BC Hydro
Power smart

Closed Transition Transfer of Power Generators Technical Interconnection Requirements (CTTIR)

March 20, 2024

Table of Contents

1 Introduction

1.1 Scope

This document, including any updates in the form of bulletins and amendments published by BC Hydro on its website, Closed Transition Transfer of Power Generators Technical Interconnection Requirement (CTTIR), provides minimum technical requirements for the connection of Power Generators (PG) to the Distribution System (DS) to transfer load between the Distribution System and the PG in Closed Transition Transfer (CTT) fashion. The CTT is also called make-before-break, bumpless, or seamless load transfer.

These requirements are to ensure that the Power Generator:

(a) is compatible with the BC Hydro DS (utility), and that the interconnection is safe for BC Hydro employees and its agents, for BC Hydro customers and the public, at all times,

(b) meets BC Hydro protection, control, commissioning, operating, and maintenance requirements.

The CTT systems are, in this document, grouped as follows:

Momentary CTT (Section 3) - is the seamless transition of load between the PG(s) and utility (Distribution System) sources by paralleling the sources momentarily (less than 100ms) through CTT-capable Automatic Transfer Switches (ATS). For the application of Momentary CTT, if the CTT-capable ATS is factory built and tested and certified to applicable CSA standard(s) it will be considered as Certified Momentary CTT.

Extended CTT (Section 4) - is the seamless transition of load that takes a transition time between 100ms and 20s through CTT capable ATS(s) or schemes that parallel the PG(s) with the utility (Distribution System) for up to 20s.

Appendix A provides a more detailed definition of the terms and terminology used in this document. The technical requirements and required application information are relatively straightforward for Momentary CTT.

BC Hydro Requirements for Customer-owned Primary Services Supplied at 4 kV to 35 kV (Primary Guide), Section *6,* describes the BC Hydro general system characteristics.

This document does not apply to facilities with PG(s) that:

(a) run in parallel with BC Hydro for longer than 20s (e.g., generators used for load displacement or to export power to BC Hydro or, shore power CTT), or

(b) employ open transition transfer (break-before-make) automatic transfer switches or schemes.

1.2 Copyright and Reprint

1.3 Disclaimer

The information contained in this document is subject to future revisions. Important notes of limitations include:

- this document is not a replacement for electrical codes or other applicable standards
- this document is not intended or provided by BC Hydro as a design specification or as an instruction manual for the PG owner, employees or agents, and proponent, proponent's employees or agents shall not use the document for those purposes. Persons using this information do so at no risk to BC Hydro. They rely solely upon themselves to ensure that their use of all or part of this document is appropriate in a specific circumstance,
- the PG owner, employees or agents recognize that they are always solely responsible for the generator plant design, construction and operation. BC Hydro and its employees or agents shall not be or become the agent of the proponent in any manner, howsoever arising,
- the advice by BC Hydro, its employees or agents that the PG facility design or equipment meets specific BC Hydro requirements does not mean, expressly or by implication, that the owner meets all or any of the requirements of the law or good Engineering practice and such judgment shall not be construed by the owner or others as an endorsement of the design or as a warranty by BC Hydro, its employees and agents, of the design or equipment, or any part thereof.

1.4 Project Responsibilities

The Interconnection Customer owns and is responsible for the design, installation, operation, and maintenance of all equipment, station and distribution line facilities downstream of the Point-of-Interconnection (POI) unless otherwise agreed to in writing.

The Interconnection Customer is also responsible for submitting all required engineering documentation (plant and generator drawings, specifications, data sheets, manuals, relay data sheets, and other supporting documents) to BC Hydro, as per the Submission Requirements in Appendix F, for review by BC Hydro and completion of project specific tasks, before receiving permission to operate PG(s) in parallel with BC Hydro.

2 Common Requirements

2.1 General

Per CEC Part I, Section 84, the Interconnection Customer may only operate a Power Generator in parallel with BC Hydro DS with written approval by BC Hydro. This requirement applies to all Power Generators, including those running parallel via Momentary CTT ATS(s) or schemes.

All PG(s) and CTT-related equipment interconnected with BC Hydro shall comply with the latest versions of all applicable CSA standards, including, but not limited to, CSA C22.3 No. 9 Interconnection of

Distributed Resources and Electricity Supply Systems, CSA C22.2 No. 178.1 Requirements for Transfer Switches, CSA C22.2 No. 178.3 Requirements for Transfer Switches – over 1000 volts, and CSA 22.2 No. 31 Switchgear Assemblies. Nevertheless, the governing document shall be the CTTIR.

The PG Facility shall be a BC Hydro load customer.

The PG shall not, under any circumstances, energize any de-energized portion of the BC Hydro DS. The protection device shall provide all required protection functions, which shall be functional in automatic and manual modes of operation.

The PG parallel operation with BC Hydro DS shall be for a short period for seamless transfer of the customer load from the BC Hydro DS to the PG and vice versa.

PG(s) capable of CTT shall not export power to BC Hydro DS.

2.2 Main Disconnect Device(s)

Main Disconnect device(s) of a PG Facility shall be accessible, lockable, and a means to load-break.

The Main Disconnect device(s) for PG Facilities connected to primary Voltage shall have means for visual verification of open position (Visible Disconnection Point). The *BC Hydro Primary Guide (clauses 9.1.1 and 9.1.2)* and *CEC Part I (clauses 84-020 to 84-024)* describe further the Main Disconnect device (also known as the service switch). The Main Disconnect device(s) installed on Secondary Voltage do not require visual verification.

The PG Facility Main Disconnect device(s) shall be assigned a unique identification name(s) or number(s) and labelled with a permanent label(s) for identification and reference.

According to Section 5 of *BC Hydro Requirements for Secondary Voltage Revenue Metering* (750 V and less), PG facilities connected to the Distribution System at secondary Voltage and containing instrument transformer metering shall provide a main service box with the customer Main Disconnect device on the supply side of the instrument transformer compartment. Because of the potential of the back energization, the load side of the instrument transformer enclosure requires an additional lockable disconnect device. Please note that the CTT that uses CSA-certified Momentary CTT ATS (s) does not require the disconnect on the load side of the instrument transformer enclosure.

3 Momentary CTT ATS(s) Requirements

3.1 General

Certified Momentary CTT ATS is an automatic transfer switch capable of operating in CTT mode that

- parallels the PG with BC Hydro DS for up to 100ms (6 cycles),
- is a factory built and shipped as a single piece of equipment, and
- is certified to CSA C22.2 No. 178 for Momentary CTT operation

Note: The above definition corresponds to the “Closed Transition Transfer Switch” defined in the CSA C22.2 No. 178.1:22.

Since the duration of the CTT is very short, the ATS(s) that are factory built and certified CSA C22.2 No. 178 and installed at the site without modifications from the factory; interconnection requirements for Certified Momentary CTT ATS(s) are less stringent than for other CTT ATS(s) or schemes. For example, the momentary CTT scheme that includes switchgear assembly (certified to CSA 22.2 No.31) with an ATS

not certified to CSA C22.2 No. 178, requires both BC Hydro line side and load side disconnect interlocked with Revenue Metering CT/PT enclosure and demonstrate the CTT operation, including the transfer time.

3.2 Protection Requirements

Momentary CTT ATS shall have the following protection functions for utility interconnection protection:

Table 1 – Required Protection Functions for Momentary CTT ATS(s)

Protective Function (IEEE Device #)	**Remark**
Under-voltage (27)	Monitoring each phase is required to ensure that the PG cannot energize any de-energized portion of the Distribution System. To permit CTT operation, all Phases must exceed 88% of Vn. Note: Table C.1 is not applicable for Momentary CTT ATS.
Synchronism-check (25)	For settings, refer to Table C.3 in Appendix C. During the enter service period an intentional time delay of 5 min should be added to ensure synchronizing voltage and frequency steadiness.
Maximum Parallel Operation Time (62)	The timer shall allow no more than 500 ms. Exceeding this time shall result in aborting the CTT and initiating a local alarm to inform the PG facility operator.

Note: Refer to Appendix D for illustration of simplified SLD on Momentary CTT ATS.

4 Extended Closed Transition Transfer Requirements

4.1 General

Extended CTT allows the PGs to run parallel with the BC Hydro DS system for up to 20s. Therefore, the Extended CTT can use any Softload CTT ATS(s) (as defined in CSA C22.2 No. 178.1:22) or schemes capable of transferring the load between 100ms and 20s among PGs and BC Hydro DS. Subject to the BC Hydro study outcome, if the aggregated size of the generation connecting through a single ATS is sufficiently large to create any Power Quality issue or system stability problem that may occur due to any momentary switching, BCH may recommend Softload CTT.

4.2 Protection Requirements

Extended CTT ATS or scheme shall have the following protection functions for utility interconnection protection. The location of measurement for all the protection function should be at Point of Interconnection (POI) a.k.a. PCC if the aggregated generator size within a facility is more than 500kVA. For all other sizes, the measurement location could be located between POI and PG Point of Connection (POC) unless otherwise explicitly specified.

Table 2 – Required Protection Functions for Extended CTT ATS(s) or Schemes

Protective Functions (IEEE Device #)	**Protection from**	**Remark**
Under-voltage (27P)	Energizing a de-energized Distribution System (DS)	To permit CTT operation, all Phases must exceed 88% of Vn.
Under-voltage (27P)	Islanding a (portion of) Distribution System	Upon detecting under-voltage conditions on any phase, the breaker shall trip using an under-voltage relay function (27). Refer to Table C.1 for acceptable settings.
Over-voltage (59P)		Upon detecting over-voltage conditions on any phase, the breaker shall trip using an over-voltage relay function (59). Refer to Table C.1 for acceptable settings.
Under-frequency (81U)		Upon detecting under-frequency conditions on any phase, the breaker shall trip using an under-frequency relay function (81U). Refer to Table C.2 for acceptable settings.
Over-frequency (81O)		Upon detecting over-frequency conditions on any phase, the breaker shall trip using an over-frequency relay function (81O). Refer to Table C.2 for acceptable settings.
Reverse Power (32R)		Monitoring power direction towards the Public Utility (BC Hydro). The maximum acceptable time delay is 1s. Failure to meet such conditions shall cease the CTT operation with no time delay. This function can be used as an additional protective function to prevent islanding operation[1]. The magnitude of the reverse power flow should be chosen conservatively for an ungrounded system, e.g., the interconnection transformer winding configuration on the BC Hydro side is delta without having any Grounding Transformer installed.

[1] IEEE Std 1547.2™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems (Clause 8.4.1.3.3)

……Continuation of Table - 2

Protective Functions (IEEE Device #)	**Protection from**	**Remark**
Maximum Parallel Operation Time (62)	Prolonged Paralleling	Maximum acceptable time delay: designed (Normal) CTT time + 1s but not more than 20s. Exceeding this time shall result in aborting the CTT and initiating a local alarm to inform the PG facility operator.
Phase Overcurrent (50/51) & Ground Fault Overcurrent (50N/51N)	Phase-to-phase and phase-to-ground fault(s) on Distribution System	PG can contribute to faults on the DS. The CTT ATS or scheme shall detect faults on the DS and cease energization. 3-phase monitoring is required. Directional overcurrent protective functions (IEEE 67P and 67N) are also acceptable.
Breaker Failure Protection, Utility Interconnection Protection Breaker(s)	Breaker Failure	All the breaker(s), called to trip by all the protective functions listed in this table, shall have a breaker protection scheme. The scheme shall be fast and subject to the acceptance of BC Hydro. If the interconnection protection system or breaker trip coils fail or the auxiliary supply is lost, the CTT scheme shall cease energization of the distribution system without delay.
Relay Failure Protection, Utility Interconnection Protection Relay(s)	Relay Failure	All the relay(s) that provide the protective functions listed in this table shall have a relay protection scheme. The scheme shall design with self-diagnostic capabilities, fail-safe, or prevent or abort CTT. Backup relays are also acceptable.
Shunt Trip	Energizing a de-energized Distribution System (DS)	Any external bypass to the ATS or scheme shall have a shunt-tripping mechanism to trip the upstream breaker (BC Hydro side of the Transfer switch), ensure open transition transfer, and prevent any inadvertent manual attempt to energize the de-energized Hydro system. Any internal bypass with an interlocking mechanism (as per CSA C22.2 No. 178.1:22) warranting open transition transfer is also acceptable as an alternate to Shunt Trip and subject to BC Hydro evaluation or assessment.
Synchronism-check (25)	Synchronization prior to paralleling with *public utility* system	Refer to Table C.3 in Appendix C for acceptable settings for a PG to enter in service. During the enter service period an intentional time delay of 5 min should be added to ensure synchronizing voltage and frequency steadiness.

Notes:

1. For the conditions listed above, unless otherwise noted, the relay(s) shall trip open a breaker which will remove the PG from parallel operation with the Distribution System or, if already open, shall not provide permission for breaker closing.

2. Extended CTT schemes shall employ Utility Grade relays, physically separated from programmable controllers, for at least protection functions 27, 59, 81U, 81O, 32U, 50/51 and 50N/51N. Refer to Appendix A (Definitions) for information on utility grade relays.

The protection schemes, complete with their settings proposed by the PG in their application, will be reviewed for acceptance of BC Hydro.

Additional protection, other than those listed in the CTTIR, might be required depending on the application and shall be communicated to the CTT applicant before issuing the finalized Project Interconnection Requirement (PIR) document.

There can be a different design of CTT protection schemes; however, the examples shown in Appendix-D are for informational purposes only. It may also require additional protection functions. Generator protection functions are independent of the CTTIR and may require a coordinated setpoint; however, BC Hydro has no specific requirements for generator protection setpoint.

4.3 Facilities with Delta Connection on HV Side of Entrance Transformer(s)

PG Facilities connected to the Distribution System via transformer(s) with delta winding configuration on the high voltage side could pose additional risks to BC Hydro. When a PG is interconnected, damaging temporary (swells caused by neutral shifting) and transient overvoltage (Ferro-resonance and resonance) could occur on the Distribution System under certain conditions (ground faults, single phase switching, and other similar events). The abnormal condition must be detected quickly, and PG disconnected from the BC Hydro Distribution System.

These requirements do not apply to PG facilities with only Certified Momentary CTT ATS(s) (described in section 2).

One or more of the following solutions is the acceptable solution to mitigate or minimize the impact of potential temporary and transient overvoltage issues:

1. Addition of High Voltage Grounding Transformer (HVGT)
2. Use the voltage measurement location on the delta side of the transformer.
3. Monitoring Reverse Power flow

There are illustrations of CTT protection diagrams in Appendix D.

a. Addition of High Voltage Grounding Transformer (HVGT)

This scheme prevents the occurrence of temporary over-voltages and protects from transient over-voltages. The HV side of the entrance transformer(s) shall install an HVGT. The HVGT shall be in the same protection zone as the entrance transformer. Note that all the protection functions, as shown in Appendix -C, can be implemented on the transformer's secondary side (CTT facility side).

The intent for PG facilities having a High Voltage (HV) delta transformer connection is to eliminate any possibility of transient overvoltage within the islanding zone by preventing neutral shifting to any potential ungrounded system. However, it requires a study to identify the impact and size of the HVGT accordingly.

b. Use the voltage measurement location on the delta side of the transformer

The PG shall install an Over-voltage protection function (IEEE #59) for Phase-to-ground voltage monitoring on all three phases at the entrance of the PG Facility at the Primary Delta side[2] of the interconnection transformer. The breaker shall trip on over-voltage conditions on any Phase. The recommended voltage set point shall follow Table C.1 in Appendix -C.

c. Monitoring Reverse Power Flow

This scheme uses the protection function at the facility entrance, which could use the secondary side of the transformer as a measurement location, including all the measurements for other protection functions as per Appendix -C. Considering the isolation zone and the potential Load within an islanded portion, the magnitude of reverse power flow (32R) should trip the facility's main entrance breaker or generator breaker within 1s. Note that the extended CTT ATS scheme shall equip all other protection functions, including fault overcurrent protection and the Undervoltage protection function. Therefore, any fault during the paralleling time (not more than 20s for extended CTT) in the vicinity of the CTT facility should be quickly picked up and disconnected. For any remote high-impedance fault, if the overcurrent pickup or the Undervoltage pickup is inadequate, the reverse power flow protection function may be sufficient to trip the breaker as the Load between the remote fault location and the CTT premise can be considerably high; however, if the Load within islanded portion is too small to determine the reverse power flow magnitude, primary measurement location should be considered for protection function implementation as discussed in b.

5 Commissioning and Verification Requirements

5.1 General

The Interconnection Customer is fully responsible for inspecting, commissioning, testing, and calibrating its equipment.

Commissioning testing of the PG Facility CTT ATS or scheme shall conform, as applicable, to CSA C22.3 No. 9, Section 8. The CTT applicant shall perform these tasks.

Testing shall include end-to-end verification of all inputs to the protection and control schemes (instrument transformers, breaker positions), correct processing of those inputs by the protection and control systems for anti-islanding and clearance of external faults, and end-to-end verification of all outputs - breaker tripping, breaker failure initiation, closing interlocks, and alarms.

Certified Momentary CTT ATS(s) only need to meet (a), (b), (g), (k) and (l) of the requirements below. Factory-built Extended CTT ATS(s) will likely have reduced requirements.

The commissioning testing shall include, as a minimum, the following:

(a) Verification and recording of ‘as-found’ Interconnection Protection relay(s) settings

[2] IEEE Std C37.95™-2002(R2007), IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.

(b) Verification of field-installed power and control wiring for compliance with drawings and manufacturer requirements
(c) Verification of the polarities, burdens, and ratios of field-wired instrument transformers against the design documentation
(d) Calibration checks of each protective relay by using an injection of appropriate AC quantities, secondary injection, or set-point adjustment verification
(e) Functionality of the protective relays and circuit breakers to verify that they operate as a system
(f) Verification that, upon loss of power supply to the protective relays, the protection scheme trips the appropriate circuit breaker
(g) Verification that the CTT will not initiate at off-nominal voltages (under-voltage only for Certified Momentary CTT switch).
(h) Verification that the CTT will not initiate at off-nominal frequencies
(i) Verification that it will block the CTT for 'relay-failed' condition (applies only to digital relay schemes equipped with self-diagnostic capabilities)
(j) Verification of reverse power relay setting and breaker trip.
(k) Verification of by-pass operation mechanism, if applicable.
(l) Verify that the CTT is immune to any inadvertent energization of the de-energized BC Hydro line.

Before the acceptance of interconnection for operation, the PG shall correct the deficiencies identified during commissioning in the form of a signed Declaration of Compatibility (DoC).

5.2 Field Verification

Once the CTT-related commissioning is complete, BC Hydro will complete Field Verification (FV) before the CTT ATS or Scheme enters service. The purpose of the FV is to verify that the installed CTT ATS or Scheme meets the requirements of the BC Hydro Project Interconnection Requirements (PIR), this document, and all other applicable standards.

BC Hydro will prepare and send the CTT applicant a project-specific list of what requires verification during the FV, typically including verifying equipment installed, protection settings and demonstrating CTT speed and operation.

The PG shall advise BC Hydro at least 15 business days (or 30 business days during the winter period of December to February) before testing and reserves the option to send a representative to witness the Field Verification. Alternatively, the CTT applicant may request to complete the FV independently, following BC Hydro specifications and submit the Field Verification report, signed by a Professional Engineer, for acceptance by BC Hydro.

5.3 Documentation

The following material shall be retained by the IC and provided to BC Hydro upon request:

1. A copy of the testing commissioning reports signed by a Professional Engineer
2. A summary of testing results, including any permits, certificates of inspection or other applicable authorizations or approvals certifying that any of the CTT ATS or scheme new, modified or replacement facilities have passed the relevant tests and comply with all applicable requirements and standards referred to in this document
3. Record (aka 'as-built') drawings (single line diagram showing protection and metering, applicable AC

and DC schematics, final relay settings, individual protective relay trip test record, testing and commissioning results for interconnection protection, and other relevant drawings)

4. CTT ATS manufacturer's technical specifications or datasheet complete with CSA standards the ATS complies with.

This documentation shall indicate the facility, protection designation, settings date, test date, the name of the tester(s), relay type (manufacturer and model), test equipment details (manufacturer, model, serial number, accuracy, last calibration date), and instrument transformer ratios.

5.4 Declaration of Compatibility (DoC)

The DoC, listed in Appendix E, refers to the main aspects where BC Hydro must be confident of the correct operation, setting, calibration and installation of PG equipment. BC Hydro and the IC must sign the DoC, and IC signifies agreement that the PG's interconnection is compatible with the BC Hydro system and is capable of operating in CTT mode.

BC Hydro's issuance of a completed DoC to the IC constitutes BC Hydro's acceptance of the PG Facility to operate in CTT mode.

5.5 Operation and Maintenance Requirements: Distribution Operating Order

CTT ATS or scheme requires a 3D Distribution Operating Order (DOO).

A DOO is a document that lists authorized personnel from the PG and BC Hydro, their contact information, procedures for interconnected operation of the PG with regards to BC Hydro, and the procedures that the BC Hydro personnel will follow to perform work on boundary equipment between a PG and the BC Hydro system. A specific DOO will be developed for each PG Facility and jointly signed by BC Hydro and the IC. The DOO requires revision and updates, typically every two years.

The DOO needs to be in place before the commissioning of the CTT.

5.6 Maintenance Requirements

The IC shall assume full responsibility for maintaining its equipment up to the Point of Interconnection so that the reliability of the Distribution System is unaffected. BC Hydro reserves the right to inspect and test the equipment given reasonable notice and request any necessary maintenance. This inspection shall not relieve the customer of any or all responsibility for maintaining the customer's facility.

Periodic maintenance of the Interconnection System shall include, but not be limited to, calibration testing of all protective relays and function testing of associated circuit breakers. PG shall complete maintenance at intervals of 2 years at maximum. PG shall submit the test reports to BC Hydro for review upon request.

The IC shall obtain approval from BC Hydro before making changes to the Interconnection System that would alter the compliance of the CTT ATS or scheme concerning the PIR and CTTIR.

Appendix A Terms and Definitions

CEC – Canadian Electrical Code

CT – Current Transformer

VT – Voltage Transformer

Vn – Nominal Voltage

DER – Distributed Energy Resources

Interconnection Customer (IC) – Any entity that proposes to interconnect its Power Generator to BC Hydro's System.

Power Generator (PG) – The Interconnection Customer's device(s) for the production of electricity identified in the 'Application for Interconnection Request, Power Generator(s)' in Closed Transition Transfer Mode. The PG can be synchronized and run in parallel with the BC Hydro System.

BC Hydro Control Centre (aka FVO) – Control centre responsible for the control and operation of BC Hydro Distribution System.

BC Hydro System – encompasses electrical transmission and distribution system operated by BC Hydro.

Distribution System (DS) – Part of the BC Hydro system that operates at 34,500 V or less.

Primary Voltage – Service voltage above 750 V, measured phase to phase. The most common, standard, BC Hydro primary distribution voltages are: 2,400/4,160 V, 7,200/12,470 V, and 14,400/24,940 V.

Secondary Voltage – Voltage up to and including 750 V, measured phase to phase. Standard, 3-phase, secondary voltages are 120/208 V, 240/416 V, and 347/600 V.

Protection Scheme – Protection functions, including associated sensors, relaying, circuit breakers, and power supplies, intended to protect the Distribution System or interconnection equipment.

Utility Grade Relay– Utility grade relays are designed to provide the highest degree of reliability, repeatability, longevity, security, and calibration accuracy. Such relays comply with the IEEE Standard C37.90, "Standard for Relays and Relay Systems Associated with Electrical Power Apparatus".

Point of Interconnection (POI) – The physical boundary point where the change of ownership between BC Hydro and the IC takes place. It is also referred as Point of Common Coupling (PCC).

Power Generator Facility (PG Facility) - all facilities and equipment on the IC's side of the POI, including the Power Generators, facility load, distribution, transmission, protection, control and communication facilities owned and operated by the Interconnection Customer, and any modifications, additions, upgrades, repairs or replacements thereof.

Point of Connection (POC) – The first physical point where the PG interconnect with other loads or generator units within the PG facility.

Parallel Operation – The simultaneous energization of the PG facility by the BC Hydro and a PG.

Interconnection (aka intertie) – The result of the process of electrically connecting a Power Generator in parallel to the Distribution System.

Interconnection System – The collection of interconnection equipment and functions used to interconnect a PG to the Distribution System (i.e., utility interconnection protection relay(s), associated circuit breaker(s), voltage and current transformers, and similar equipment).

Closed Transition Transfer (CTT) - An automatic transfer of load through a transfer switch in a make-before-break fashion between normal and alternative power sources that are (actively or passively) synchronized at the time of transfer.

CTT Scheme – An electrical scheme that enables automatic transfer of load from normal to alternative power source, and vice versa, in closed transition fashion. The term is used to describe when CTT elements (relays, circuit breakers, etc.) are distributed (not confined within a CTT ATS enclosure) and, typically, are controlled by a programmable logic controller (PLC).

Automatic Transfer Switch (ATS) – Self-acting transfer switch used for transferring a load from one power source to another.

CTT ATS (CTT Switch) – An automatic transfer switch with overlapping contacts to provide a make-before-break transfer operation between normal and alternative power sources that are (actively or passively) synchronized at the time of transfer.

Momentary CTT – "*the momentary interconnection (≤100ms) of a DER system to the distribution system with the purpose of transferring load from the distribution system to the DER and then operating in stand-alone (emergency) mode or transferring load from the DER back to the distribution system.*" – CSA C22.3 No. 9:20. The term, 'DER' in this definition is interchangeably used as Power Generators throughout this document.

Certified Momentary CTT ATS – A momentary CTT ATS (a single assembly) designed, built, and factory tested as per the CSA C22.2 No. 178 that does not allow the CTT ATS to parallel two sources more than 100 msec.

Softload CTT ATS – "*An automatic transfer switch executing the transfer of power to the load from normal source to generator or generator to normal source while minimizing voltage and frequency fluctuations by actively synchronizing voltage, frequency and phase-angle between normal sources and generator sources capable of paralleling the sources for greaten than 100 msec while load is transferred."* – CSA C22.2 No. 178.1:22. A Softload CTT ATS that is capable to transfer load within 100 msec can also be used for Momentary CTT application if the Softload CTT ATS is certified to CSA C22.2 No. 178.1:22 for Momentary CTT operation.

Extended CTT – A CTT, ATS or scheme, that have parallel operation time between 100 msec and 20 sec. Extended CTT may employ either Softload CTT ATS or, CTT Scheme.

Field Verification (FV) – IC's demonstration, performed at site, to BC Hydro representative of Power Generator's compliance with the PIR.

Closed Transition Transfer of Power Generators, Technical Interconnection Requirements (CTTIR) – This document including any updates in the form of bulletins and/or amendments that are published by BC Hydro on its website.

Project Interconnection Requirements (PIR) - A document that includes the specific requirements for the interconnection of the PG Facility to BC Hydro's System which are based on the CTTIR as well as on all plant-specific information provided by the Interconnection Customer to BC Hydro.

Project – The electrical generation and distribution facilities owned and operated, or intended to be owned and operated, by Interconnection Customer, and as specifically described in Project Interconnection Requirements.

Professional Engineer – An electrical engineer registered, in good standing, with The Engineers and Geoscientists British Columbia (EGBC).

Appendix B References

1. BC Hydro, "Requirements for Customer-owned Primary Services Supplied at 4 kV to 35 kV – Primary Guide." https://app.bchydro.com/accounts-billing/electrical-connections/distribution-standards.html#primaryguides

2. BC Hydro, "Interconnection Requirements for Power Generators 35kV and Below." https://app.bchydro.com/content/dam/BCHydro/customer-portal/documents/distribution/standards/ds-dgi-requirements.pdf

3. CSA C22.1:21, "Canadian Electrical Code Part 1, Safety Standards for Electrical Installations, 25th Edition", January 2021.

4. Safety Standard Act, Electrical Safety Regulation – B.C. Reg. 100/2004; amended October 1, 2022, by B.C. Reg. 179/2022.
https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/12_100_2004

5. CSA-C22.3 No. 9:20, "Interconnection of Distributed Resources and Electricity Supply Systems." January 2020.

6. CSA C22.2 No. 178.1:22, "Transfer Switch Equipment", July 13, 2022.

7. CSA C22.2 No. 178.3:17, "Transfer Switch Equipment, over 1000 volts", Revised April 2020 and reaffirmed 2022.

8. CSA C22.2 No. 31-18, "Switchgear Assemblies." January 2018.

9. IEEE C37.90-2005(R2011), "IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus"

10. IEEE Std C37.95™-2002(R2007), "IEEE Guide for Protective Relaying of Utility-Consumer Interconnections"

11. IEEE Std 1547.2™, "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems"

Appendix C Tables

Table C.1 – Response to Abnormal Voltage

(Source: *CSA C22.3 No. 9:20* Table 10, Adapted from)

% of Nominal Voltage (%Vn) [1]		Maximum Clearing Time (seconds)[2]
UV1	V < 50%	0.16 s
UV2	50% ≤ V < 88%	2 s
UV3	88% ≤ V < 94%	May ride through not exceeding 20 s
	94% ≤ V < 106%	Normal range
OV3	106% < V ≤ 110	May ride through not exceeding 20 s
OV2[3]	110% < V ≤ 120	1 s
OV1	120% < V	0.16 s

Notes:

1. Nominal system voltage shall be in accordance with Clause 6.2 of CAN/CSA-C22.3 No. 9:20.

2. "Clearing time" is the period between the start of the abnormal condition and the interconnection device ceases to energize the BC Hydro system, i.e., relay detection time plus CB operating time.

3. For a transformer winding configuration of delta on BC Hydro side, the OV2 should be chosen much conservative to trip much faster and limit the duration of overvoltage condition (CSA C22.3 No. 9:20, C.4) to BC Hydro customers. The recommended clearing time delay should be set between 300 ms to 500ms.

Table C.2 – Off-Nominal Frequency Limits

(Source: *CSA C22.3 No. 9:20* Table 9, Adapted from)

Frequency (Hz)	Maximum Clearing Time (seconds)
57.0	0.16 s
61.8	0.16 s

Notes:

1. *Since the maximum paralleling time for Extended CTT is limited within 20 sec, the other set points which are required to exceed 20 sec are ignored.*

Table C.3 – Synchronization Criteria

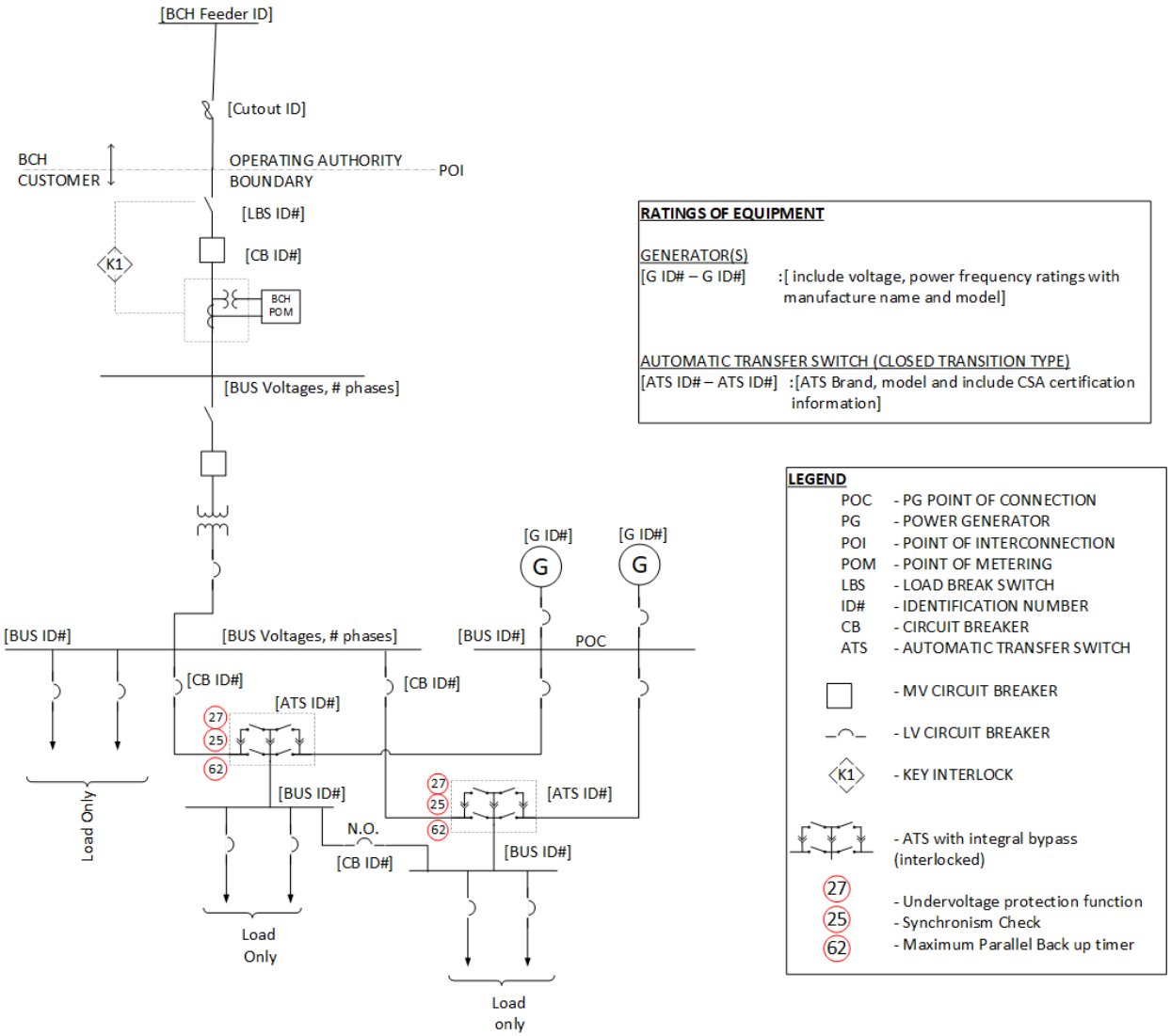
(Source: *CSA C22.3 No. 9:20* Table 18, Adapted from)

Aggregate Rating of Generators (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

Appendix D Typical Diagrams – CTT Generators

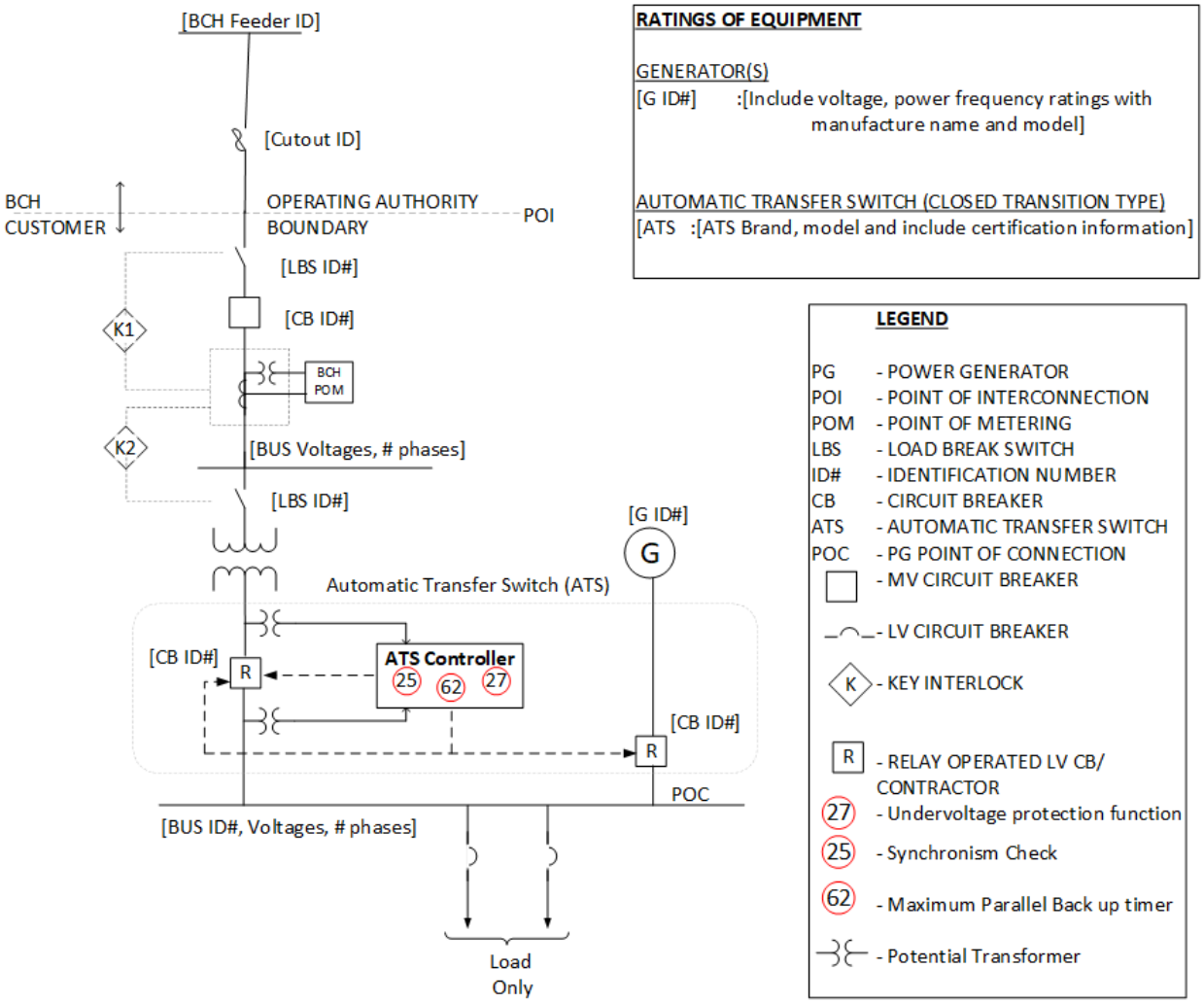
The following notes are applicable to all the example SLDs in this appendix:

1. The ID# prompted to the only elements relevant to BC Hydro PIR. Proponent shall provied all the name tags in the format as shown on the SLD. The device ID can be 2 to 4 digits long.
2. Proponent should provide all the name tags to other equipmetn as applicable be CEC Part – I. All device ID and the name must be unique.
3. Load only means there are no customer generators capable of running in parallel with BC Hydro.
4. If the transformer is owned by BC Hydro, the transformer should be outside of the POI.



Note: CSA CERTIFIED MOMENTARY CTT ATS ARE DEEMED TO HAVE NO POTENTIAL FOR BACK ENERGIZATION AND ONLY A LINE SIDE DISCONNECT DEVICE IS REREQUIRED (BC Hydro RM BULLETIN NO. 20230306 ADOPTED FROM CEC PART-I (CSA C22.1:21), RULE NO. 36-214 AND 84-008)

Figure D.1 – One-Line Diagram, Protection & Control, Certified Momentary CTT ATS (s) (Example)

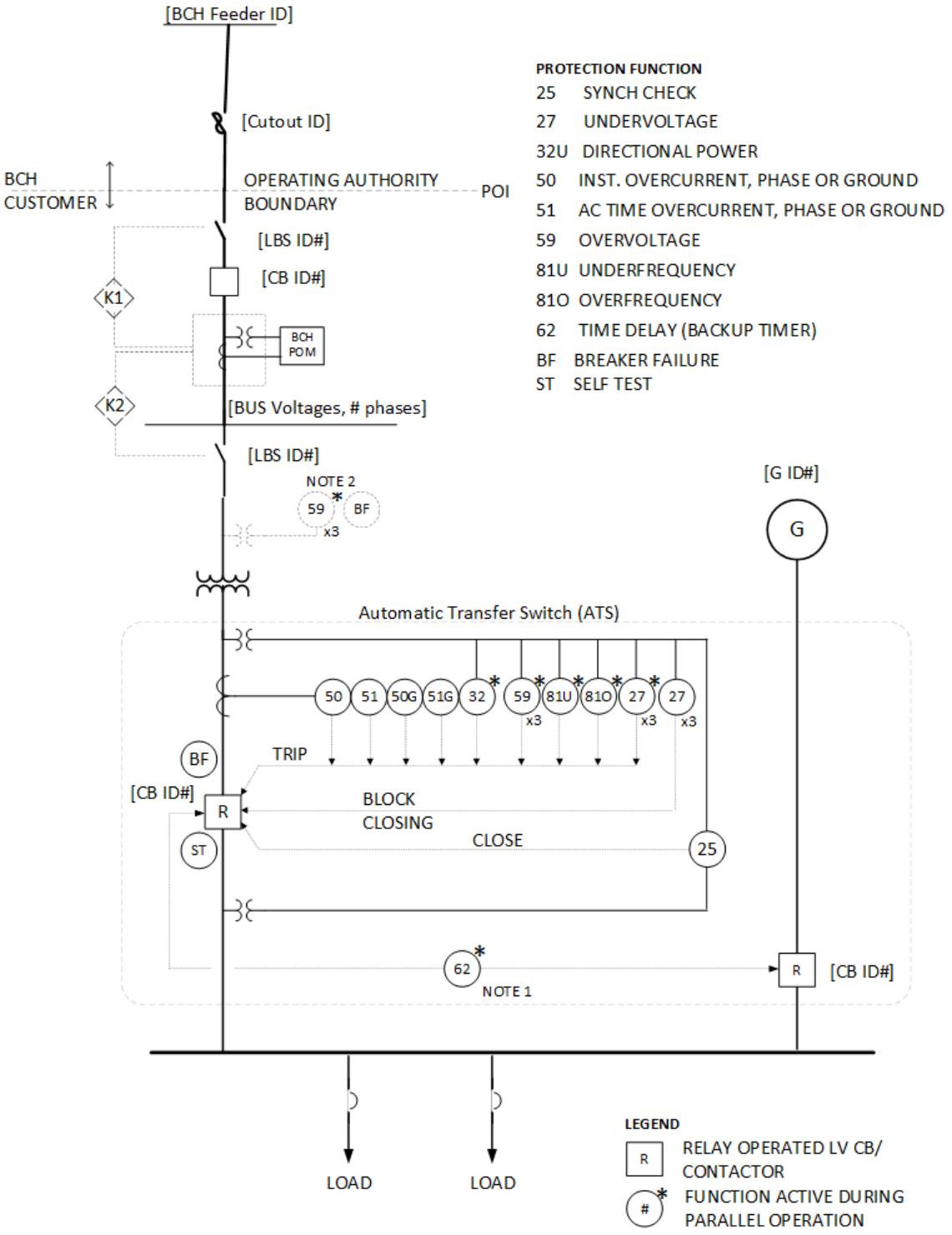


Note:

a. ONLY THE BACKUP TIMER FUNCTION, 62, SHOULD DETECT THE CONDITION OF EXTENDED PARALLEL OPERATION AND TRIP ONE OR BOTH SUPPLY CONTACTS TO OPEN TO REMOVE THE CONDITION. THIS FUNCTION SHALL BE ACTIVE DURING PARALLEL OPERATION.

b. MOMENTARY CTT ATS OR SCHEME REQUIRES LOAD SIDE DISCONNECT INTERLOCKED (K2 AS SHOWN ABOVE) WITH RM CT/PT ENCLOSURE AND DEMONTRATION OF ALL FUNCTIONS DURING FIELD VERIFICATION

Figure D.2 – One-Line Diagram, Protection & Control, Momentary CTT ATS (s) (Example)



NOTES

1. HAVE CIRCUITRY TO DETECT AN EXTENDED PARALLEL OPERATION TIME AND CAUSE ONE OR BOTH SUPPLY CONTACTS TO OPEN TO REMOVE THE CONDITION.
2. WHERE TRANSFORMER IS DELTA CONNECTED ON DISTRIBUTON SYSTEM SIDE, AN OVERVOLTAGE (59) RELAY SHALL BE ADDED ON THE TRANSFORMER HIGH VOLTAGE SIDE.

Figure D.3 – One-Line Diagram, Protection & Control, Extended CTT (Example for PG < 500KVA)

Appendix E Declaration of Compatibility (CTT)

The compatibility of generation (1st Synchronization) describes conditions that must be satisfied before the Generator facility can be connected to generate electricity for the purposes of testing and commissioning the facility or its components.

Declaration of Compatibility, Generator (1st Synchronization), Generator's Facilities		
Generator:		
Project:		
The Generator shall design, construct, own, and maintain the Generator's Facilities.		
Interconnection	Yes	No
1. BC Hydro has reviewed the Generator's proposed facilities to confirm compliance with BC Hydro's technical interconnection requirements for Closed Transition Transfer of Power Generators.	☐	☐
2. A copy of the Certificate of Final Inspection (granted by BC Safety Authority or Local Regulatory Authority) or Electrical Contractor Authorization and Declaration of Compliance Form showing work completed signed by the Field Safety Representative.	☐	☐
3. Professional Engineer's declaration(s) that the Generator facility has been designed, constructed and tested to a state suitable for operation and in accordance with the Project Interconnection Requirement (PIR).	☐	☐
4. Distribution Operating Order (DOO) approved by the Generator and BC Hydro operation including the approval to energize the Generator and both have copies.	☐	☐
Field Verification		
1. Field Verification completed successfully by the Generator.	☐	☐
Provide explanation if "No" has been checked for any item above.		
The undersigned do hereby declare that the Generator's Substation is compatible for interconnection with the BC Hydro system for the purpose of generator closed transition transfer operation.		

_____ Name	_____ Signature with Date	_____ Name	_____ Signature with Date
(Power Generator Facility representative)		(BC Hydro Representative)	

Appendix F Application Requirements

A CTT applicant must submit a complete set of technical documents and drawings (the application package) to initiate the interconnecting of PG(s) in CTT mode. The application package aims to enable BC Hydro to review the proposed CTT ATS/scheme(s) against the CTTIR and put together a PIR (PG Facility specific interconnection requirements). The application package-related requirements depend on the type of CTT (ATS or scheme, momentary or extended) and entrance transformer HV winding connection (wye or delta).

"Issue for Construction" or "Issue to BC Hydro for CTT Application" engineering drawings require signed and sealed by a Professional Engineer. BC Hydro prefers Electronic files (in PDF format) which must follow Engineers and Geoscientist BC (EGBC) Quality Management guideline for digital sealing and signing the document.

Momentary CTT ATS(s)

a) An **Application for Interconnection, Power Generator(s) in Closed Transition Transfer Mode**. BC Hydro's Application for Interconnection, Power Generator(s) in Closed Transition Transfer Mode is available on bchydro.com (on the Distribution Generator Interconnections page). The form is to be signed and sealed by a Professional Engineer.

b) A **Narrative Description**. Description of the CTT system operating modes (normal, auto, manual and/or test mode) should include utility interconnection protection, normal and maximum closed transition transfer time limits and to lesser level of detail, a description of the facility power scheme and generator(s) operation. The description is to be signed and sealed by a Professional Engineer.

c) A **simplified overall PG Facility electrical power distribution one-line diagram.** Diagram should show the service entrance, major power distribution equipment, all onsite generators, CTT switches/ATS(s), entrance transformer(s) complete with their winding connections, BC Hydro revenue metering, key interlock scheme(s), mechanical interlocks, entrance disconnect devices with assigned tag (aka identification) numbers, point of interconnection, voltage levels with equipment ratings and clear demarcation between existing and newly proposed equipment/change. Sample SLD for Certified Momentary CTT can be found in Appendix - D for reference. The SLD is to be signed and sealed by a Professional Engineer.

d) A **PG Facility site plan.** Plan should show the location of service entrance and major electrical equipment (including incoming vaults, generators, switchgear, CTT switches).

e) **Technical Specification(s) or Data Sheet**. Manufacturer's technical specifications for the ATS(s) used in the CTT.

f) **Manufacturer's Documentation on CSA Certification for CTT ATS**. The Canadian Standards Association (CSA) standard each ATS is certified to including the publishing year. For example, to be considered as Certified Momentary CTT ATS rated for 1000V and below, it should state 'CSA C22.2 No. 178.1-14' that was published in 2014.

Extended CTT ATS(s) or Schemes

a) An **Application for Interconnection, Power Generator(s) in Closed Transition Transfer Mode**. BC Hydro's Application for Interconnection, Power Generator(s) in Closed Transition Transfer Mode is available on bchydro.com (on the Distribution Generator Interconnections page). The form is to be signed and sealed by a Professional Engineer.

b) A **Narrative Description**. Description of the CTT system operating modes (normal, auto, manual

and/or test mode) including utility interconnection protection, normal and maximum closed transition transfer times and to lesser level of detail, a description of the facility power scheme and generator(s) operation. The description is to be signed and sealed by a Professional Engineer. For "distributed" (non-ATS) CTT control schemes (e.g., use of PLC controller) the description should cover:

i) Facility entrance protection system with associated breaker(s). The protection system must include protection relay function numbers, relay sensing points, relay-controlled devices, type of signal (permissive, trip, close), mechanical and electrical interlocks, as applicable to the CTT.

ii) Interconnection system of the CTT control scheme(s) demonstrating the flow of control signal(s) to the relay(s).

c) A **simplified overall PG Facility electrical power distribution one-line diagram.** Diagram should show the service entrance, major power distribution equipment, all onsite generators, CTT switches/ATS(s), entrance transformer(s) complete with their winding connections, any grounding transformers, BC Hydro revenue metering, key interlock scheme(s), mechanical interlocks, entrance disconnect devices with assigned tag (aka identification) numbers, point of interconnection, voltage levels with equipment ratings and clear demarcation between existing and newly proposed equipment/change. Sample SLD for Extended CTT can be found in Appendix - D for reference. The SLD is to be signed and sealed by a Professional Engineer.

d) A **PG Facility site plan.** Plan should show the location of service entrance and major electrical equipment (including incoming vaults, generators, switchgear, CTT switches).

e) **Technical Specification(s) or Data Sheet**. Manufacturer's technical specifications for the ATS(s) used in the CTT.

f) **Protection & Control One line diagram, or control schematic, or three-line diagram**. Diagram of the CTT transfer switch to show protective devices, protective function numbers and sensing points (CT/PT) by considering the entrance transformer(s) winding configuration, number of phases, relay controlled associated devices, type of control signals (trip, permission, close), flow of control and communication signals between the devices (e.g., PLC to relay, relay to relay etc.). In preparing this one-line diagram, the previously mentioned Sample SLD can be used for reference. The SLD is to be signed and sealed by a Professional Engineer.