR Owner if this protection is required.

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

4. Only required for non-exporting or export limited generators.

5. Transfer trip or equivalent protective relay function required for all synchronous generators rated 500 kW and larger with export capability. May also be required for exporting synchronous generators under 500 kW, depending upon characteristics of the distribution circuit. The Wires Owner will advise.

6. System controller requirement for all generators 5 MW and larger. The Wires Owner may also require telemetry for smaller generators depending upon location and distribution circuit characteristics.

7. Exporting to the Wires Owner's system may require additional operational/ protection devices and will require coordination of operations with the Wires Owner.

8. Three directional overcurrent relays may be substituted for a reverse power relay.

9. Above to be in accordance with CSA C22.1 - Canadian Electrical Code, CSA C22.2.

Table 3

Protection for Closed Transition Switching

Interconnection Control, Protection and Safety Equipment Single-Phase Connected to Secondary System	**For 30 Cycles or Less (Closed Transition Switching)**
Interconnect Disconnect Device	X
Generator Disconnect Device	X
Undervoltage Trip	X
Overvoltage Trip	X
Over & Under Frequency Trip	X
Overcurrent	X
Neutral Overvoltage Trip[1]	X
Directional Power Trip	X
Synchronizing Control[2]	Manual or Automatic
Synch-Check (At PCC)[2]	X

"X" denotes a requirement for this Guideline.

Notes:

1. Selection depends upon grounding connection of interconnection transformer.

2. For synchronous and other types of generators with stand alone capability.

Appendix A

Applicable Codes and Standards

The DR interconnection shall conform to this guideline and to the applicable sections of the following codes and standards. When the stated version of the following standards is superseded by an approved revision, then that revision shall apply.

Specific types of interconnection schemes, DR technologies, and DSs 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. Users of this guideline shall address those concerns. This list of standards is therefore not to be regarded as all-inclusive.

Power Quality Standards

ANSI C84.1-2020: Electric Power Systems - Voltage Ratings (60 Hz)

CSA C22.3 No. 9:20 Interconnection of Distributed Energy Resources and Electricity Supply Systems

CSA - C235 - 2020 - Preferred Voltage Levels for AC Systems up to 50,000 V

CAN/CSA-C61000-3-6-09 (R2018) Electromagnetic Compatibility (EMC) - Part 3-6: Limits - Assessment of Emission Limits for the Connection of Distorting installations to MV, HV and EHV power systems

CAN/CSA-C61000-3-7:09 (R2014) Electromagnetic Compatibility (EMC) – Part 3-7: Limits – Assessment of Emission Limits for the Connection of Fluctuating Installations to MV, HV and EHV Power Systems

CAN/CSA-CEI/IEC 61000-4-3:07 (R2020) Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio-Frequency, Electromagnetic Field Immunity Test (Adopted CEI/IEC 61000-4-3:2006, third edition, 2006-02)

CAN/CSA-IEC 61000-4-7:13 (R2017) Electromagnetic Compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and Inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto

IEC 61000-4-15 – Testing and Measurement Techniques – Flickermeter - Functional and Design Specifications

IEEE Std. 493-2007 IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)

IEEE Std 519-2014 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.

IEEE Std. 1100-2005 IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book).

IEEE Std 1159-2019 IEEE Recommended Practice for Monitoring Electric Power Quality.

IEEE Std 1250-2011 IEEE Guide for Identifying and Improving Voltage Quality in Power Systems.

IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resource with Associated Electric Power Systems Interfaces

In addition to the power quality standards, the following standards are applicable to the interconnection of distributed generation resources on the Wires Owner's system:

Alberta Electrical and Communication Utility Code, 2nd Edition, 2002, declared in force pursuant to the Electrical Code Regulation, Alta. Reg. 145/2002

ANSI C12.20-2015 Standard for Electricity Meters- 0.1, 0.2, and 0.5 Accuracy Classes

ANSI C37.44-1981 (R1987) American National Standard Specifications for Distribution Oil Cutouts and Fuse Links

ANSI/ NEMA CC 1-2018- Electric Power Connection for Substations

ANSI/ NEMA C37.50 - 2018 – Switchgear—Low Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures

ANSI/ NEMA C37.51 - 2018 Switchgear - Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies - Conformance Test Procedures

ANSI/ NEMA C37.54-2002 Standard for Switchgear—Indoor Alternating-Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear Assemblies—Conformance Test Procedures

ANSI/ NEMA C37.55-2020 Standard for Switchgear—Metal-Clad Switchgear Assemblies--Conformance Test Procedures

ANSI/ NEMA C37.57-2003 Standard for Switchgear—Metal-Enclosed Interrupter Switchgear Assemblies—Conformance Testing

ANSI/ NEMA C37.58 - 2000 Switchgear - Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear - Conformance Test Procedures

ANSI/ NEMA C37.85-2020 Standard for Switchgear—Alternating-Current High-Voltage Power Vacuum Interrupters — Safety Requirements for X-Radiation Limits

ANSI/ NEMA MG-1- 2018 Motors

ANSI/ UL 1008 - 2014 Transfer Switch Equipment

CSA - C22.1 Canadian Electrical Code, most current version in force in NWT

CSA - C22.2 No. 31-M89 (R1995) - Switchgear Assemblies

CSA - C22.2 No. 107.1 - 2016 – Power Conversion Equipment

CSA - C22.2 No. 144.1 - 2020 - Ground Fault Circuit Interrupters

CSA - C22.2 No. 193 - 2019 - High Voltage Full-Load Interrupter Switches

CSA - C22.2 No. 201 - 2019 - Metal Enclosed High Voltage Busways

CSA - C22.2 No. 229 - 2017 - Switching and Metering Centres

CSA C22.3 No. 9:20 Interconnection of Distributed Energy Resources and Electricity Supply Systems

IEEE Std. 100-1996 IEEE Standard Dictionary of Electrical and Electronics Terms

IEEE Std 315-1975 (Reaffirmed 1993) ANSI Y32.3- 1975 (Reaffirmed 1989) CSA Z99-1975 Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)

IEEE Std 421.6-2017 - IEEE Recommended Practice for the Specification and Design of Field Discharge Equipment for Synchronous Machines

IEEE Std 929 - 2000 IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems

IEEE 1291-1993 - IEEE Guide for Partial Discharge Measurement in Power Switchgear

IEEE 1547- 2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resource with Associated Electric Power Systems Interfaces

IEEE Std 2030.2 - 2015 IEEE Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure

IEEE Std 2030.7 - 2017 Standard for the Specification of Microgrid Controllers

IEEE Std 2030.8 - 2018 Standard for the Testing of Microgrid Controllers

IEEE C37.04 - 2018 IEEE Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V

IEEE/ANSI C37.06 - 2000 - American National Standard for AC High-Voltage Circuit Breakers - Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities

IEEE C37.09-2018 - IEEE Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V

IEEE C37.010-2016 - IEEE Application Guide for AC High-Voltage Circuit Breakers > 1000 Vac Rated on a Symmetrical Current Basis

IEEE C37.011-2019 - IEEE Guide for the Application of Transient Recovery Voltage for AC High-Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V

IEEE C37.012-2014 - IEEE Guide for the Application of Capacitance Current Switching for AC High-Voltage Circuit Breakers Above 1000 V

IEEE C37.012a-2020 - IEEE Guide for the Application of Capacitance Current Switching for AC High-Voltage Circuit Breakers Above 1000 V Amendment 1

IEEE C37.013-1997 - IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

IEEE C37.015-2017 - IEEE Guide for the Application of Shunt Reactor Switching

IEEE C37.081-1981 - IEEE Guide for Synthetic Fault Testing of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (Withdrawn)

IEEE C37.11-2014 - IEEE Standard Requirements for Electrical Control for AC High-Voltage (>1000 V) Circuit Breakers

IEEE C37.13-2015 - IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures

IEEE C37.14-2015 - IEEE Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures

IEEE 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

IEEE C37.2-2008 - IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations

IEEE C37.20.1-2015 - IEEE Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear

IEEE C37.20.2-2015 - IEEE Standard for Metal-Clad Switchgear

IEEE C37.20.3-2013 - IEEE Standard for Metal-Enclosed Interrupter Switchgear (1 kV–38 kV)

IEEE C37.20.6-2015 - IEEE Standard for 4.76 kV to 38 kV Rated Ground and Test Devices Used in Enclosures

IEEE C37.23-2015 - IEEE Standard for Metal-Enclosed Bus

IEEE C37.24-2017 - IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear

IEEE C37.27-2015 - IEEE Guide for Low-Voltage AC (635 V and below) Power Circuit Breakers Applied with Separately-Mounted Current-Limiting Fuses

IEEE C37.29-1981 - IEEE Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures

IEEE C37.30.1-2011 - IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V

IEEE C37.30.1a-2017 - IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V -- Amendment 1: Criteria for acceptance

IEEE C37.32-2002 American National Standard for Switchgear—High-Voltage Air Switches, Bus Supports, and Switch Accessories—Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide

IEEE C37.34-1994 IEEE Standard Test Code for High-Voltage Air Switches

IEEE C37.35-1995 IEEE Guide for the Application, Installation, Operation, and Maintenance of High-Voltage Air Disconnecting and Load Interrupter Switches

IEEE C37.42-2016 - IEEE Standard Specifications for High-Voltage (>1000 V) Fuses and Accessories

IEEE C37.66-2005 - IEEE Standard Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV)

IEEE C37.81-2017 - IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies

IEEE C37.90-2005 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C37.90.1-2012 - IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C37.90.2 - 2004 IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

IEEE C37.95 - 2014 IEEE Guide for Protective Relaying of Utility-Consumer Interconnections

IEEE C37.98 - 2013 IEEE Standard for Seismic Qualification Testing of Protective Relays and Auxiliaries for Nuclear Facilities

IEEE C57.12.00-2015 - IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.13 - 1982 Conformance Requirements for Liquid Filled Transformers Used in Unit Installations including Unit Substations (Inactive)

IEEE C57.13-2016 - IEEE Standard Requirements for Instrument Transformers

IEEE C57.13.1-2017 - IEEE Guide for Field Testing of Relaying Current Transformers

IEEE C57.13.2-2005 - IEEE Standard for Conformance Test Procedure for Instrument Transformers

IEEE C57.13.3-2014 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases

IEEE C57.19.100 - 2012 - IEEE Guide for Application of Power Apparatus Bushings

IEEE C57.98-2011 - IEEE Guide for Transformer Impulse Tests

IEEE C57.110-2018 - IEEE Recommended Practice for Establishing Liquid Immersed and Dry-Type Power and Distribution Transformer Capability when Supplying Nonsinusoidal Load Currents

IEEE C62.11-2020 - IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)

IEEE C62.23-2017 - IEEE Application Guide for Surge Protection of Electric Generating Plants

IEEE C62.41-1991 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

IEEE C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits (withdrawn Mar 25, 2021)

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

IEC 1000-3-3 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current less than 16A

IEC 1000-3-5 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current greater than 16A

UL1741 – 2010 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

Appendix B

Typical Arrangement

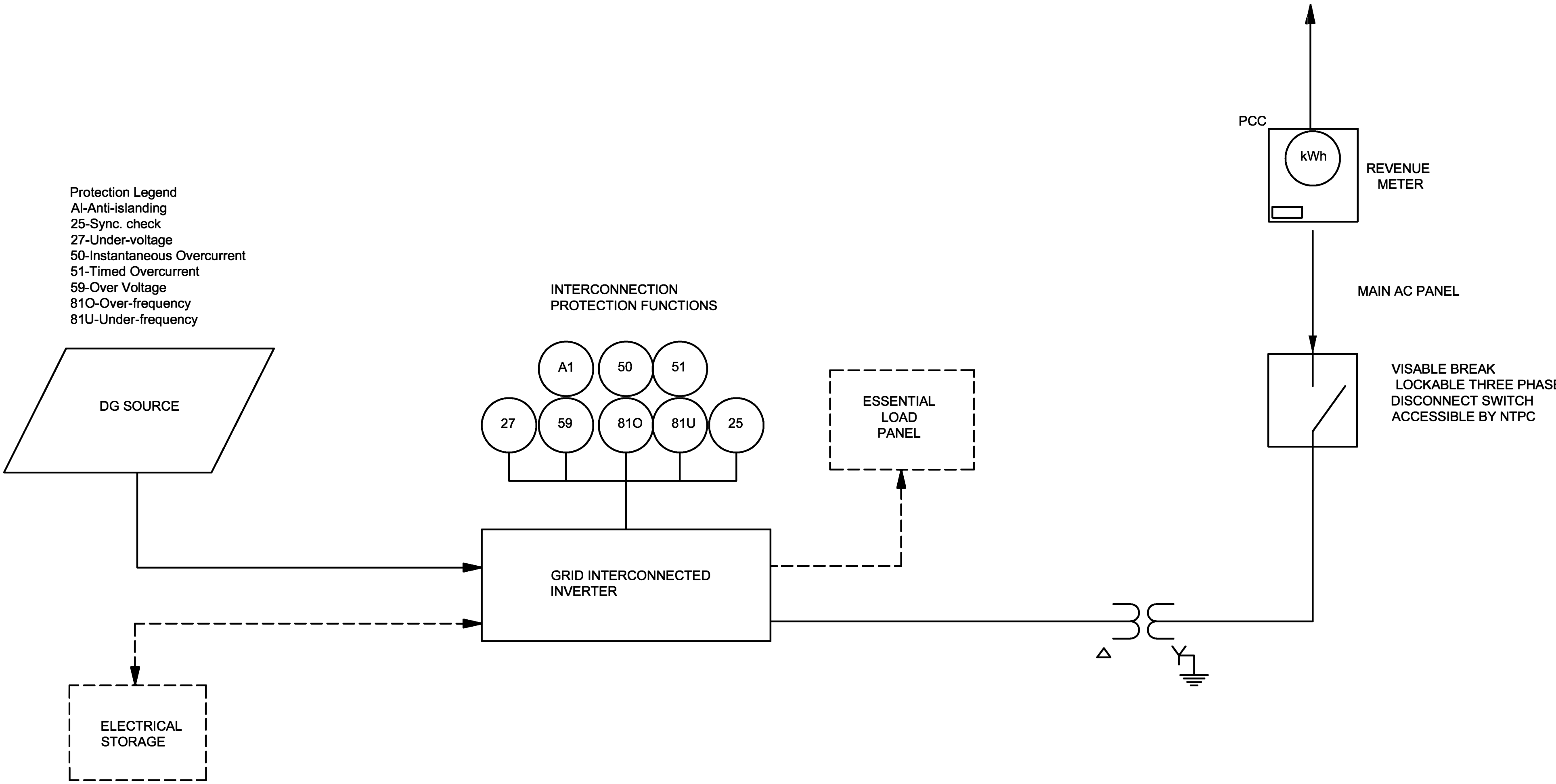


Figure 1 – Single Line Diagram of a Typical Inverter-Based Simple or Complex DG System
(Source: Adapted From CAN/CSA-C22.2 No. 257-06 Figure B.1)

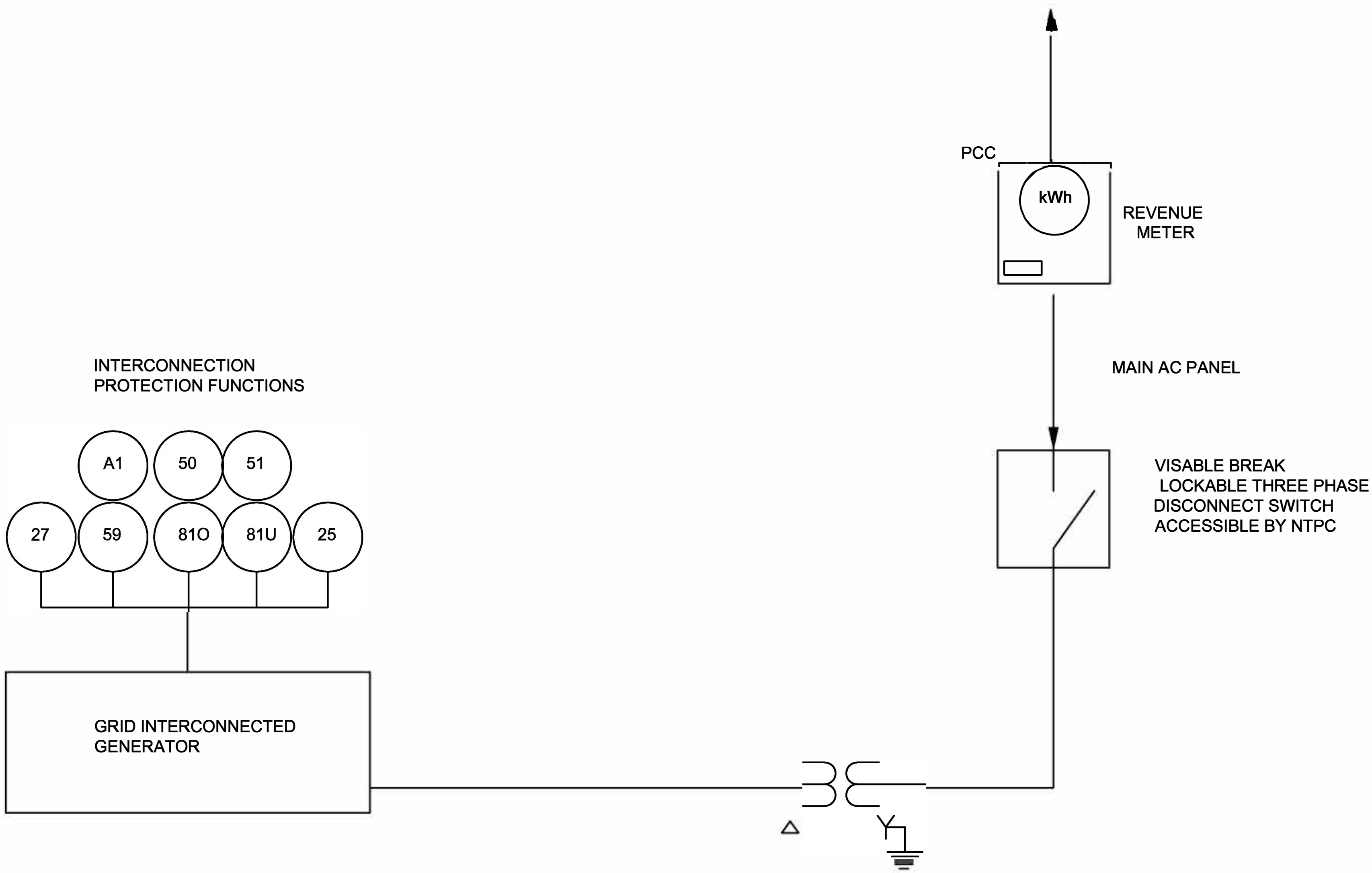
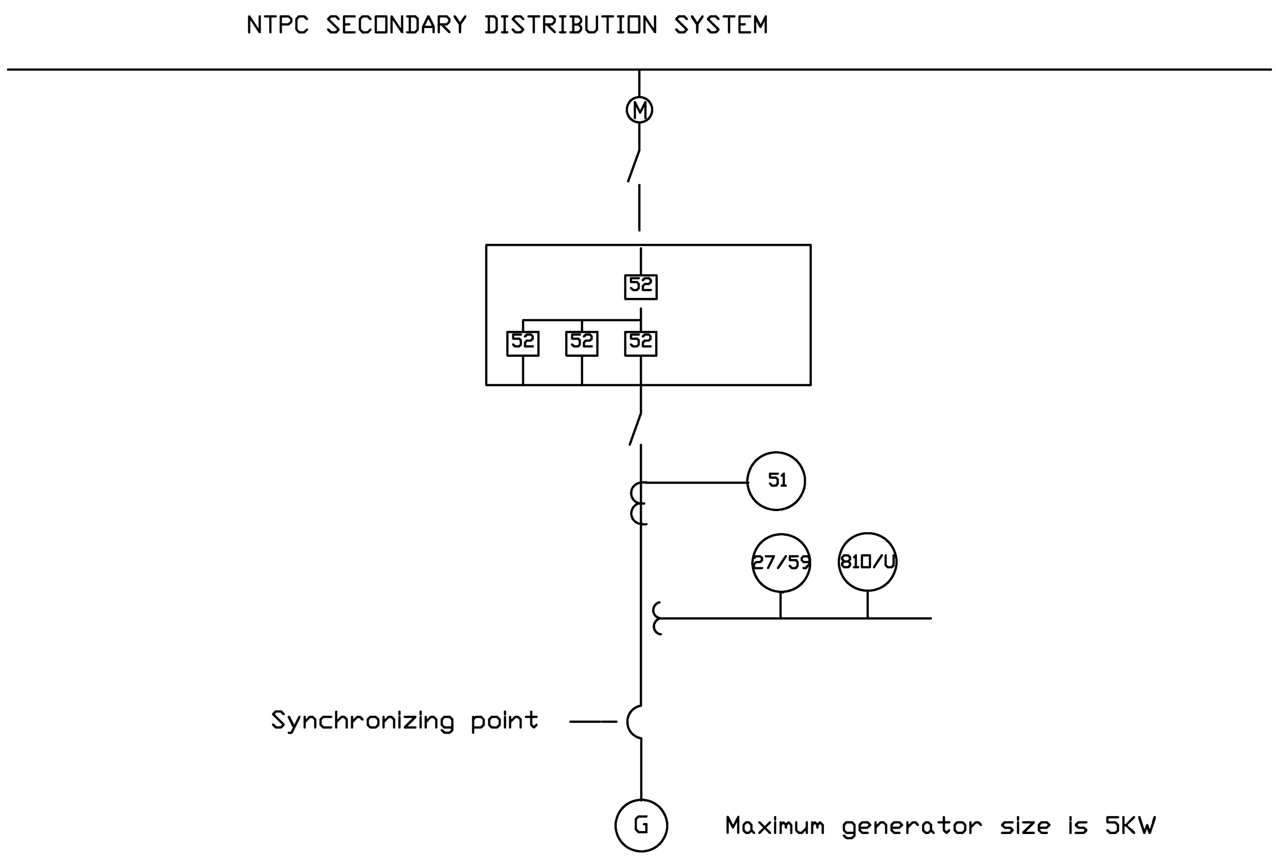


Figure 2 – Single Line Diagram of a Typical Induction or Synchronous Generator -Based Simple or Complex DG System



Protection function:
52 Circuit Breaker
51 Overcurrent protection
81O/U Over/Under frequency protection
27/59 Inder/Over voltage protection
M Revenue metering
Note: Typical requirements shown. DG shall evaluate requirements for further protection

FIGURE#3
TYPICAL SINGLE PHASE GENERATOR INSTALLATION CONNECTED T NTPC's SECONDARY SYSTEM

Appendix C

Metering Equipment Accuracy Schedule

Schedule 1

Schedule of Accuracies for Metering Equipment Approved Under Section 9(1) of the *Electricity And Gas Inspection Act*

Metering Point Capacity (MVA)	Watt-hour Meter Accuracy Class	Varhour Meter Accuracy Class	Measurement Transformers Accuracy Class
10 and Above	0.2%	0.5%	0.3%
Below 10	0.5%	1.0%	0.3%

Notes:

1. The columns apply to requirements set out in the Metering Section.

2. 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

Schedule 2

Schedule of Accuracies for Meters Approved Under Subsections 9(2) or 9(3) of the *Electricity And Gas Inspection Act*

Meter Accuracy		
Metering Point Capacity (MVA)	**Points of Delivery**	**Points of Supply**
10 and Above	1.0%	1.0%
Below 10	1.0%	1.0%

Notes:

1. The columns apply to requirements set out in the Metering Section.

2. 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 D

References

[A1] A.B. Sturton (Canadian Electricity Association), *Connecting Small Generators to Utility Distribution systems*, Chapter 11.

[A2] Power Technologies Inc., Schenectady, New York. *Transformer concepts and application course notes.*

[A3] Allan Greenwood, *Electrical Transients in Power Systems.*

[A4] Westinghouse, *Electrical Transmission & Distribution Reference Boo*k. .

[A5] J. Lewis Blackburn, *Protective Relaying, Principles and Applications*, details on sub-synchronous resonance (Chapter 7).

[A6] Westinghouse, *Electrical Transmission & Distribution Reference Book*.

[A7] Westinghouse, *Electric Utility Engineering Reference Book - Distribution Systems,* Harmonic and Resonant Effects on Application of Capacitors (Chapter 8).

[A8] A.B. Sturton (Canadian Electricity Association), *Connecting Small Generators to Utility Distribution systems*, Chapters 11, 12.

[A9] B.M. Weedy, *Electric Power Systems*, Switching surges-interruption of capacitive circuits (Chapter 10)

[A10] A.B. Sturton (Canadian Electricity Association), *Connecting Small Generators to Utility Distribution systems*, Chapter 4.