NET METERING INTERCONNECTION REQUIREMENTS, 50 KW & BELOW

RATE SCHEDULE RS 1289

22 October 2003

BC hydro

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1.0 INTRODUCTION

This document guides generator owners in connecting generators to the BC Hydro (BCH) distribution system where the BCH service voltage is 600 V or less. The generator may export electricity periodically across the BCH revenue meter into the BCH distribution system.

This document applies to dc-ac inverter-based systems and rotating machines (induction or synchronous generators) for plant ratings up to 50 kW. An induction generator is an induction motor driven as a generator. The net metering customer is referred to as a Distributed Generator (DG).

This document describes BCH connection requirements, the minimum design standards the DG System must satisfy, and the range of normal and emergency system conditions the DG System may encounter while connected to the BCH distribution system. When information on the location, size and type of the DG development is received, BCH will provide the DG technical interconnection requirements.

The information contained in this document is subject to future revisions.

The intent of this document is to assist BCH in attaining the common goal that the design, construction and operation of the DG will:

(a) be compatible with and safe at all times for the BCH equipment and system, for BCH employees or agents, for BCH customers and the general public,
(b) maintain a high standard of power quality for electricity generated,
(c) meet revenue metering requirements,
(d) facilitate timely and efficient handling by BCH of information provided by the proponent relevant to design, construction and operation of the DG.

Important notes of limitations include:

(a) this document is not intended or provided by BCH as a design specification or as an instruction manual for the DG owner, employees or agents and the document shall not be used by the proponent, his employees or agents for those purposes. Persons using this information do so at no risk to BCH and they rely solely upon themselves to insure that their use of all or part of this document is appropriate in the particular circumstance,

(b) the DG owner, employees or agents recognize that they are, at all times, solely responsible for the generator plant design, construction or operation. BCH, its employees or agents shall not be or become the agent of the proponent in any manner howsoever arising,
(c) the advice by BCH, its employees or agents, that the generating plant design or equipment meets certain BCH requirements does not mean, expressly or by implication, that all or any of the requirements of the law or good Engineering practices have been met by the owner and such judgement shall not be construed by the owner or others as an endorsement of the design or as a warranty by BCH, its employees and agents, of the design or equipment, or any part thereof.

2.0 DEFINITIONS AND REFERENCES

2.1 Acronyms and Definitions

2.1.1 Acronyms

BCH: BC Hydro

CSA: Canadian Standards Association, an accredited standards development organisation within Canada.

IEEE: The Institute of Electrical and Electronics Engineers, Inc., an organisation that develops voluntary standards relating to electrical safety and product performance.

UL: Underwriters Laboratory, an accredited standards development organisation within the United States of America.

2.1.2 Definitions

Alternating Current (ac): Electric current that periodically alternates direction of flow and is zero at some time during its period.

Direct Current (dc): Electric current that flows in one direction.

Distributed Generation (DG): Electric power generation facilities connected to the BCH Distribution System through the Point of Delivery & Receipt (PODR).

Distribution System**:** That part of the BC Hydro system that operates at 34,500 V or less and distributes electric power between BC Hydro substations and PODRs.

Hertz (Hz): The common unit used to describe periodic event frequency. It is a measure of the number of times or cycles that a periodic signal repeats in a second, also denoted as *cycles per second*.

Interconnection: The result of the process of electrically connecting a DG System in parallel with the BCH Distribution System.

Inverter: A power electronic device, which converts dc power into ac power.

Island: A condition in which a portion of the BCH Distribution System is energized by one or more DG Systems while that portion of the Distribution System is electrically separated from the rest of the Distribution System.

DG System: The aggregate of the DG electricity generator, inverter(s), control system(s), sensing device(s) or function(s), and protection devices and functions to the customer service entrance disconnect switch.

Parallel Operation: the simultaneous energization of a PODR by the Distribution System and the DG System.

Point of Delivery & Receipt (PODR): The point where the BCH service conductor/cable is connected to the BCH revenue meter(s).

***Stabilized**:* Refers to the Distribution System voltage returning to the normal range of level and frequency for 5 minutes or a time as co-ordinated with BCH, following a disturbance.

Total Harmonic Distortion (THD): A measure of the total sum of squares of harmonic frequency signals compared to a fundamental frequency signal.

Voltage Follower Mode: An inverter operation mode that follows the waveform of an external source and depends on the external source to initiate and maintain its operation while delivering power to that source.

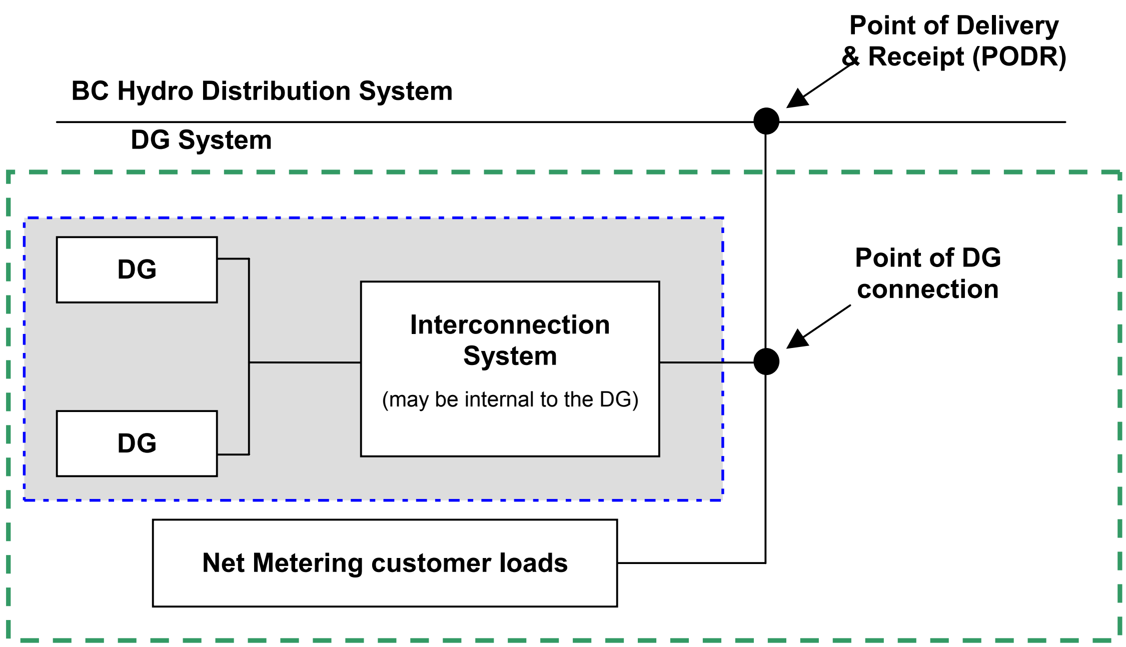


Figure 1: Relationship of DG System and Interconnection Terms

2.2 References

CSA Standard 2002 Canadian Electrical Code Part 1, Nineteenth Edition, C22.1-02, *Safety Standards for Electrical Installations* (CE Code)

CSA Standard C22.2 No. 107.1-01 *General Use Power Supplies.* Section 15 covers grid-connected inverters.

CSA CAN-3-C235-1995 *Preferred Voltage Levels for AC Systems, 0 to 50,000 Volts,* Canadian Utility Distribution systems.

IEEE 519 – 1992 *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.*

3.0 GENERAL INTERCONNECTION AND PROTECTION REQUIREMENTS

Refer to Definitions section 2.1.2 for a diagram showing the DG System and interconnection to BCH.

Section 3.1 lists the typical BCH Distribution System operating and power quality conditions within which the DG System operates. It lists representative values of parameters that BCH attempts to maintain and some abnormal conditions that the DG equipment needs to be designed to withstand.

Section 3.2 lists typical conditions and response to abnormal conditions that the DG System shall meet.

3.1 BC HYDRO DISTRIBUTION SYSTEM OPERATING CONDITIONS

It is the DG owner's responsibility to ensure that the DG System operates correctly in this environment.

3.1.1 System Frequency

The Distribution System operates at 60 Hz. Frequency deviations are typically 59.7 Hz to 60.2 Hz for small contingencies that cause modest disturbances, i.e. where the DG System continues connected to the Distribution System. For large contingencies, broader frequency variations can occur. These variations can be experienced under severe Distribution System loads, load variations, or when major generation or transmission is lost, or BCH load shedding schemes are employed.

3.1.2 System Voltage

CSA Standard CAN3 C235-95, ***Preferred Voltage Levels for AC Systems 0 to 50,000 V,*** provides recommended Canadian utility Distribution System steady-state service voltage levels. DG Systems must operate satisfactorily within the extreme voltage level variation limits shown in Table 1 and may continue to operate beyond these limits (per 3.2.7) to allow the utility automatic voltage regulation equipment time to function. Voltage regulation is a utility responsibility and voltage regulation schemes should not be employed by DG Systems except under agreement with BCH.

Table 1: Recommended Steady-State Service Voltage Variation Limits for Canadian Utilities

Nominal System Voltages	Recommended Voltage Variation Limits for Circuits Up to 1000 volts, Applicable at Service Entrance			
	Extreme Operating Conditions			
		Normal Operating Conditions		
Single Phase 120/240 240 480 600	106/212 212 424 530	110/220 220 440 550	125/250 250 500 625	127/254 254 508 635
Three Phase 4-Conductor 120/208Y 240/416Y 277/480Y 347/600Y	110/190 220/380 245/424 306/530	112/194 224/388 254/440 318/550	125/216 250/432 288/500 360/625	127/220 254/440 293/508 367/635
Three Phase 3- Conductor 240 480 600	212 424 530	220 440 550	250 500 625	254 508 635

Source: Preferred Voltage Levels for AC Systems, 0 to 50 000V- Canadian Standards Association

3.1.3 Harmonic Distortion

IEEE Standard 519-1992, ***Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems***, sets the quality of power that the utility is to deliver to the customer PODR, and describes the voltage and current waveforms that exist throughout the Distribution System. Transient conditions exceeding the limits may be encountered. Remote sections of rural Distribution System may exceed the limits. IEEE 519 Section 11.5 recommends that the voltage harmonic distortion limits as a percentage of the nominal fundamental frequency voltage in the utility service should not exceed 3% for any individual harmonic, and 5% for the total voltage harmonic distortion.

3.1.4 Voltage Unbalance

The voltage unbalance on the Distribution System under normal operating conditions is typically under 3% but may reach 5% due to the unbalanced loading and single-phase voltage regulation. Voltage unbalance is included in the BCH service voltage range of Table 1 in section 3.1.2.

Voltage unbalance is calculated using RMS voltage levels measured phase to phase at the service entrance under no load conditions:

Voltage unbalance (%) = 100 x [(max. deviation from average) / (average)]

3.1.5 Fault and Line Clearing

BCH may use automatic reclosing to maintain the reliability of the Distribution System. The DG owner needs to be aware of line reclosing when designing DG System protection schemes to ensure that the DG System ceases to energize the Distribution System prior to automatic reclose of BCH substation circuit breakers or line reclosers.

3.2 DG SYSTEM INTERCONNECTION

This section provides the technical requirements to be met by the DG System interconnection with the Distribution System. Typical operating conditions, protection functions, and response to abnormal conditions that the DG System should meet are listed.

3.2.1 Point of Delivery & Receipt – Responsibilities and Quantity Measurement

The Point of Delivery & Receipt (PODR) will be identified on the DG System single line diagram. BCH will co-ordinate design, construction, maintenance and operation of the facilities on the BCH side of the PODR. The DG owner is responsible for the design, construction, maintenance and operation of the facilities on the DG side of the PODR.

In regard to protection functions, the aggregate of DG units rated 30 kW and under may measure voltage level and frequency directly on the ac side of the power generator. Aggregate of DG units larger than 30 kW may measure voltage amplitude and frequency at the customer's service entrance mainswitch, or directly on the ac side of the power generator, as agreed with BCH.

3.2.2 Point of Disconnection - Safety

A disconnecting means to provide a point of isolation between the DG System and the Distribution System is required. Low voltage disconnecting means must meet the intent of the CE Code, Section 84. The purpose of the disconnecting means is to provide safe isolation between the Distribution System and the DG System for safe work purposes. BCH may require additional warning tags or labels to be placed at the DG site.

BCH Safety Practice Regulations:

(a) the customer installs an accessible, load-break disconnect switch, lockable in the open position with a visible break, near the utility meter. This switch is installed between the inverter's ac output and the customer's service entrance ac circuit breaker. This disconnect switch is also required under Rule 84-026 of the Canadian Electrical Code, Part 1. A low-voltage safety switch, where the cover can be opened when the switch is in the "open" position, thus providing visual verification that the contacts are open, is acceptable,

(b) a Local Operating Order will be prepared by the BCH Area Control Centre, for signature by the DG owner. This document defines such items as the switching authority boundary between BCH and the DG, the procedure for either party to obtain a Guarantee of Isolation from the other party, and personnel contact names and phone numbers for BCH and the DG owner.

3.2.3 Interconnection Grounding

DG Systems must be grounded as per manufacturer's recommendations, the CE Code, and take into account that BCH electric service conductors/cables are grounded.

3.2.4 Interrupting Device Ratings

The design of the DG System must consider the fault current contributions from both BCH and the DG System, to ensure that all circuit fault interrupters are adequately sized. If requested, BCH will inform the DG owner of the present and anticipated future fault current contribution from the BCH Distribution System at the PODR.

3.2.5 Overcurrent Protection

The DG System must detect and promptly cease to energize for overcurrent fault conditions in the DG System.

3.2.6 Under-Voltage and Over-Voltage Protection

Every grid-connected DG System requires under/over voltage protection and under/over frequency protection.

Three-phase inverter DG Systems shall cease to energise when any individual phase-to-neutral voltage on a grounded-wye system or any individual phase-to-phase voltage on a ungrounded-wye or delta system goes outside the range of Table 2. Single-phase inverter DG Systems shall detect the phase-to-neutral voltage if connected to neutral. Single-phase equipment connected line-to-line but not to the neutral conductor shall detect the line-to-line voltage.

DG Systems rated more than 30 kW may be required to meet the alternate limits and trip times shown in Table 2.

The DG System shall not attempt to regulate the voltage and shall not adversely affect voltage at the PODR. BCH will decide if voltage regulation is expected to be a concern and identify solutions during the technical review.

DG Systems using rotating machines (induction or synchronous generators) without inverters submit their proposed under/over voltage protection settings/timing to BCH for approval.

Table 2: Inverter Response to Abnormal Voltage Levels

For DG Systems Rated ≤ 30 kW **Source CSA C22.2 No. 107.1-01 Table 16**		**For DG Systems Rated > 30 kW**	
Voltage Condition	Max. number of cycles to disconnect	Voltage Condition	Max. number of cycles to disconnect
V < 50%	6 cycles	V < 50%	6 cycles
50% < V < 88%	120 cycles	50% ≤ V < 88%	120 cycles
---	---	106% < V < 110%	Field adjustable trip may be required*
110% < V < 137%	120 cycles	110% ≤ V < 120%	120 cycles
		120% ≤ V < 137%	120 cycles (10 cycles may be required)*
137% < V	2 cycles	137% ≤ V	2 cycles

**The CE Code Part 2 Product Standard allows a wider normal voltage range than 3.1.2 to allow line regulation equipment time to function. Field adjustable settings for larger DG Systems may be required to improve protection. Field adjustable settings shall be adjusted by qualified personnel only.*

3.2.7 Under Frequency and Over Frequency Protection

DG inverter Systems shall cease to energize during over and under frequency conditions and at preset delay times per Table 3 and shall not reconnect until the Distribution System has Stabilized. For inverter DG Systems capable of supplying more than 30 kW, at least one adjustable under frequency setting and one over frequency setting with adjustable clearing time is generally advised. Individual DG units rated greater than 30 kW require adjustable settings.

Table 3a: Inverter Frequency Operating Limits for DG ≤ 30 kW

Frequency Operating Limits		Source CSA C22.2 No. 107.1-01 Table 16
Utility Voltage Condition	Frequency	Maximum number of cycles to disconnect
Rated voltage	F < rated – 0.5 Hz*	6
Rated voltage	F > rated + 0.5 Hz	6

*The UL 1741 standard and the new IEEE 1547 use F < rated – 0.7. Update when CSA C22.2 No. 107.1-01 is changed.

Table 3b: Inverter Frequency Operating Limits for DG > 30 kW

Frequency Operating Limits		
DG System capacity.	Frequency Range	Number of cycles to disconnect
> 30 kVA	First 59.8 – 57	6 – 18,000
	F > 60.5 Hz	6 – 10,800

DG Systems using rotating machines (induction or synchronous generators) without inverters submit their proposed under/over frequency protection settings/timing to BCH for approval.

3.2.8 Anti-Islanding

The DG System shall meet the anti-islanding requirements of CSA Standard C22.2 No. 107.1-01, ***General Use Power Supplies***, Section 15, and cease to energize the Distribution System within a time no greater than two seconds after the formation of an unintentional island.

3.2.9 Power Factor

The DG System is not required to be capable of adjusting the power factor but shall operate in the preferred range of ±0.90. If the DG System disturbs the Distribution System voltage levels at the PODR, then the DG may be required to operate the DG System within a smaller range or take other compensatory measures.

3.2.10 Voltage Flicker

The DG System shall not cause objectionable flicker on the Distribution System. It is recognised that flicker is a site dependent condition. Voltage flicker is an increase or decrease in voltage over a short period of time, normally associated with motor starting or fluctuating load. The characteristics of a particular flicker problem depend on the characteristics of the load change.

The limits for voltage flicker caused by the DG System at the PODR are:

Voltage Dip Not to Exceed	Number of Times Permitted
3.3% of normal voltage	up to once per hour in urban systems supplying many customers
6.5% of normal voltage	up to once per hour in rural systems supplying few customers

Voltage dips more frequent than once per hour must be limited to the "Borderline of Irritation" curve of Figure A-3, "B.C. Hydro's Voltage Flicker Limits".

3.2.11 Harmonic Distortion

DG Systems are expected to comply with IEEE Standard 519 current distortion limits, as listed in Table 4, below. For inverters only capable of operating in voltage follower mode, voltage harmonic distortion limits are not specified. Inverters certified to CSA Standard 107.1-01 are considered to meet these requirements. CSA Standard 107.1-01 excludes current harmonics due to voltage distortions in the utility Distribution System. Total current harmonic distortion shall not exceed 5% of rated current.

Table 4: Inverter or Rotating Machine Limit of Current Harmonic Distortion

Limits of Current Harmonic Distortion*	***Source CSA C22.2 No. 107.1-01 Table 15**	
Harmonic Numbers	Maximum distortion	
	Even Harmonics	Odd harmonics
2^{nd} through 9^{th}	1.0%	4.0%
10^{th} through 15^{th}	0.5%	2.0%
16^{th} through 21^{st}	0.4%	1.5%
22^{nd} through 33^{rd}	0.2%	0.6%
Above 33^{rd}	0.1%	0.33%

3.2.12 Voltage Unbalance

When single-phase DG units are connected in multiple units, if three-phase service is available, then approximately equal amounts of generation capacity should be applied to each phase of a three-phase circuit.

3.2.13 DC Injection

The DG System shall not inject a dc current greater than 0.5% of the unit rated output current after a period of six cycles following connection to the Distribution System.

3.2.14 Synchronization

DG Systems that can generate an ac voltage waveform independent of the Distribution System shall be connected in parallel with BCH only in combination with synchronizing capabilities. The DG System shall synchronize to the Distribution System while meeting the flicker requirements of 3.2.10 and without causing voltage variation at the PODR of greater than 5%. The DG System may synchronise when the Distribution System is Stabilized.

Induction generators do not require synchronization since there is no generated voltage prior to connecting to BCH. The generator speed is brought to within 0.5% of its rated value then connected. Induction generators may be started as induction motors using power from the BCH system provided that these units do not cause unacceptable voltage flicker on start-up or on connect/disconnect. Induction generators shall be compensated in the DG System to a full load power factor of 0.90 or better.

For synchronous generators, an approved automatic synchronization device must be provided in all cases where the plant is to be operated unattended. If the plant is attended, the generator may be equipped with a manual synchronization device with relay supervision. The operator on site must have sufficient training to perform the function safely. Synchronization controls shall satisfy the following conditions:

(a) the generator speed should be matched to within 0.5% of its rated speed or a frequency difference within +/- 0.5 Hz,

(b) the phase angle difference between the generator and BCH should be less than 15 degrees,

(c) the RMS voltage magnitude difference between the two systems should be less than 4% to avoid excessive currents,

(d) field current should not be applied until the generator speed is at least 85% of its nominal value.

3.3 TYPICAL INTERCONNECTION PROTECTION FUNCTION REQUIREMENTS

The DG System shall meet the applicable protective functions in Table 5.

Table 5: Inverter & Rotating Machine Interconnection Protection Function Requirements[1,2,3]

Function		1 Phase	3 Phase		
			≤ 30 kW	30 kW – 50 kW	
	AC Disconnect Means	Y	Y	Y	
	Anti-Islanding	Y	Y	Y	
25	Automatic Synchronizing[4]	Y	Y	Y	
27	Under-Voltage Trip	Y	Y(3)	A(3)	
59	Over-Voltage Trip	Y	Y(3)	A(3)	
50	Instantaneous Overcurrent[5]	Y	Y(3)	Y(3)	
51	Timed Overcurrent[5]	Y	Y(3)	Y(3)	
81/U	Under-Frequency Trip	Y	Y	A	
81/O	Over-Frequency Trip	Y	Y	Y	
	Secondary Injection Capability				

Notes:

1. Interconnection of 1 and 3 phase generation units connected at 600 volts or less in accordance with Canadian Electrical Code
2. Y = required; A = adjustable set points may be required as per 3.2.6 and 3.2.7.
3. Number of phases monitored shown in parentheses, e.g. (3)
4. Inverters with standalone capability, and synchronous generators.
5. 50/51 functions may be met by fuses or circuit breaker

4.0 INSPECTION, TESTING AND COMMISSIONING

4.1 General

B.C. Hydro's interest in commissioning is to ensure that the DG System does not pose safety hazards, meets the performance criteria of power quality and system reliability during normal and abnormal conditions, and does not adversely affect the operation of the BCH power system. Involvement of BCH personnel in commissioning does not mean, expressly or by implication, that all or any of the requirements of the law or good Engineering practices have been met by the DG System.

BCH may inspect DG System equipment, documents and installation procedures, and witness field tests. The DG owner shall notify BCH at least 2 weeks before the initial energizing and start-up testing of the DG System. Wherever practical, inspection timing and scheduling shall be mutually agreed by the DG owner and BCH.

For DG systems rated > 5 kW, step-by-step energizing and commissioning procedures shall be provided to BCH prior to DG System commissioning. The DG owner shall make available to BCH a complete set of manuals for use during inspection, testing, and commissioning.

BCH must approve the settings and timing applied to overcurrent and power quality protection relays.

The DG owner has full responsibility for commissioning and periodic maintenance of the interconnection equipment. Commissioning and maintenance must be performed by competent personnel from the DG owner or a recognized service consultant. A copy of the commissioning and maintenance test reports signed by the person in charge shall be retained by the DG owner.

All electrical equipment in the DG System shall be certified and approved by the appropriate regulatory agency.

4.2 Type Testing

All inverters shall be certified to CSA Standard 107.1-01, Section 15, or be demonstrated to meet the anti-islanding test in CSA 107.1-01 as part of another product certification standard.

4.3 Protection Function Testing

(i) If microprocessor-controlled protective functions are used, and production line testing has been done to verify conformance with 3.2.6, 3.2.7, and 3.2.8, then a repeat of the production line testing (subject to item (ii) below) in the field is not required. Recommended manufacturer commissioning testing is required,

(ii) The anti-islanding function shall be checked by operating a disconnecting means to verify that the DG System ceases to energize the Distribution System and does not energize the Distribution System for the required time delay after the disconnecting means is closed,

(iii) If batteries are used, verify that the protection settings are stored in non-volatile memory. Disconnection or removal of batteries for a minimum of 10 minutes without change of the protection settings is an acceptable method of demonstrating non-volatile memory,

(iv) Testing of the DG System, where required, shall include procedures to functionally test all protective elements up to and including cease to energize the Distribution System at the point of DG System connection to the customer's internal wiring. Testing will verify all adjustable protective set points, if any, and relay/breaker trip timing, if any.

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

5.0 MAINTENANCE & OPERATION

The DG owner has full responsibility for routine maintenance of the DG System and shall keep maintenance records according to the equipment manufacturer recommendations and accepted industry standards, in particular CE Code Part 1, paragraph 2-300.

DG System protection function operation shall be verified according to the manufacturer's recommended schedule, or at least annually if there is no manufacturer recommendation. Operating the disconnecting means and verifying that the DG System automatically ceases to energize the Distribution System and does not resume energizing until the Distribution System is Stabilized after the disconnecting means is closed is an acceptable verification method.

Failure to maintain CE Code and industry accepted maintenance standards can result in disconnection of the DG facility.

INFORMATIVE ANNEX A

SINGLE LINE DIAGRAMS FOR TYPICAL DG TECHNOLOGIES

FIGURE A-1: GRID-INTERACTIVE DG USING SOLAR PV, FUEL CELL OR DC-GENERATING WIND SYSTEMS

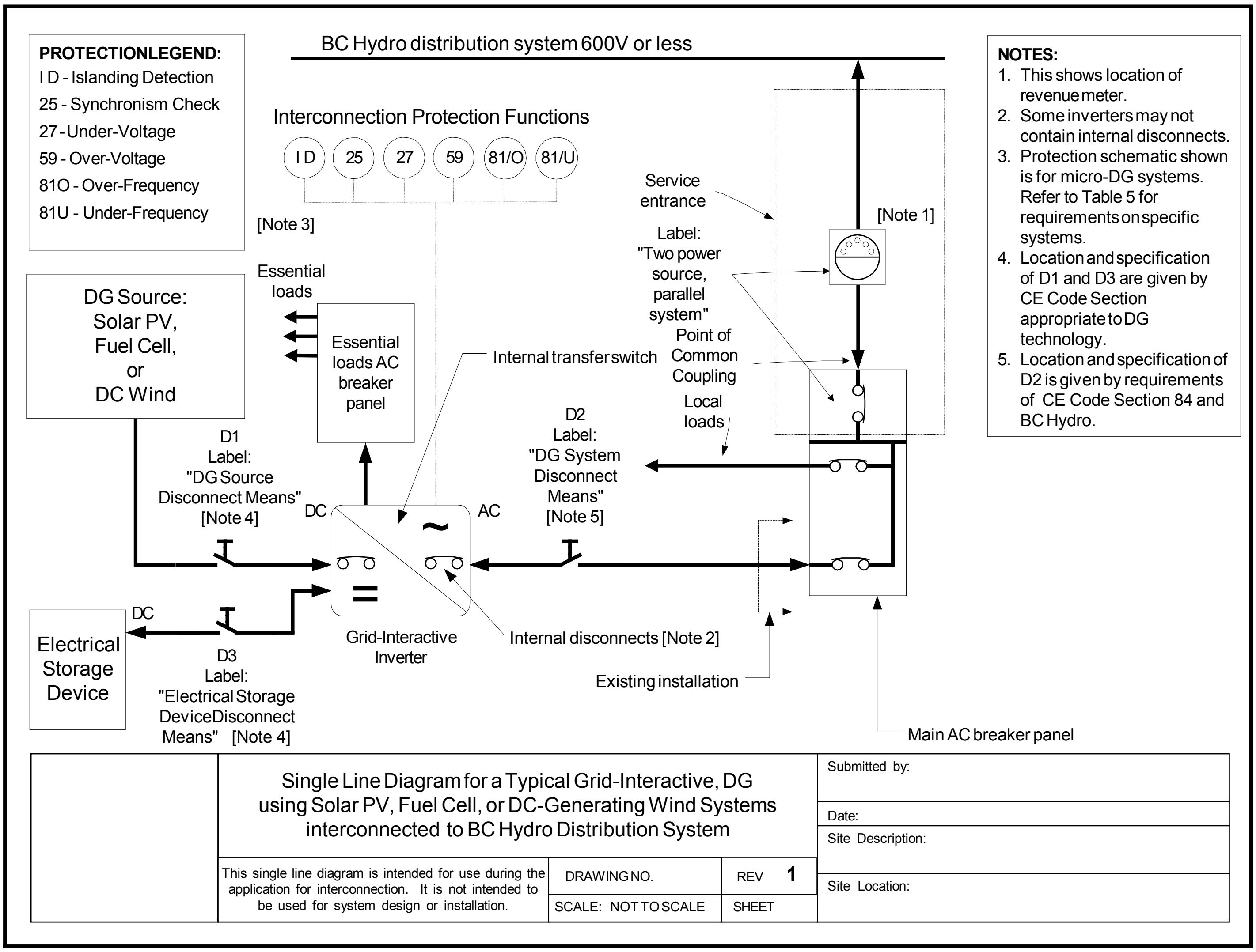


FIGURE A-2: DG USING INDUCTION OR SYNCHRONOUS GENERATORS

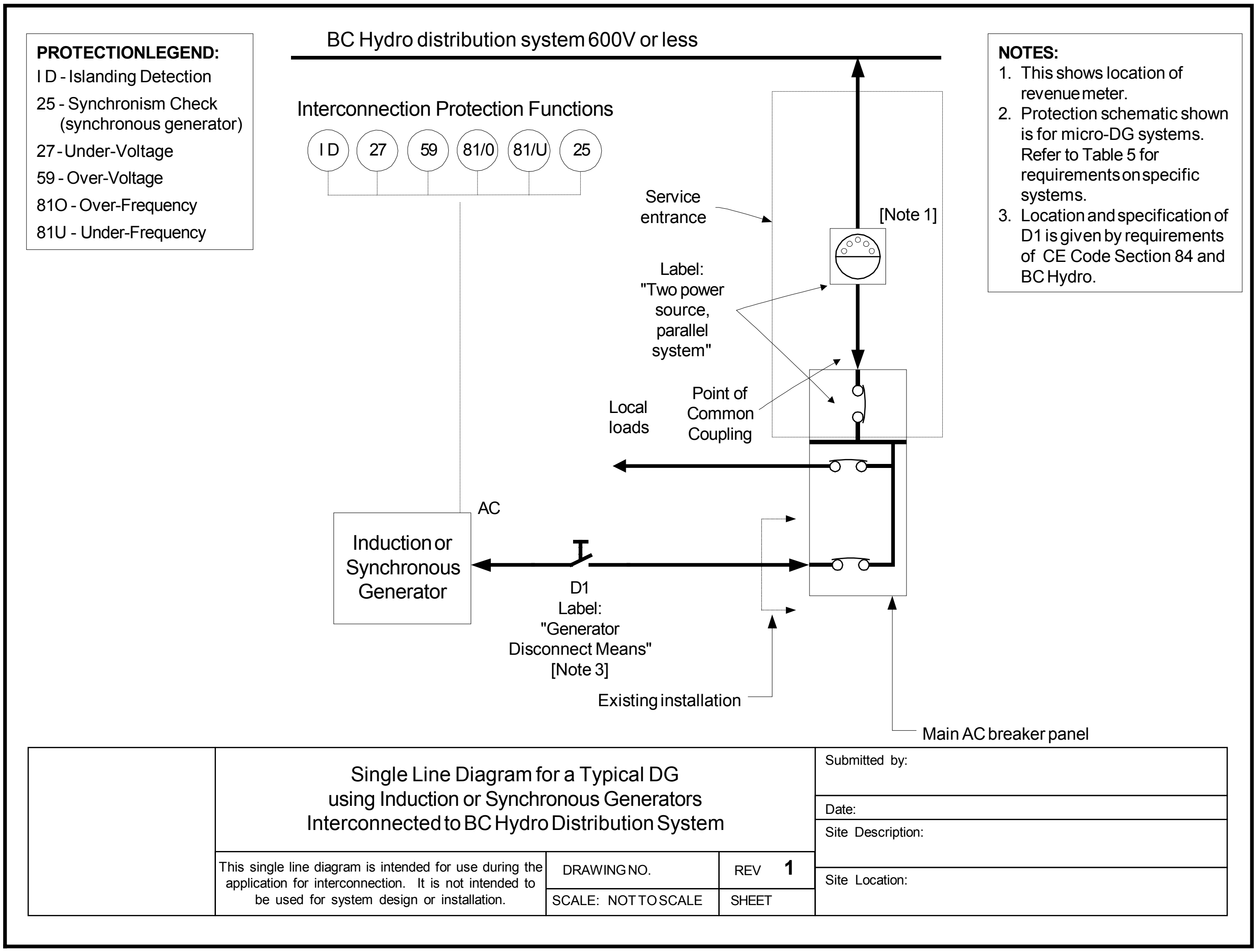
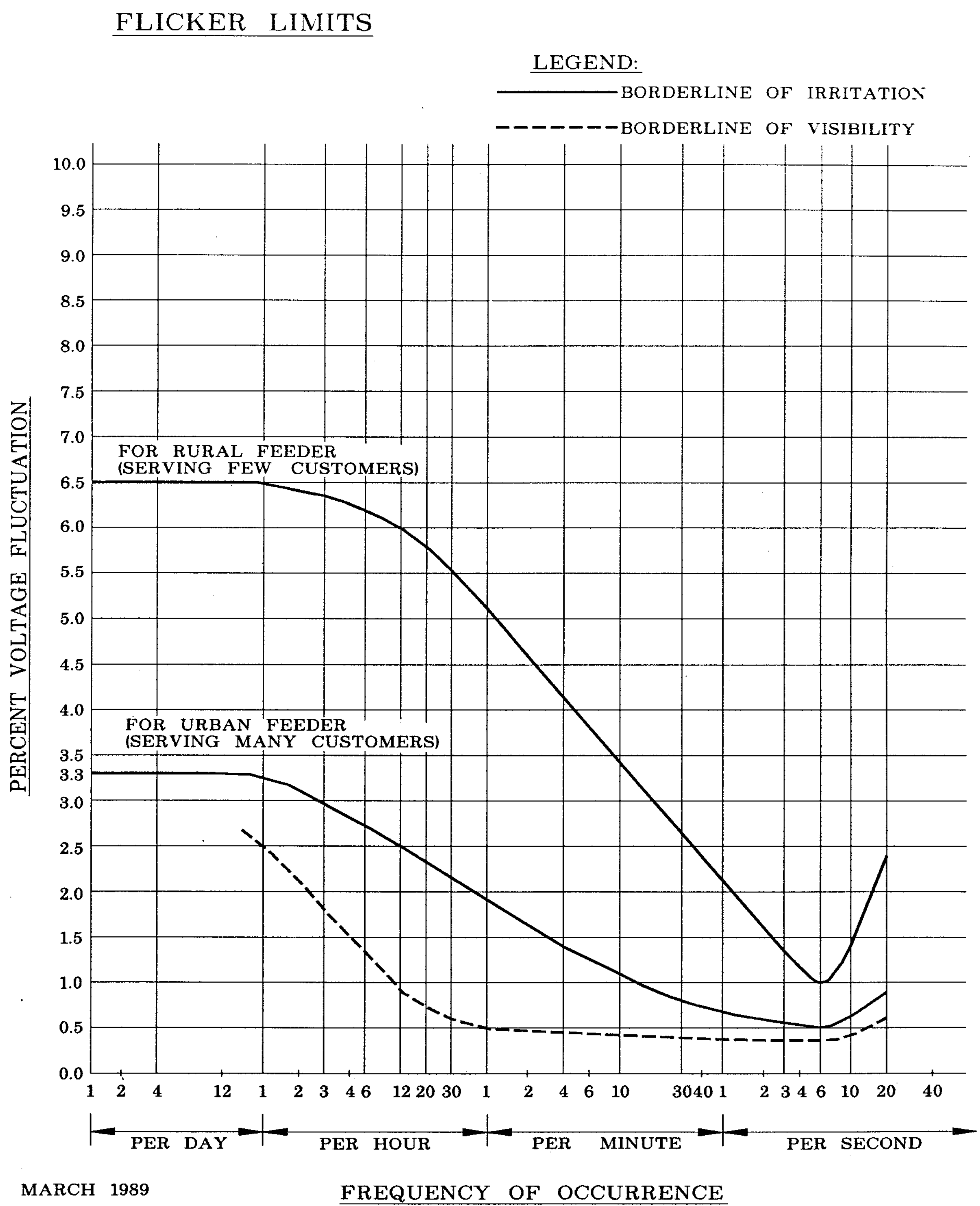


FIGURE A-3: BC HYDRO VOLTAGE FLICKER LIMITS



INFORMATIVE ANNEX B

INVERTER CLASSIFICATIONS AND OPERATING MODES

This informative annex is intended to provide a basic awareness of the types of inverters available and their operation.

B.1 Classification based on the dc link

Voltage source inverter: An inverter in which the dc link has a constant voltage, usually by way of a bank of capacitors, battery cells, or other electrical storage device.

Current source inverter: An inverter in which the dc link has a constant current, usually by way of an inductor.

B.2 Classification based on method of commutation

Self-commutated inverter: An inverter in which its semiconductor devices such as transistors, IGBTs, MOSFETs, GTOs and thyristors can be turned off by their own control circuits or auxiliary circuits. Most grid-connected inverters are self-commutated. Also known as a forced-commutated inverter.

Line-commutated inverter: An inverter in which its semiconductor devices, such as thyristors, are turned off with the help of an external source. Most line-commutated inverters are current controlled.

Load-commutated inverter: An inverter in which its semiconductor devices, such as thyristors, are turned off with the help of a load such as a synchronous motor.

B.3 Classification based on the output control

Voltage controlled inverter: An inverter that directly controls its voltage output.

Current controlled inverter: An inverter that directly controls its current output: waveform, magnitude and phase angle. Most grid-connected inverters and small inverters are of this type.

B.4 Classification based on the output waveforms

Sinusoidal wave inverter: An inverter that has a sinusoidal- output waveform.

Square wave inverter: An inverter that has a periodic square wave output, 180 degrees positive followed by 180 degrees negative.

Modified sine wave inverter: An inverter that has a periodic quasi-square wave output, usually 120 degrees positive, 60 degrees zero, 120 degrees negative, 60 degrees zero.

Voltage-following inverter: An inverter that operates in voltage-following mode.

B.5 Classification based on relationship to utility interconnection

The following modes can describe inverter operation:

a) ***Stand-alone mode***: in which an inverter operates in isolation from a Wires Owner's distribution facility, and generates its own voltage, phase, and frequency conditions.

b) ***Grid-parallel mode:*** in which an inverter operates in parallel with a Wires Owner's distribution facility and contains provision for synchronising its voltage, phase, and frequency to that facility.

c) ***Grid-dependent mode:*** in which an inverter operating in grid-parallel mode depends on a Wires Owner's distribution facility to initiate and maintain its operation.

Stand-alone inverter: An inverter that operates only in stand-alone mode and thus contains no facility to synchronise its output with a Wires Owner's distribution facility (can also be termed a grid-isolated inverter).

Grid-connected inverter: An inverter that is able to operate in grid-parallel mode. Also known as a grid-intertie or a grid-tied inverter.

Grid-dependent inverter: A type of grid-connected inverter that operates only in grid-dependent mode.

Grid-interactive inverter: A type of grid-connected inverter that is able to operate in both stand-alone and grid-parallel modes according to the availability of the Wires Owner distribution facility. It can be considered as a UPS that is also able to operate in grid-parallel mode. Note that this type of inverter initiates grid-parallel operation.

B.6 Classification based on the number of output phases

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

Three-phase inverter: An inverter that generates a three phase electrical output. Also known as a polyphase inverter.