Distribution Distributed Energy Resources Interconnection Requirements

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Manitoba Hydro
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1.0 General Information

1 General Information

This section identifies general document preamble, consistent customer with interconnection requirements.

1.1 Legislative Authority

Section 15.0.3(1) of The Manitoba Hydro Act (C.C.S.M. c. H190) authorizes Manitoba Hydro to: (a) make rules, set terms and conditions, or issue directions respecting (i) the interconnection of the works of others with the corporation's works, and (ii) the operation of the works of others that are interconnected with the corporation's works; and (b) carry out studies to evaluate the effects of a proposed interconnection. Works is defined as including all roads, railroads, plant, machinery, buildings, structures, erections, constructions, installations, materials, devices, fittings, apparatus, appliances, equipment, and other property for the development, generation, transmission, distribution, or supply of power.

Pursuant to Section 10 of Regulation 186/90 – Electric Power Terms and Conditions and Supply, Manitoba Hydro is authorized to determine the voltage, frequency, phasing and other characteristics of power, the determination of which is final and binding on the user.

Pursuant to this legislative authority, Manitoba Hydro has established the following Distribution System Interconnection Requirements document for the facilities of third parties interconnected to Manitoba Hydro's distribution system.

1.2 Authors

This document update was developed in collaboration with staff from Distribution Engineering, Engineering Standards, Station Design, Grid Infrastructure Planning, Transmission Operations and Maintenance, Electrical Inspections and Customer Energy Services.

1.3 Revisions

REVISION	DATE	CHANGES
3.0	September 2022	• Major updates
2.1	January 2011	• Revised telemetry requirements
2.0	June 2010	• Revised specification to reflect adoption of new CSA Standard C22.3 No.9-08 "Interconnection of distributed resources and electricity supply systems".
1.0	January 2006	• Revised title • Removed reference to policy and procedures as this will be covered in other documents • Established four interconnection types • Added Annex E and F • Revised data sheet
0.0	January 2003	• Major updates

Manitoba Hydro periodically updates this document and makes revisions necessary to reflect changing system conditions and industry practices. It is the customer's responsibility to ensure they check for the latest version of this document found on the Manitoba Hydro Website.

1.0 General Information

1.4 Introduction

Manitoba Hydro is a provincial Crown Corporation and is one of the largest integrated electricity and natural gas distribution utilities in Canada.

Our mission is to help all Manitobans efficiently navigate the evolving energy landscape, leveraging our clean energy advantage while ensuring safe and reliable energy at the lowest possible cost.

Distributed energy resources (DER) offer customers the opportunity to generate their own energy while interconnected to the distribution system and to other Manitoba Hydro customers.

The technical interconnection requirements identified in this document are intended to maintain safe operation and electrical performance of the distribution system.

1.5 Scope

This document identifies the minimum technical requirements for safely and reliably connecting customer owned DER Systems, generating 10 MW or less at voltages equal to or less than 25 kV, to the Manitoba Hydro electrical distribution system.

Interconnection requirements include but are not limited to maximum DER capacity, protection schemes to detect system and DER facility abnormal conditions, power quality operating performance, reliability, communications, monitoring, interrupting devices, transformation, grounding and commissioning.

Manitoba Hydro may limit proposed DER capacity, based on DER technology, system strength, location, proximity to other DER installations, connected DER, connected customer loads, communications availability, and reverse power flow on critical Manitoba Hydro infrastructure.

This document is an interconnection requirement guide and as such is not a substitute for responsible engineering practice. The DER owner is advised to hire a qualified and licensed technical professional to design the DER system. In some cases, Manitoba Hydro may require that the DER system design be Sealed by a Professional Engineer based on the perceived complexity of the DER facility.

This document is not an operating agreement and does not address revenue metering, rates, tariffs, distribution system upgrade costs to accommodate DER or other contractual agreements.

This document does not address the requirements of the Manitoba Electrical Code or Provincial and Municipal regulations associated with the DER system installation and operating requirements. The DER Owner is responsible to apply for an electrical permit before electrical work is started.

This document is based on the standards provided in the references section and include adaptations by Manitoba Hydro. Due to the rapidly evolving nature of DER technology, Manitoba Hydro may update these interconnection requirements and post them to the Manitoba Hydro website without notice.

1.6 Definitions

This section provides definitions of terms used in this document.

Abnormal Conditions

Refers to the performance of electrical indices occurring outside normal operating ranges as identified in this document. Typically, DER Systems are to cease operation or disconnect when abnormal conditions are detected. Abnormal conditions also refers to contingency operation or untypical configuration of the distribution system.

Automatic Circuit Recloser (ACR)

An interrupting device used by utilities to detect and clear faults on distribution feeders by automatically opening and reclosing a circuit breaker. The ACR can reclose multiple times.

Bidirectional Revenue Meter
A Revenue Canada approved energy meter used to record Customer energy usage, such as kWh (kilo-Watt hour) consumed, and kVA (Demand) peak loading.

Cease to Energize
The ability of an inverter to phase back power output without physically opening interrupting contacts. This does not necessarily imply disconnection, isolation, or a trip of the DER System.

Complex DER Systems
Those DER Systems identified by Manitoba Hydro as requiring non-typical interconnection requirements or having performance characteristics capable of causing Abnormal Conditions on the distribution station or feeder.

Curtailment
A temporary reduction or limit on power output of DER systems as contractually specified or signaled by Manitoba Hydro supervisory systems.

Disconnecting Means
A device or group of devices that disconnect or isolate conductors or equipment of a circuit from their source of supply.

Distributed Energy Resource (DER)
Are small-scale energy generators and storage resources, that can be used to supply customer facility loads or be used to supply the distribution system. DER technologies include those identifies in Table 1.6.

FUEL SOURCE	ENERGY CONVERSION	INTERCONNECTION
Sunlight	Solar Panel	DC to AC Inverter
Diesel Fuel	Reciprocating Engine	Synchronous Generator
Hydrogen	Fuel Cell	DC to AC Inverter
Natural Gas	Turbine	Synchronous Generator
Wind	Wind Turbine	Induction Generator
Biomass	Sterling Engine	Induction Generator
Waste Gas	Turbine	Induction Generator
Multiple	Battery Storage	DC to AC Inverter

Table 1.6 DER Technologies

DER Facility
The electric service location or premise where the DER System is installed and operating.

DER Owner
The owner of the DER Facility and System, responsible for its design, operation and maintenance.

DER System
See Distributed Energy Resource.

Displacement
Customer owned generation that is used to supply all or part of a customer's energy needs.

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Distribution System
The portion of the electrical system operating at less than 66 kV and delivering electric power to an end user customer. Distribution system feeders can be radial or mesh connected, connected to the bulk power system or independently off-grid.

Export
Customer owned generation that exceeds a customer's energy needs and is supplied back to the distribution system.

Independent Power Producer (IPP)
Any DER Facility interconnected with Manitoba Hydro solely for the purpose of exporting power.

Engineering Study
Performed by Manitoba Hydro, this study investigates transient and steady state performance of the DER System while connected to the utility. This study also reviews and clarifies with the DER Owner how their DER System design meets the interconnection requirements of this document.

Grid Following
DER Systems that cannot synthesize voltage and frequency without an external utility reference. These devices are intended to operate only while connected to an energized grid.

Grid Forming
DER Systems that can synthesize steady state voltage and frequency without an external utility reference. These devices can operate in both grid connected and islanded mode. This definition includes inverters and synchronous generators. Induction generators are theoretically not capable of supplying isolated loads when separated from the Utility, unless they become self-excited.

Hosting Capacity
The maximum generating capability of a proposed DER System that can be added to a distribution system before corrective actions are required to maintain system safety, reliability and performance.

Hosting Capacity limits vary depending on system characteristics and utility control of the DER system. Examples of factors that can limit DER generation, include but are not limit to, DER technology, DER primary mover, system strength, thermal ratings, protection reach, voltage class, location (includes on feeder and within the province), proximity to other DER installations, connected DER, connected customer load, communications bandwidth and reverse power flow on critical Manitoba Hydro infrastructure.

Induction Generator
A rotating machine generating alternating current, where armature field excitation is provided by external means and is typically started like a motor. The induction generator is generally not capable of operating while not connected to the utility, unless it has a source of excitation and is not overloaded.

Interconnection Operating Agreement (IOA)
A contractual agreement between Manitoba Hydro and the DER Owner that stipulates terms and conditions of interconnection, including sustainable operating and maintenance requirements.

Interconnection Requirements
The technical requirements for safely and reliably connecting customer owned DER Systems to the Manitoba Hydro electrical distribution system.

Inverter
A static power converter used to connect energy resources, e.g. solar voltaic arrays and batteries, to the power system.

1.0 General Information

Islanding
A scenario where a portion of the utility's distribution system that contains both customer load and DER systems become electrically isolated from the utility but remains energized by one or more DER Facilities.

Momentary Closed Transition
A transfer switch that allows two electrical power sources to operates in parallel for a brief period of time. e.g. less than 100ms. Also know as "make before break", the full transition time must take less than 100 msec.

Intertie Relay
Is a protection relay capable of multiple protection elements and control strategies. This relay is a standalone device in addition to the built-in protection provided by the manufacturer of the DER inverter.

NERC
The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Off Grid
Remote power stations that are not connected to the bulk Manitoba electrical system. This includes remote diesel generating stations and islanded power stations.

Parallel Operation
Electrical connection between the utility distribution system and the DER Facility.

Point of Common Coupling (PCC)
The location on the Manitoba Hydro system electrically nearest to the customer installation. It can be located on either the primary or secondary side of a supply transformer depending on a) who owns the transformer, and b) whether multiple customers are (or will be) supplied from the secondary of the transformer.

Point of Interconnection (POI)
The location where equipment ownership changes from Manitoba Hydro to the customer. Electrical performance measurements will be made at the nearest accessible monitoring point, and adjusted, if needed, to reflect measurements at the POI.

Independent Power Producer
A DER Facility with generation that exceeds two times their power consumption requirements, with the intent of exporting this excess energy to the distribution system.

Power Quality Benchmark
An assessment of the performance of recorded electrical indices against limits identified in Manitoba Hydro's Power Quality Interconnection Requirements.

Primary Metered Service
Manitoba Hydro will provide customers with revenue metered high voltage (>1000 V) connection where the customer provides their own transformer.

Protection Scheme
The protection and control systems, including associated sensors, and relays, intended to protect a distribution system or connected DER Systems from electrical faults or abnormal operation.

Rapid Shutdown
Required by the Manitoba Electrical Code when installing solar DER systems on or inside buildings. It is not presently required when DER Systems are installed outside and away from buildings.

Stale Data
Data that hasn't changed state within an expected period of time and is now suspect, e.g. lost communications or device malfunction.

Supervisory Controller
A remote terminal unit (RTU) and gateway, also known as supervisory control and data acquisition (SCADA), used for the selective control and data acquisition of remotely located DER systems over one or more communications protocols.

Synchronous Generator
A rotating machine generating alternating current, using a rotor with a DC field connected to an external power source. The synchronous generator is capable of generating steady state power while not connected to the utility.

Transfer Trip
A remote signal from the utility to command the DER Facility interrupting breaker or Utility interrupting breaker to open, isolating the DER Facility or System from the utility.

Type Testing
Testing by the Manufacturer that determines whether a product complies with the requirements of a specification or technical standard.

Watchdog Timer
A process that routinely monitors the activity of communications, electronic devices and data exchange to confirm activity and automatically initiating a cease to energize command to the DER system in the event of a detected failure.

Winnipeg Secondary Network System
An underground Secondary Network System consisting of multiple network transformers that supply a mesh connected secondary bus throughout downtown Winnipeg. The unique power flow protection scheme used by network protectors and mesh connections prevent the connection of DER on this network.

2.0 Interconnecting DER to Manitoba Hydro

2 Interconnecting DER to Manitoba Hydro

The DER Owner is to submit an Interconnection Request application found on the Manitoba Hydro website to provide the information necessary for Manitoba Hydro to initiate an evaluation of the proposed new or upgraded interconnection. Once the DER Owner has provided all required information, as listed in Appendix B hereto, Manitoba Hydro will review the feasibility of the application in meeting the interconnection requirements identified therein, advising the DER Owner of the DER classification, if the DER system can be accommodated within the existing Hosting Capacity, additional required Engineering Studies (due to the complexity of the proposal) and any major accommodation requirements.

Manitoba Hydro may also require that the single line diagram and design package, provided by the DER Owner, be Sealed by a qualified and licensed professional engineer based on the perceived complexity of the DER system.

Once the DER Owner decides to proceed with an Engineering Study, the appropriate Appendix B Interconnection Requirements, based on DER Classification, is to be completed and submitted to Manitoba Hydro to confirm compliance with interconnection requirements. Independent Power Producers and complex Displacement & Export proposals will be required to submit a written report detailing how the DER System design meets each of the interconnection

2.0 Interconnecting DER to Manitoba Hydro

requirements in Section 5. Manitoba Hydro will then review the submitted report and Appendix B form to ensure interconnection requirements have been recognized and addressed. Successful proposals will continue with the Engineering Study process.

Once the Engineer Study is completed, a cost estimate to construct the interconnection to the Manitoba Hydro system will be initiated.

Manitoba Hydro will process interconnection applications in a sequential order based on when Manitoba Hydro receives a valid and completed interconnection request, the validity and completeness of which shall be based on Manitoba Hydro's sole and unfettered determination. Manitoba Hydro will process reserve Hosting Capacity based on approved applications for a limited time duration.

Manitoba Hydro assesses the DER interconnection to ensure compliance with to the Distribution Distributed Interconnection Requirements and does not guarantee performance, curtailment, reliability, coordination with the utility or safety of the proposed DER system. It's recommended that the DER Owner employ qualified and experienced technical resources to design their DER System to meet the Interconnection Requirements of this document.

The DER Owner is required to obtain an electrical permit from Manitoba Hydro's Electrical Inspections department or if the DER is located within the City of Winnipeg, then from The City of Winnipeg. The electrical permit provides review and approval that the DER design meets electrical code requirements, and that equipment is CSA certified.

3.0 DER Classification

3 DER Classification

DER Classification assists with identifying the interconnection requirements and the processes to be followed by the DER Owner.

3.1 Standby Generation - Non-Parallel Operation

Non-Parallel Operation (break-before-make) with the distribution system. This type of interconnection uses an open transition transfer switch to connect a standby generator to electrical load within the customer's facility but never in parallel with the distribution system.

3.2 Standby Generation – Momentary Transition Operation

Standby Generation is a DER system that is briefly operated in parallel with the distribution system. This type of interconnection uses a CSA approved closed transition transfer switch, (make-before-break) to momentarily connect a standby generator to the utility. The transfer switch must be rated to transfer the generator from parallel operation with the distribution system in less than 100 ms.

3.3 Load Displacement (non-export)

Load Displacement is a DER system that operates in parallel with the utility for the purpose of displacing customer load. The DER generation is less than the total facility load and reverse power is not allowed back to the utility. Residential installations are considered as having a total facility load of equal to or less than 5 kW.

Manitoba Hydro may require the DER Owner to install a reverse power relay or other power monitoring control devices to regulate DER generation to prevent reverse power flow to the utility.

A bi-directional revenue meter is not required.

3.0 DER Classification

3.4 Load Displacement & Export

Load Displacement & Export is a DER system that operates in parallel with the utility to supply the facility's power needs and to also export excess power to the utility.

Power export is limited by the available Hosting Capacity as determined by Manitoba Hydro.

The Load Displacement & Export classification limits DER System size to a maximum of 200% of the recorded Demand billing or as determined by Manitoba Hydro in keeping with Hosting Capacity limits, e.g. 10 kW for residential facilities.

3.5 Independent Power Producer (IPP)

Independent Power Producer (IPP) is a DER Facility designed mainly for the export of power to the distribution system or a Load Displacement & Export category greater than 200% of the recorded demand billing or as determined by Manitoba Hydro in keeping with Hosting Capacity limits.

Power export is limited by the available Hosting Capacity as determined by Manitoba Hydro.

The IPP classification is limited to a maximum of 10MW or as set by Manitoba Hydro.

Manitoba Hydro will require an advanced bi-directional revenue meter with remote communications to trend system performance.

4.0 Distribution System Characteristics and Performance

4 Distribution System Characteristics and Performance

DER Facilities must be designed to reliably operate and adhere to performance requirements identified in the Manitoba Hydro Distribution System Customer Load Interconnection Requirements (DSCLIR), the Power Quality Interconnection Requirements (PQIR) documents and the Manitoba Hydro Interconnection Operating Agreements.

Depending on DER Classification, DER Facilities may also be required to be designed to reliably operate and adhere to performance requirements identified in the Manitoba Hydro Transmission System Interconnection Requirements (TSIR) document.

The DER Owner must ensure that they are compliant with other Federal, Provincial and Municipal jurisdictional code requirements.

4.1 Distribution System Customer Load Interconnection Requirements

The DSCLIR defines technical requirements and characteristics for DER Facilities wishing to connect to the Manitoba Hydro distribution system at voltages exceeding 750 V but less than 100 kV.

For DER Facilities connecting to the Manitoba Hydro distribution system at voltages less than 750 V, the DSCLIR applies except for voltage performance which is provided in Appendix E.

Manitoba Hydro does not allow DER interconnections to the Winnipeg Downtown Secondary Network System.

The phase sequence and direction of rotation shall be compatible with the Manitoba Hydro system.

4.0 Distribution System Characteristics and Performance

4.2 Power Quality Interconnection Requirements

The PQIR specifies power quality system characteristics and required facility electrical performance requirements for interconnecting to the Manitoba Hydro electrical system. The DER Owner must ensure that their DER Facility does not introduce flicker, dynamic voltage variations, voltage unbalance, voltage variation and harmonic emissions that exceed the requirements in the PQIR. e.g. DER Systems must not cause objectionable voltage variations due to sudden changes in energy input.

Equipment that is IEEE 1547 certified, is Type tested to meet the 5% harmonic distortion current limits at the maximum output of the inverter. Equipment that is not certified will need to provide a letter from the DER equipment Manufacturer stating the harmonic current emissions.

4.3 Interconnection and Operating Agreement

DER Facilities will need to be designed to reliably operate and adhere to requirements described in their Manitoba Hydro Interconnection and Operating Agreement.

DER Owners will need to resolve safety, reliability and performance issues and respond to questions from Manitoba Hydro in a timeframe identified by Manitoba Hydro.

4.3.1 Limitation of Operation

As further identified in the Interconnection Operating Agreement, Manitoba Hydro reserves the right to disconnect the DER System or restrict DER System output generation for, but not limited to, the following reasons:

4.3.1.1 Abnormal Operation

a. Utility line maintenance work.
b. Utility system emergency or abnormal conditions.
c. Identified DER System hazardous conditions or equipment failure.
d. Failure of the DER Owner to provide maintenance and testing reports when applicable.
e. Identified safety or electrical performance issues.
f. DER System modifications not approved by Manitoba Hydro.

4.3.1.1 Dispatch and Curtailment

DER System output generation may be restricted to accommodate system hosting capacity limits or abnormal conditions.

4.4 Hosting Capacity

The maximum generating limit of a proposed DER system based on available Hosting Capacity as assessed by Manitoba Hydro on a case-by-case and on a sequential order basis.

The DER Owner will be advised of their responsibility to pay for distribution system upgrades required to accommodate their proposed DER system(s).

5.0 Interconnection Requirements

5 Interconnection Requirements

This Section identifies DER System requirements to maintain safe and reliable distribution operation within electrical performance requirements. The DER Owner will be responsible to ensure their design meets all other regulatory requirements, such as the Manitoba Electrical Code and Provincial and Municipal regulations.

Independent Power Producer and complex Displacement & Export classified DER Facilities will need to submit a written report to Manitoba Hydro detailing how their design meets the requirements of Section 5 in keeping with the format of Section 5.

5.1 Means of Isolation

A facility means of disconnect, installed, owned, maintained, and exclusively operated by Manitoba Hydro, is required at the Point of Interconnection or Point of Common Coupling supplying the customer facility. For multiple DER systems in a facility, one disconnect means must be capable of electrically isolating all generators simultaneously. This disconnect is in addition to the requirements of the Manitoba Electrical Code which requires the provision of either a breaker or fuses preceded by a disconnect means adjacent to the point of interconnection

All Customer owned disconnect switches are to be identified on the DER Owner provided Single Line Diagram using Standard Device Number 89 for switches and 52 for AC Circuit Breakers, refer to Appendix D.

5.2 DER Equipment Requirements

Manitoba Hydro will approve the inverter equipment certification requirements to ensure the latest Advanced Grid Features to maximize system performance, reliability, Hosting Capacity and safety are incorporated into the design.

In addition to the required sections below, all equipment will need to be approved to the CSA/UL standards or equivalent by an organization accredited by the Standards Council of Canada as required by the Manitoba Electrical Code

5.2.1 Inverter IEEE Certification

Load Displacement categorized DER inverters must be certified to a minimum of IEEE 1547-2003.

Load Displacement & Export and Independent Power Producer DER categorized inverters, requires Manitoba Hydro to approve inverter IEEE 1547 certification year, depending on the complexity of the application, e.g. may require certification greater than IEEE 1547-2003.

5.2.2 Grid Following/Forming

DER Systems are to be configured as Grid Following to support protection sensitivity, such as islanding and single phasing .

Manitoba Hydro will consider Grid Forming inverter technology on a case-by-case basis by assessing the impact on utility worker and public safety, performance and reliability.

Grid Forming inverters configured as uninterruptible power supplies will need to have an internal or external mechanical transfer switch with interlocking synchronizing relays, approved for the application by the Manitoba Electrical Code.

5.2.3 Advanced Inverter Mode

Manitoba Hydro will identify the advanced inverter mode of operation which includes Volt-Watt, Frequency-Watt, Power Factor Control, Dynamic Volt/Var and Ride Through. For Load Displacement classification the default requirement is Power Factor Control. For Load Displacement & Export the default requirement is Dynamic Volt/Var. For Independent Power Producer the mode will be identified in the Manitoba Hydro Engineering Study.

5.2.4 Ramp Rate Control

The rate of change of total DER system output will need to be set at 10% per minute of the total DER system rated output.

5.2.5 Communication

DER equipment will need to be capable of interfacing to Manitoba Hydro Supervisory and Control system components. Protocols such as Modbus, Modbus based protocols, and DNP3 are presently acceptable communication protocols. Encryption and security measures may be required. Manitoba Hydro will confirm the communication requirements.

5.2.6 Inverter AC Abnormal Conditions Settings Access

Some Inverter Manufactures password protect AC Abnormal Conditions Settings and will need to be contacted for their approval to change these settings. The DER Owner must provide the actual AC Trip Settings to Manitoba Hydro to confirm compliance with the setting requirements in this document. Manitoba Hydro may require the DER Owner to change these settings.

5.2.7 Equipment Rating

All equipment will need to be sized to account for fault contributions from the generating facility and the interconnected distribution system, facility loading and operating voltage. Manitoba Hydro may provide the fault current contribution from the distribution system for primary metered services. It's recommended that the DER Owner size their equipment using infinite bus or the next commercially available transformer nameplate rating.

DER Systems shall be rated for the environment they are operating in.

5.3 Interconnection Transformer

Three phase transformer winding configurations change the path of ground fault currents, change expected fault current magnitudes, change the overvoltages experienced during faults, and change the effectiveness of protection. The DER Owner will be required to address these issues in the design of their DER Facility.

When transformers are provided by Manitoba Hydro, three phase transformer windings are specified as either a Delta primary Grounded-Wye secondary or a Grounded-Wye primary Grounded-Wye secondary, Single phase transformers are Grounded primary, Grounded secondary. If legacy transformer configurations exist, DER connections will be assessed on a case by case basis.

DER systems utilizing delta primary, grounded wye secondary may require a protection scheme to prevent damaging phase to ground voltages that can exist during unintentional islanding of the distribution system.

The DER Owner will be required to provide official documentation from their DER Manufacturer that all required DER protection elements will operate as intended to detect both distribution system and local DER Facility faults based on all transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection. When Manitoba Hydro provides Facility transformers, this assessment is to include the primary of the Manitoba Hydro owned facility transformer. If the DER Manufacturer document is unavailable, additional intertie relays will need to be installed, refer to transfer trip, reverse power and anti-islanding section requirements.

Independent Power Producer must acquire and install transformation that connects directly to the primary voltage of the distribution feeder.

Customer owned DER interconnection transformers are required to have off-load tap changers on their primary (high voltage) side with a minimum capability of +/- 2.5% of nominal voltage.

5.4 Grounding

The DER Facility must be effectively grounded, consistent with IEEE Std. 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems and as required by Manitoba Electrical Code requirements.

The DER Facility may be required to complete a grounding study to confirm safe touch, step and transferred potentials.

The DER Owner is to identify DER System grounding (resistive, solid or open) for transformers and generators on the Single Line Diagram.

5.5 Protection Requirements

The customer will be required to design, install, coordinate, and maintain a protection system for their entire DER Facility.

Interconnection Protection Requirements are intended to allow the DER System to operate in parallel with the utility system, adequately isolating or deenergizing the DER System when Abnormal Conditions are detected, within the allotted time, using failsafe best industry practices.

Interconnecting transformer construction and winding configuration have a major impact on protection strategy and protection elements used to meet the requirements of this interconnection document. The DER Owner will be required to identify the issues imposed by the interconnecting transformers and implement protection that includes additional protection schemes or use a separate intertie relay. Appendix D, provides a general list of transformer issues and protection elements.

The minimum protection scheme shall be designed to detect the following Utility System and DER Facility conditions at the PCC, refer to Appendix B:

- Balanced and unbalanced faults (i.e. any phase-to-ground, phase-to-phase, and three phase faults);
- Under/Over frequency;
- Under/Over voltage;
- Open phase;
- Islanding;
- Reverse power, (when applicable);
- Utility reclosing

Depending upon location and power conversion technology, the protection scheme may be required to detect additional conditions such as ferro-resonance, negative sequence voltage and current, and zero sequence currents.

The protection scheme will need to fully coordinate with all existing distribution system protective devices.

The DR owner will need to submit a complete protection design package including all relay settings, tripping schemes, high-level control logic block diagrams and control logic (both in printable and device settings files) to Manitoba Hydro for review and preliminary approval prior to final approval.

5.5.1 Interrupting Breaker

Abnormal Conditions will occur on the utility system that require the DER System to cease to energize or isolate from the utility system in addition to Section 5.1 “Means of Isolation” and Manitoba Electrical Code requirements.

Grid Following DER Systems less than 250 kW, classified as Load Displacement (non-export) or Load Displacement & Export do not require a customer owned shunt trip breaker actuated by the DER protection scheme if the DER System provides a suitable means of Cease to Energize active power delivery to the Utility when Abnormal Conditions are detected.

All other Grid Following DER Systems classified as Load Displacement (non-export), Load Displacement & Exportor Independent Power Producer (IPP) require a customer owned shunt trip breaker actuated by the DER protection scheme.

DER facilities that have been approved by Manitoba Hydro to operate in Grid Forming configuration will require a customer owned shunt trip breaker actuated by the DER protection scheme, capable of electrically isolating all generators simultaneously under Abnormal Conditions.

A redundant protection scheme to isolate or remove DER generation, when the DER breaker fails to open, is to be identified by the DER owner and approved by Manitoba Hydro.

All interrupting AC Circuit Breakers are to be identified on the DER Owner provided Single Line Diagram using Standard Device Number 52 or 52G, refer to Appendix D for device numbering.

5.5.2 Phase Overcurrent

The DER System Timed Phase and Instantaneous protection elements must be able to detect and disconnect (in keeping with Section 5.5.1) faults between phases, and between phase(s) and ground, both within the DER Facility and on the Manitoba Hydro distribution system.

All protection elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Numbers 50/51, 51V or 67, refer to Appendix D for device numbering.

5.5.3 Ground Overcurrent

The DER System Timed Phase and Instantaneous protection elements must be able to detect and disconnect (in keeping with Section 5.5.1) faults between phase(s) and ground, both within the DER Facility and on the Manitoba Hydro distribution system.

Three phase DER Systems must detect and interrupt ground faults when interconnected to the utility through a transformer or onto a bus where there is no path for zero sequence components.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Number 51N and 59N, refer to Appendix D for device numbering.

5.5.4 Under/Over Frequency

The DER facility must be equipped with under/over frequency protection that meets the requirements of Table 5.5.4

Manitoba Hydro may require the DER System to be set to Ride Through, refer to Section 5.2.3, to extend Under/Over Frequency response to improve system performance.

MINIMUM TIME	UNDER FREQUENCY LIMIT	OVER FREQUENCY LIMIT
(continuous operating range)	59.0 - 60.0 Hz	60.0 - 61.5 Hz
10 minutes	59.0 - 60.0 Hz	61.6-62.0 Hz
30 seconds	59.0 - 60.0 Hz	62.1 - 63.5 Hz
instantaneous trip	59.0 - 60.0 Hz	Greater than 63.5 Hz

Table 5.5.4 Under/Over Frequency Operating Limits

Manitoba Hydro will confirm requirements for Off Grid Systems.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Numbers 81U and 81O, refer to Appendix D for device numbering.

5.5.5 Under/Over Voltage

The generating facility protection must have the ability to detect voltage (measured phase to ground) that is outside the normal operating limits of 90% < V < 106% of nominal and trip the generator breaker within the trip times shown in Table 5.5.5.

PU VOLTAGE	TRIP TIME
V < 50%	Instantaneous
50% < V < 90%	120 cycles
90% < V < 106%	Normal Operation
106% < V < 120%	30 cycles
V > 120%	Instantaneous

Table 5.5.5 Per Unit Voltage Operating Limits

Manitoba Hydro may require the DER System to be set to Ride Through, refer to section 5.2.3, to extend Under/Over Voltage response to improve system performance.

Manitoba Hydro will confirm requirements for Off Grid Systems.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Numbers 27 and 59, refer to Appendix B & D.

5.5.6 Open Phase

The DER Facility protection elements must be able to detect and cease to energize or isolate (in keeping with Section 5.5.1) on the loss of any phase to which the DER System is connected both within the DER Facility and the Manitoba Hydro distribution system.

On three phase systems, voltage protection may not be an effective solution to detect phantom phase conditions due to magnetic couplings between transformer winding and core configurations. The DER Owner will need to confirm their open phase protection scheme will operate as required and prevent the DER system from reconnecting until the single phase condition is corrected.

In keeping with Section 5.3, the DER Owner will be required to provide official documentation from their DER Manufacturer that open phase protection elements will operate as intended to detect both distribution system and local DER Facility faults based on all three phase transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Numbers 27, 59, 46, 47, 60 or other, refer to Appendix D.

5.5.7 Anti-Islanding

Anti-islanding protection is intended to avoid out-of-phase reclosing between the Manitoba Hydro system and the DER Facility as well as high voltages on the distribution feeder when the feeder is isolated from the station, depending on the transformer winding configuration.

The DER facility protection elements must be able to detect and cease to energize or isolate (in keeping with Section 5.5.1) in less than 2.0 seconds on the loss of any or all phases from Manitoba Hydro to which the DER System is connected. Manitoba Hydro will confirm the isolation time for Independent Power Producers.

DER Systems that are in parallel with the distribution system for less than 100 ms, utilizing a CSA approved transfer switch do not require anti-islanding protection but must incorporate automatic synchronization elements.

Displacement only category DER Systems equal to or exceeding 250 kW or exceeding Hosting Capacity requirements will require a reverse power relay.

Manitoba Hydro will require a Transfer Trip system that includes a Supervisory Control and a distribution class Automatic Circuit Recloser or may provide the DER Facility with a transfer trip signal for DER Systems equal or exceeding 500 kW, or exceeding Hosting Capacity requirements. The DER Owner will need to address maintaining power to critical DER Facility equipment when a transfer trip is implemented.

Grid Forming DER Systems are not permitted to remain connected to a de-energized distribution system. Customer owned anti-islanding protection at the point of interconnection between the DER facility and the Manitoba Hydro distribution system is required, regardless of whether intentional islanding is allowed. Manitoba Hydro may install a transfer trip system that includes supervisory control and a distribution class recloser.

DER Owner should consider mitigation to prevent load rejection overvoltage on operation of the transfer trip as the transfer trip is intended to protect Manitoba Hydro's system and connected customers but is not intended to protect the DER Facility.

DER Owner to assess and mitigate the possibility of self-excitation if using induction generators.

In keeping with Section 5.3, the DER Owner will need to provide official documentation from their DER Manufacturer that anti-islanding protection elements will operate as intended to detect distribution system outages based on all transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection.

It's recommended that the three phase DER Owner undertake a ferroresonance study to determine and mitigate the DER facility's susceptibility to this phenomena. Ferroresonance concerns differ from traditional single phasing initiating factors, refer to Appendix A, reference 34.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Numbers 27, 32, 59, 46, 60, 78, 81O/U/R or other, refer to Appendix D.

5.5.8 Reverse Power

Displacement only category DER Systems equal or exceeding 250 kW, or exceeding Hosting Capacity requirements will require a reverse power relay to cease to regulate DER System generation to prevent reverse power flow to the utility.

Provided the reverse element is dedicated to regulating DER System generation, it is required to reduce DER System output to below export limits within 5 minutes.

This device cannot interfere with the other stated protective uses and operating requirements of reverse power element 32.

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Number 32, refer to Appendix D.

5.5.9 Feeder Reclose, Interruption & Reconnecting

Identified in Section 4.1, Manitoba Hydro employs automatic feeder reclosing practices which requires the DER System to cease to energize or isolate as per 5.5.1 upon the loss of any or all phases from Manitoba Hydro, in less than 2.0 second and remain off for 5 minutes.

The DER system must cease to energize or remain isolated from the utility system for a minimum of 5 minutes after power has been completely restored by the utility at the point of interconnection.

The DER System shall not be capable of energizing the distribution system when the distribution system is de-energized.

Independent Power Producer DER System protection relays shall have an uninterruptible power supply that will remain operational following distribution system disturbances or loss of supply for a period of 10 minutes.

5.5.10 Synchronization

All Grid Forming DER Systems require synchronization relays before connection is permitted. The DER system shall maintain synchronization with the Manitoba Hydro distribution system while operating in parallel.

Connection shall be prevented when the generating facility and/or the Manitoba Hydro distribution system is operating outside of the following limits:

TOTAL GENERATION	FREQUENCY DIFFERENCE	VOLTAGE DIFFERENCE	PHASE ANGLE DIFFERENCE
0 - 500 KVA	0.3 Hz	10%	20°
500 - 1500 KVA	0.2 Hz	5%	15°
1500 KVA	0.1 Hz	3%	10°

Table 5.5.10

Depending on the protection scheme, all elements are to be identified on the DER Owner provided Single Line Diagram using Standard Device Number 25, refer to Appendix D.

5.5.11 Intertie Protection Relays

When DER System protection elements are deemed insufficient to detect utility system faults or Abnormal Conditions, additional intertie protection elements are to be installed at the point of interconnection.

Intertie relay protection elements will be required to trip the interrupting breaker.

5.6 Battery Energy Storage System

Battery Energy Storage System (BESS) is to be approved for the application as required by the Manitoba Electrical Code and Provincial and Municipal Life Safety System regulations.

Manitoba Hydro will approve the BESS operating mode strategy as identified by the DER Owner, e.g. extended generating capacity, frequency regulation, emergency back-up, voltage regulation, peak shaving, generation support on loss of DER asset, etc.

The DER Owner is to provide capacity, loading and charging characteristics of the BESS based on charging strategy. DER Owner to control current inrush to within Dynamic Voltage Limits identified in the Power Quality Interconnection Requirements document, specifically Section 4.2 and Ramp Rate Control requirements in Section 5.2.4

5.7 Supervisory Dispatch and Control

The DER Facility may be required to receive remote dispatch and control inputs from Manitoba Hydro's remote Utility Supervisory Controller to maintain Utility System safety, reliability and performance requirements. l

The remote Utility Supervisory Controller can include direct operational control (e.g. transfer trip) and/or be used to limit allowable DER System output generation, to below rated DER System generation output.

The DER Owner will need to design failsafe systems to respond to Supervisory Control commands from Manitoba Hydro.

Schematics and high-level logic block diagrams identifying all DER System control logic interlocks, required by this document, are to be provided by the DER Owner. The DER Owner provided Single Line Diagram is to include all communications and controllers providing protection and permissive control.

The DER System requires a communication Watchdog Timer or similar operation that continuously monitors the state of its communication connections and provides a handshake acknowledgement back to the Utility Supervisory Controller. If a loss of communication or Stale Data is detected between the DER System and all Utility and DER Facility supervisory controllers, the DER System is to cease to energize, ramping down power output within 5 minutes until communications are restored. The Watchdog Timer strategy is to be approved by Manitoba Hydro.

The DER System Supervisory Controller must be able to provide secure and encrypted communications between the DER Facility and the Utility Supervisory Controller, as identify by Manitoba Hydro.

Manitoba Hydro will identify required communication protocols, point lists and preferred supervisory controller equipment.

Sufficient communications bandwidth and reliability must be available to securely operate large DER Systems. Manitoba Hydro will assess the capability of available utility infrastructure.

The DER System Supervisory Controller shall remain operational following distribution system disturbances or on loss of supply power for a period of 10 minutes.

5.8 Monitoring and Information

The DER Owner may be required to provide Manitoba Hydro with real time information regarding Interrupting Breaker status, DER System Status and DER System performance.

The communication protocol and the equipment required will be specified by Manitoba Hydro.

Displacement and Displacement & Export category DER Systems, less than equal to 250 kW, shall be capable of remote communications for future use, refer to Section 5.2.5.

Displacement & Export category DER Systems, exceeding 250 kW may require the installation of an advanced

bidirectional revenue meter equipped with communications at the Point of Interconnection, Manitoba Hydro will advise. In addition, the DER Owner may be required to provide DER System status and performance indices to Manitoba Hydro's Supervisory Controller.

Independent Power Producers require an advanced bidirectional revenue meter equipped with communications and are to provide DER System status and performance indices to Manitoba Hydro's Supervisory Controller.

The minimum DER System status and performance indices required are;

- Total DER Facility hourly integrated kWh (watt hour), and kVArh (volt ampere reactive hour);
- Total DER Facility instantaneous, directional kW and kVAr, kVA (volt ampere), kV (Voltage line to neutral), Power Factor, A (ampere);
- Individual DER System(s) instantaneous, directional kW and kVAr, kVA, kV, Power Factor, A when applicable;
- DER System(s) interrupting breaker (section 5.5.1) status;
- Individual DER System(s) on/off status,if no interrupting breaker exists;
- Real time indices shall be polled in 10 second intervals.

5.9 Performance and Reliability Requirements

The PQIR in Section 4.2 specifies power quality system characteristics and required facility electrical performance requirements for interconnecting to the Manitoba Hydro electrical system. The DER Owner must ensure that their DER Facility does not introduce flicker, dynamic voltage fluctuations, voltage unbalance, voltage variation and harmonic emissions that exceed the requirements in the PQIR.

5.9.1 Current and Voltage Harmonic Distortion

Equipment that is IEEE 1547 certified, is Type tested to conform to the 5% harmonic distortion current limits, and is approved for interconnection to the distribution system. However, harmonic mitigation will be required if field Power Quality Benchmarking identifies the equipment to be exceeding limits.

Equipment that is not certified to IEEE 1547 will need to provide a letter from the DER equipment Manufacturer stating the total and individual harmonic current emissions meet the emission limits in Table 5.9.1

CURRENT DISTORTION LIMITS TAKEN FROM PQIR					
<11	11sh<17	17<h<23	23sh<35	35sh	TOD
4.0	2.0	1.5	0.6	0.3	5.0

Table 5.9.1 Current Distortion Limits

5.9.2 Voltage Unbalance

The DER phase-to-phase voltage unbalance must not exceed 1.0%, when measured at no-load.

Section 64 of the Manitoba Electrical Code does not allow single-phase inverters for renewable energy systems and ac modules in interactive renewable energy systems to be connected to three-phase systems.

5.9.3 Voltage Variation

The DR must maintain steady state voltage within operating ranges as measured at the revenue metering location or Point of Interconnection within the limits of Appendix E or Section 4.1. which is +/- 6% of nominal voltage.

The DER System must reduce power output when extreme operating range voltages are detected.

5.9.4 Flicker and Dynamic Voltage Fluctuations

The DER System cannot introduce flicker or dynamic voltage variations due to inadvertent tripping, cloud cover or wind that results excessive utility voltage regulator operation or exceeds the Flicker and Dynamic Voltage Fluctuations identified in Section 4.2.

5.9.5 Power Factor

The DER System must maintain a power factor of +/-0.90 or better, as measured at the revenue meter. E.g. Induction generators consume reactive power (VArs) and must provide separate reactive compensation while operating.

Grid forming DER Systems must provide all reactive power support requirements.

5.10 Facility Access

In keeping with the IOA, the DER Facility is to implement physical and cyber security access protocols and identify these protocols to Manitoba Hydro.

5.10.1 Physical Access

The DER Owner is to maintain authorized site access with locked equipment access, leveraging physical security systems where available.

5.10.2 Cyber Security Access

The DER Owner is to maintain controlled and authorized access protocols for local and remote electronic access, e.g. password control, communication access, revision control, remote work procedures, etc.

6.0 Commissioning

6 Commissioning

The goal of commissioning is to demonstrate that the DER System is designed to not only meet the requirements of this interconnection requirements document but also the DER Owner's requirements.

The DER Owner will provide written commissioning test procedures to Manitoba Hydro for approval before the tests are caried out. Manitoba Hydro may require additional commissioning tests depending on the complexity of system. Manitoba Hydro's review and recommendations will not absolve the DER Owner from correcting future faulty operation or failures.

Commissioning test sheets are to be developed by the DER Owner in consultation with their DER System Designer, Equipment Manufacturer and Manitoba Hydro. The DER Owner, Designer and Commissioning Lead are to sign the successful commissioning test sheets, noting any failures and their plans to correct the failure and submit these to Manitoba Hydro before approval to operate will be provided.

6.0 Commissioning

Manitoba Hydro will reserve the right to witness the commissioning tests, and Manitoba Hydro will need to be notified by the DER Owner at least ten (10) business days in advance of commissioning tests and be provided with a schedule of testing.

At a minimum, the commissioning test sheets are to address the testing of all items in Section 5.0 of this document, identified in Section 6.1.

6.1 Minimum Equipment Commissioning

This section identifies the minimum commissioning requirements from Section 5.0, in keeping with IEEE 1547.1 for all DER Systems installed at the DER Facility.

6.1.1 Means of Isolation

All DER Customer owned Disconnect Means switches shall be verified as operational.

6.1.2 DER Equipment Requirements

The following requirements are to be confirmed by the DER Owner:

6.1.2.1 Inverter IEEE Certification

Confirm IEEE 1547 certification year is as approved by Manitoba Hydro.

6.1.2.2 Grid Following/Forming

Confirm Grid Following/Forming is as approved by Manitoba Hydro.

6.1.2.3 Advanced Inverter Mode

Confirm Grid advanced inverter mode of operation is as approved by Manitoba Hydro.

Confirm Ride Through mode of operation if approved by Manitoba Hydro.

6.1.2.4 Ramp Rate Control

Confirm the rate of change of total DER system output.

6.1.2.5 Communication

Confirm communication protocol capability.

6.1.2.6 Equipment Rating

Confirm equipment sized to available fault current.

6.1.3 Interconnection Transformer

Confirm official documentation from DER Manufacturer that all required DER protection elements will operate as intended to detect both distribution system and local DER Facility faults based on all transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection.

Confirm customer owned DER interconnection transformers have off-load tap changers on their primary (high voltage) side with a minimum capability of +/- 2.5% of nominal voltage.

6.1.4 Grounding

Confirm facility is effectively grounded.

Confirm recommendations for safe touch, step and transferred potentials have been completed, if applicable.

6.1.5 Interrupting Breaker

Confirm the design requirement for a customer owned interrupting breaker or if utilizing cease to energize.

Confirm operation of interrupting breaker or cease to energize.
Confirm breaker failure protection.

6.1.6 Phase Overcurrent

Confirm all enabled Timed Phase and Instantaneous protection elements utilized to detect faults between phases, and between phase(s) and ground, both within the DER Facility and on the Manitoba Hydro distribution system operate within the set magnitude and time. Confirm with the manufacturer as to the process to confirm operation in keeping with IEEE 1547.1.

6.1.7 Ground Overcurrent

Confirm all enabled Timed Phase and Instantaneous protection elements utilized to detect faults between phases, and between phase(s) and ground, both within the DER Facility and on the Manitoba Hydro distribution system operate within the set magnitude and time. Confirm with the manufacturer as to the process to confirm operation in keeping with IEEE 1547.1.

Confirm detection and interruption of ground faults when interconnected to the utility through a transformer or onto a bus where there is no path for zero sequence components.

6.1.8 Under/Over Frequency

Confirm under/over frequency protection that meets the requirements of Table 5.5.4 or as provided for Off Grid Systems.

Confirm DER System Ride Through, if applicable.

6.1.9 Under/Over Voltage

Confirm under/over voltage protection that meets the requirements of Table 5.5.4 or as provided for Off Grid Systems.

Confirm DER System Ride Through, if applicable.

6.1.10 Open Phase

Confirm the DER Facility can detect an open phase at the POI and if applicable at the primary of a local transformer supplying the POI.

Confirm capability of detecting phantom phase conditions due to magnetic couplings between transformer winding and core configurations, if applicable.

Confirm official documentation from their DER Manufacturer that open phase protection elements will operate as intended to detect both distribution system and local DER Facility faults based on all three phase transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection.

Confirm ferroresonance study protection requirements and protection element requirements.

6.1.11 Anti-Islanding

Confirm operation of and clearing time of anti-islanding protection at the Point of Interconnection.

Confirm operation of a Transfer Trip signal that may be provided to the DER Facility with DER Systems equal or exceeding 500 kW, or exceeding Hosting Capacity requirements.

Confirm DER System load rejection performance

Confirm self-excitation mitigation if using induction generators.

Confirm official documentation from their DER Manufacturer that anti-islanding protection elements will operate as intended to detect distribution system outages based on all transformation combinations from the primary of the Point of Common Coupling transformer to the DER System protection.

6.1.12 Reverse Power

Confirm operation and timing of a reverse power relay for Displacement only category DER Systems equal or exceeding 250 kW or exceeding Hosting Capacity requirements.

6.1.13 Feeder Reclose, Interruption & Reconnecting

Confirm DER System to cease to energize or isolate as per 5.5.1 upon the loss of any or all phases from Manitoba Hydro, in less than 2.0 seconds and remain off for 5 minutes.

Confirm Independent Power Producer DER System protection functions shall remain operational following distribution system disturbances or loss of supply for a period of 10 minutes.

Confirm the DR System shall not be capable of energizing the distribution system when the distribution system is de-energized.

6.1.14 Synchronization

Confirm operation of synchronizing equipment.

6.1.15 Intertie Protection Relays

Confirm operation and timing of additional intertie protection elements are to be installed at the point of interconnection, if applicable.

6.1.16 Supervisory Dispatch and Control

Confirm operation of the Supervisory Dispatch and Control to carry out all identified functions. Testing is to include but not limited to:

- Loss of Supervisory Communications with DER facility (momentary and complete)
- Loss of Supervisory Uplink Communications (To Station for Transfer trip)
- Trip Control Test Confirm operation of the Watchdog Timer.
- Confirm communications of all functions with Manitoba Hydro's Supervisory Controller.

6.1.17 Monitoring and Information

Confirm communications of all functions with Manitoba Hydro's Supervisory Controller

Alarm indication to supervisory that one or more monitoring points is not functional or reporting.

6.0 Commissioning

6.1.18 Performance and Reliability Requirements

Manitoba Hydro may benchmark the facility, initially for a one-week duration and then long term, to evaluate performance:

6.1.18.1 Current and Voltage Harmonic Distortion;
6.1.18.2 Voltage Unbalance;
6.1.18.3 Voltage Variation
6.1.18.4 Flicker and Dynamic Voltage Fluctuations
6.1.18.5 Power Factor

6.1.19 Access

Confirm physical facility and cyber security access protocols are implemented.

6.1.20 As-Built Drawings & Corrective Action

Confirm DER System wiring is in compliance with the drawings.

Confirm documented corrective actions have been completed.

7.0 Maintenance

7 Maintenance

The DER Owner shall maintain the facilities in accordance with best industry practice, requirements of the IOA and Rule 2- 300 of the Manitoba Electrical Code, specifically:

1. All operating electrical equipment shall be kept in safe and proper working condition.
2. Electrical equipment maintained for emergency service shall be periodically inspected and tested as necessary to ensure its fitness for service.
3. Infrequently used electrical equipment maintained for future service shall be thoroughly inspected before use in order to determine its fitness for service.
4. Defective equipment shall either be put in good order or permanently disconnected.

Manitoba Hydro will reserve the right to periodically inspect the interconnection protection system and maintenance records to verify maintenance is being performed.

All replacement or addition of equipment, changes in protection and operation will need to be approved by Manitoba Hydro.

Appendix A: **References**

Appendix A: References
This appendix lists the standards, papers and Utility interconnection requirements used to support this document.

1. Arizona Public Service Company, July 2020, "Interconnection Requirements for Distributed Generation".

2. Awadallah, M. & Venkatesh, B. & Singh, Birendra. (2015), "Impact of Solar Panels on Power Quality of Distribution Networks and Transformers" Canadian Journal of Electrical and Computer Engineering. 38. 45-51. 10.1109/CJECE.2014.2359111.

3. BC Hydro, May 2010, "35 kV and Below Interconnection Requirements for Power Generators".

4. Basso, T. S., & DeBlasio, R. (2004). IEEE 1547 series of standards: interconnection issues. IEEE Transactions on Power Electronics, 19(5), 1159-1162.

5. CSA C22.1:18 "Canadian Electrical Code, Part 1 Safety Standard for Electrical Installations"

6. CSA C22.2 No. 107.1:16, "Power Conversion Equipment".

7. CSA C22.2 No. 257:06, "Interconnecting Inverter-Based Micro-Distributed Resources to Distribution Systems".

8. CSA C22.3 No. 9-08, "Interconnection of distributed resources and electricity supply systems"

9. CSA C235:19, "Preferred Voltage Levels for AC Systems 0 to 50,000V".

10. ENMAX, February 2019, "Distributed Energy Resource Technical Interconnection Requirements".

11. EPRI, December 2015, "Engineering Guide for Integration of Distributed Storage and Generation", Technical Report 3002005774.

12. Hydro One, March 2013, "DISTRIBUTED GENERATION TECHNICAL INTERCONNECTION REQUIREMENTS INTERCONNECTIONS AT VOLTAGES 50KV AND BELOW".

13. IEEE Std. C37.1:2007, "Standard for SCADA and Automation Systems".

14. IEEE 37.2:2008, "IEEE Standard Electrical Power System Device Function Numbers".

15. IEEE C37.95, "IEEE Guide for Protective Relaying of Utility Consumer Interconnections".

16. IEEE C57.13:1993, "IEEE Standard Requirements for Instrument Transformers".

17. IEEE C57.110:1998, "IEEE Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents".

18. IEEE Std. 100-1997 IEEE Standard Dictionary of Electrical and Electronics Terms IEEE Std 315-1975

19. IEEE Std. 115- 2019, "IEEE Guide for Test Procedures for Synchronous Machines Including Acceptance and Performance Testing and Parameter Determination for Dynamic Analysis".

20. IEEE Std. 929-1988, "IEEE Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic (PV) Systems".

21. IEEE Std. 1547-2003, "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems".

Appendix A: **References**

22. IEEE Std. 1547.1-2020 – "IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces".

23. IEEE Std. 1547.2-2008, "IEEE Application Guide for IEEE Std 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems".

24. IEEE Std. 1547.3-2007, "IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems".

25. IEEE Std. 1815-2012, "IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)".

26. IEEE Std. 2030.1.1-2022, "IEEE Standard for Technical Specifications of a DC Quick and Bidirectional Charger for Use with Electric Vehicles".

27. IEEE Std. 2030.2.1-2019, "IEEE Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems".

28. Manitoba Hydro, August 2021, "Manitoba Electrical Code – 14th Edition".

29. Mozina, C. J. (2013). Impact of smart grids and green power generation on distribution systems. IEEE Transactions on Industry Applications, 49(3), 1079-1090.

30. Nova Scotia Power, August 2020, "Interconnection Requirements, Generating Facilities Not Exceeding 100 kW".

31. Nova Scotia Power, August 2020, "Interconnection Requirements, Generating Facilities > 100 kW".

32. SaskPower, March 2005, "Generation Interconnection Requirements at Voltages 34.5 kV and Below".

33. Southern Company, July 2020, "Operation of Distributed Energy Resources (DER) in Parallel with the Distribution System Policy".

34. W. B. Gish, W. E. Feero and S. Greuel, "Ferroresonance and Loading Relationships for DSG Installations," in *IEEE Transactions on Power Delivery*, vol. 2, no. 3, pp. 953-959, July 1987, doi: 10.1109/TPWRD.1987.4308201.

Appendix B: **DER Owner Design and Setting Confirmation**

Appendix B: DER Owner Design and Setting Confirmation
This appendix provides a design and setting confirmation checklist that must be returned to Manitoba Hydro by the DER Owner for Manitoba Hydro to evaluate the proposed DER System.

•	Required
◑	Application Dependent
○	Not Required

(See Appendix B table on page 26. Refrence legend above)

ITEM	DEVICE	DESCRIPTION	SECTION	DISPLACEMENT (≤5 KW)	DISPLACEMENT	DISPLACEMENT & EXPORT	IPP	DER OWNER DESIGN AND SETTING CONFIRMATIOR
1		Interconnection Request Submitted Online	2.0	•	•	•	•	
2		New system or changes to existing DER	2.0	•	•	•	•	
3		DER Classltication	3.0	Displacement (≤ 5 kW)	Displacement	Displacement & Export	IPP	
4		Formal Interconnection Report	5.0	o	o	◐	•	
5	89/52	Means of Isolation	5.1	•	•	•	•	Manitoba Hvoro Fauin-ment. see Flectrical Code Reguirements
6		Inverter Certification minimum IEEE1547-2003	5.2.1	≥ IEEE1547-2003	≥ IEEE1547-2003	> IEEE1547-2013	> IEEE1547-2013	
7		Grid Following/Grid Forming	5.2.2	•	•	•	•	Grid Following
8		Advanced Inverter Mode	5.2.3	•	•	•	•	
9		Ramp Rate Control	5.2.4	•	•	•	•	
10		Communication Capabilitv	5.2.5	•	•	•	•	
11		Inverter AC Abnormal Conditions Settings Access	5.2.6	o	◐	◐	•	
12		Equipment Rating Fault Current	5.2.7	•	•	•	•	
13		Equipment Rating Temperature	5.2.7	•	•	•	•	
14		Interconnection Transformers intertering with DER protection	5.3	o	◐	◐	•	
15		Transformer oft-load tap changer	5.3	o	o	◐	•	
16		Effective Grounding	5.4	•	•	•	•	
17		Touch, Step & Transferred Potentials Study	5.4	o	o	◐	•	
18		Protection scheme and Loglc Identitied	5.5	o	◐	•	•	
19		Interrupting Breaker vs cease to Energize	5.51	o	◐	◐	•	
20		Breaker fail	5.51	o	o	◐	•	
21	50/51, 51V, 67	Phase Overcurrent	5.5.2	o	•	•	•	

ITEM	DEVICE	DESCRIPTION	SECTION	DISPLACEMENT (≤5 KW)	DISPLACEMENT	DISPLACEMENT & EXPORT	IPP	DER OWNER DESIGN AND SETTING CONFIRMATIOR
22	51N/59N	Ground Overcurrent	5.5.3	○	●	●	●	
23	81U/0	Under Over Frequency	5.5.4	●	●	●	●	
24	59	Over voltage	5.5.5	●	●	●	●	
25	27	Under Voltage	5.5.5	●	●	●	●	
26	27/59/46/47/60	Open Phase	5.5.6	●	●	●	●	
27		Manufacturer l etter	5.5.6	○	◑	◑	●	
28		Ferroresonance study	5.5.7	○	○	◑	●	
29	27/32/59/46/60/78/81	Anti-Islanding	5.5.7	●	●	●	●	
30		Grid Forming	5.5.7	○	○	○	◑	
31	TT	Transfer Trip	5.5.7	○	○	◑	●	
32	32	Reverse Power	5.5.8	○	◑	○	○	
33		Feeder Reclose	5.5.9	●	●	●	●	
34		Cannot operate when utility is deenergized	5.5.9	●	●	●	●	
35	25	Synchronization	5.5.10	○	◑	◑	◑	
36		Intertie Protection Relay Required	5.5.11	○	◑	◑	◑	
37		Battery Storage to be installed	5.6	○	●	●	●	
38		Supervisory Dispatch and Control	5.7	○	○	◑	●	
39		Provision for Watchdog Timer	5.7	○	○	◑	●	
40		Monitoring and Information	5.8	○	○	◑	●	
41		Performance & Reliability Requirements	5.9	●	●	●	●	
42		Facility Access	5.10	○	○	○	●	
43		Commission Procedures	6.0	●	●	●	●	

Appendix C: Typical DER Protection Schemes

This appendix provides a guide to protection interconnection requirements using various single line diagrams. Acceptable protection schemes are not limited to the examples listed. A protection scheme which meets all the requirements set out in the interconnection requirements may be approved for interconnection.

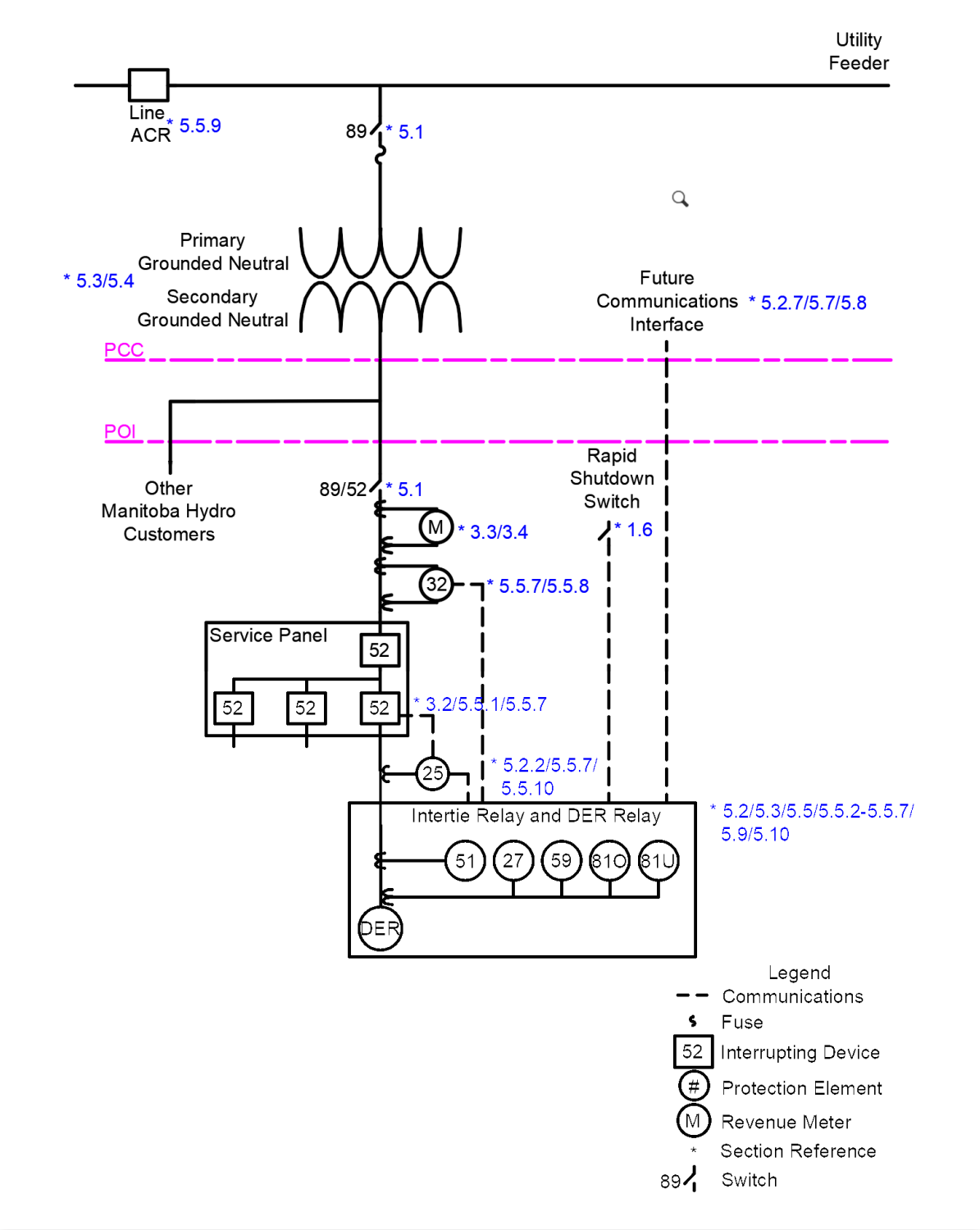

Figure C1 Single Phase Synchronous & Non-Synchronous DER Systems

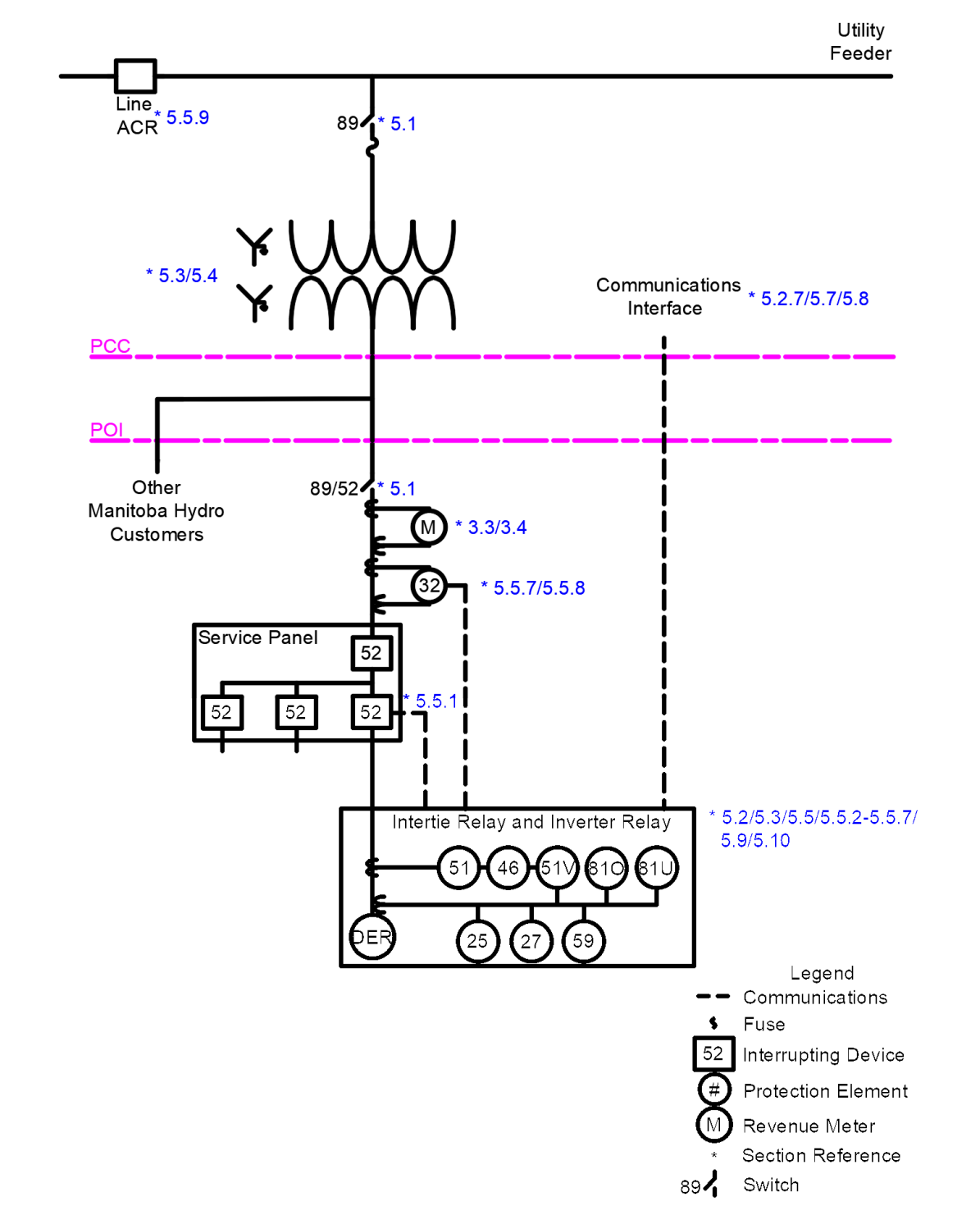

Figure C2 Three Phase Wye Wye Synchronous & Non-Synchronous DER Systems

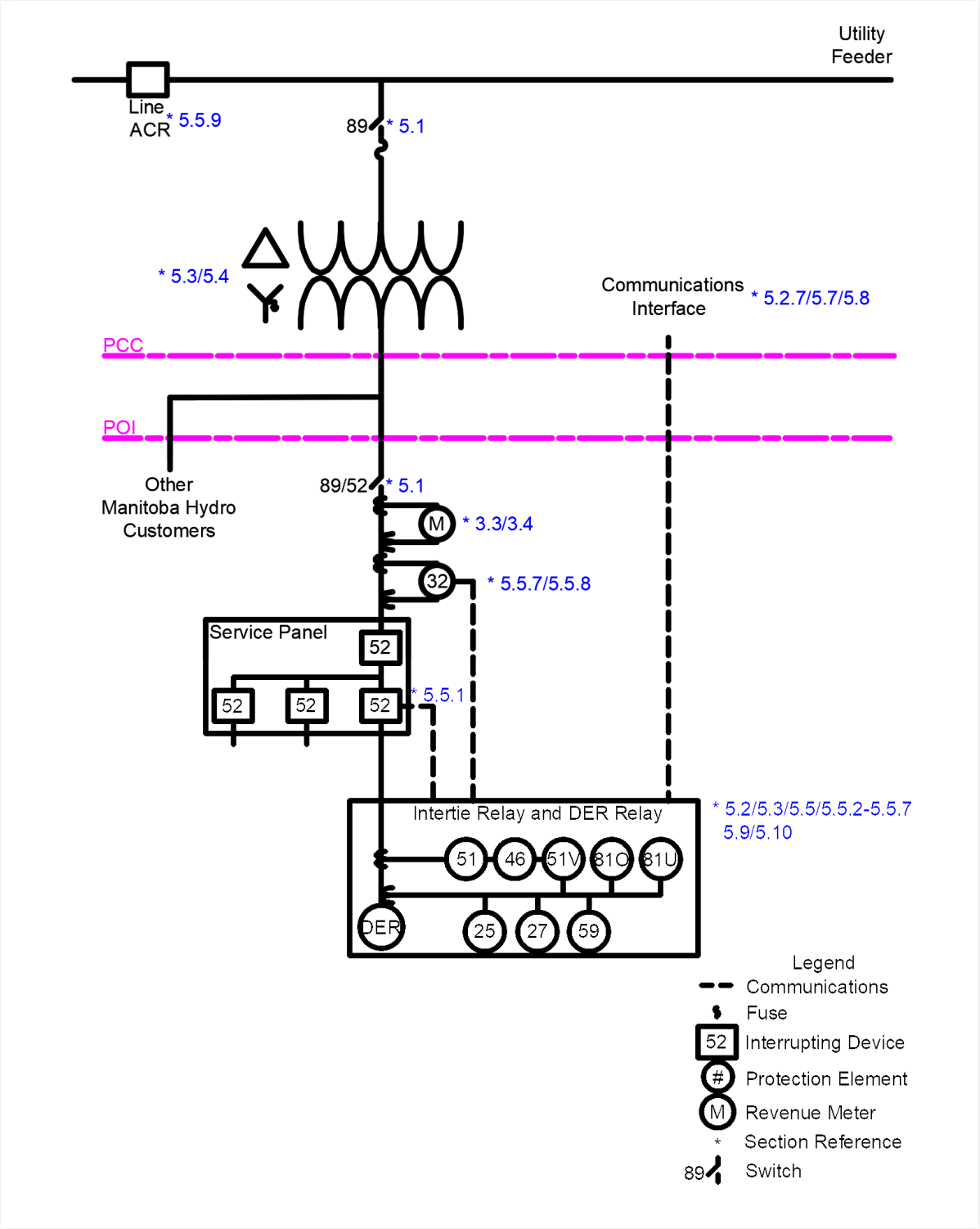

Figure C3 Three Phase Delta Wye Synchronous & Non-Synchronous DER Systems

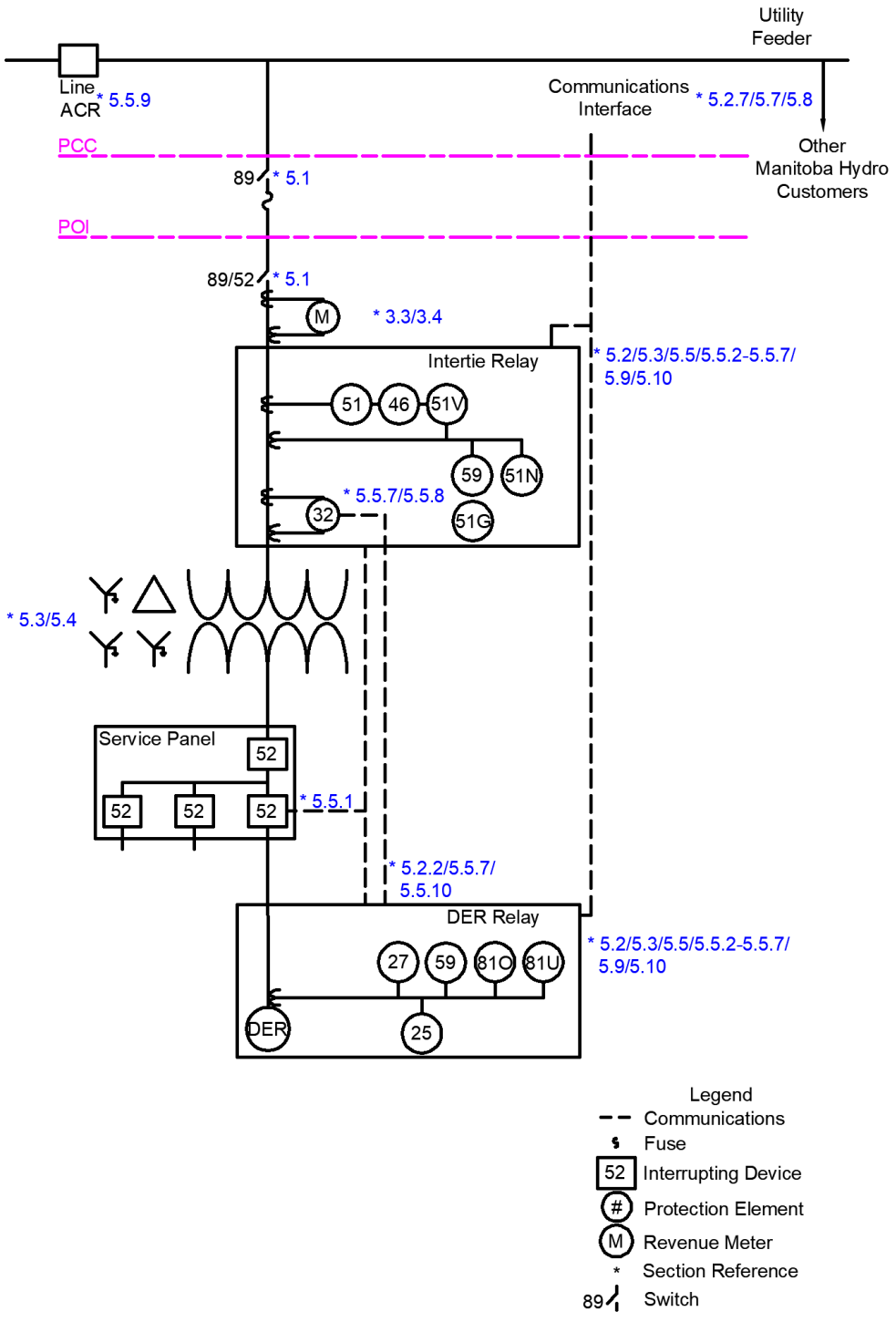

Figure C4 Three Phase Independent Power Producer Synchronous & Non-Synchronous DER Systems

Appendix D Interconnection Transformer Winding Concerns, and Typical Protection Elements
This appendix identifies protection and performance concerns due to interconnection transformer winding concerns and identifies typical protection element mitigation. A list and description of protective elements by standard device numbers and letters is also provided.

D.1 Interconnection Transformer Winding Concerns
Table D.1 identifies Interconnection Transformer Winding Concerns.

TRANSFORMER WINDING CONFIGURATION		PROBLEM	ADVANTAGE	ANTI-ISLANDING PROTECTION
Primary	Secondary			
		• Will contribute to primary Feeder faults from ungrounded generators if Feeder ACR/Fuses open and DER does not trip, resulting in Feeder overvoltage.	• Does not contribute to ground faults on the primary Feeder. • Feeder does not contribute to ground faults on secondary or within the facility.	• Zero Sequence protection to be located on the primary. Reverse Power can be on either side of the transformer.
		• Station & Feeder protection can respond to secondary facility ground faults	• No overvoltage on the utility feeder, if Feeder ACR opens, assuming a grounded generator.	• Protection can be installed on either side of the transformer
		• Will contribute to ground current for faults on the primary. • Circulating currents in delta winding, due to system unbalance.	• Feeder does not contribute to ground faults on secondary or within the facility. • No overvoltage on Feeder for faults on Feeder.	• Zero Sequence protection to be located on the primary. Reverse Power can be o either side of the transformer.

Table D.1 Interconnection Transformer Winding Concerns

D.2 Protection Elements

This appendix identifies typical relay protection elements and a description of their function.

RELAY	FUNCTION
TT	Transfer trip; this is a signal established between a utility protective device and the DR facility protection. The purpose is to ensure that the DR facility is isolated whenever the utility protective device operates. The signal can be over cable or radio frequency.
25	Synchronism Check; monitors the correct closing of the generator breaker
27	Under voltage trip; detects under voltage and should be set to approximately 90% of normal voltage. The time setting, like the 59T, should be set longer than the normal clearing time of the feeder protection but less than the substation breaker reclosing time. 30 to 60 cycles is a reasonable setting.
32	Power direction: used to detect reverse power
40	Loss of excitation
46	Negative Sequence Current; an alternative to the 51N, used to detect transformer overloads due to unbalanced feeder loads
47	Negative sequence voltage; used for permissive operation to avoid closing the generator into a single phased bus.
51	Overcurrent; set to coordinate with the DER generator protection and any protection on the local load.
51N	Neutral Overcurrent; measures zero sequence current flowing through the transformer. If the generator neutral is solidly grounded or grounded through an impedance, the 51N detects feeder ground faults or feeder load imbalance that could possibly overload the transformer. Alternative schemes would be to apply a low set negative sequence overcurrent relay (46)
51V	Voltage Controlled Overcurrent; used for fast tripping for feeder faults. 27 will also operate, but must be delayed by 30 to 60 cycles.
52 / 52G	AC Circuit Breakers / dedicated generator AC Circuit Breaker
59	Overvoltage trip
59I	High Speed Overvoltage; used to detect ferroresonance or high overvoltages that may occur during islanding conditions.
59T	Time Overvoltage; used to detect backfeed on the feeder from the DER during an islanding condition. The voltage elements are set to 110% of normal voltage. The time setting should be set less than the normal substation breaker reclosing time, but, preferably longer than the normal clearing time of the feeder protection, to avoid nuisance operations for faults on adjacent feeders. 30 to 60 cycles is a reasonable setting.
67	Directional overcurrent; The 67 relay is used to detect reverse power flow and is more reliable than a 32 relay during system faults. However, may result in nuisance tripping due to leading current created by local capacitors.
81U/O	Over and Under Frequency; faster than the 27 and 59T.
81R	Provides rapid tripping when ratio of DG generation to feeder load is high.
89	Line Switch

Appendix E: **Voltage Performance Less than 750 VAC**

Appendix E: Voltage Performance Less than 750 VAC.
This appendix identifies the voltage performance for DER Facilities connected to the Manitoba Hydro System at voltage less than 750 VAC.

NOMINAL VOLTAGE	MIN	EXTREME OPERATING RANGE		MAX
		NORMAL OPERATING RANGE		
		MIN	MAX	
SINGLE-PHASE SYSTEMS				
1 Phase, 3 Wire 120/240 V	106/212 V	110/220 V	125/250 V	127/254 V
1 Phase, 2 Wire 240 V	212 V	220 V	250 V	254 V
1 Phase, 2 Wire 480 V	424 V	440 V	500 V	508 V
1 Phase, 2 Wire 600 V	530 V	550 V	625 V	635 V
THREE-PHASE SYSTEMS				
3 Phase, 4 Wire 120/208 V	110/190 V	112/194 V	125/216 V	127/220 V
3 Phase, 4 Wire 240/416 V	220/380 V	224/388 V	250/432 V	254/440 V
3 Phase, 4 Wire 277/480 V	245/424 V	254/440 V	288/500 V	293/508 V
3 Phase, 4 Wire 347/600 V	306/530 V	318/550 V	360/625 V	367/635 V
3 Phase, 3 Wire 240 V, 480 V, 600 V	Refer to respective single-phase operating ranges			

Table: Appendix E - Steady-state voltage range limits for systems ≤ 1000 V at point of connection