GRID CODE

Interconnection Requirements
At Voltages 24.9kV and below

MAY 2014

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LIMITATION OF LIABILITY AND DISCLAIMER

BL&P "Grid Code: Interconnections Requirements at Voltages 24.9kV and below" (the "Grid Code") identifies minimum requirements for generation projects connecting to the BL&P's distribution system.

Additional requirements may need to be met by the owner of the generation project to ensure that the final connection design meets all local and national standards and codes and is safe for the application intended.

The Grid Code is based on a number of assumptions, only some of which have been identified. Changing system conditions, standards and equipment may make those assumptions invalid.

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As such, the specific quantities shall only be used as a guide, subject to in-depth evaluation, in the Connection Impact Assessment (CIA) process.

CONTACT/PUBLISHER

Please forward questions/comments regarding the Grid Code to the following email address:

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REVISION HISTORY DATE	VERSION	COMMENTS
May 2014	Rev. 1	Revisions following Public Consultation and internal review. Revisions include updating of the Limitation of Liability and Disclaimer and updating/removal of some Terms and Definitions and updating References. Pages affected 5, 9, 15, 18, 19, 23, 49, 57, 72, 85, 86, 87
April 2013	Rev. 0	First Issue

1.0 INTRODUCTION

This document, — “Grid Code: Interconnection Requirements at Voltages 24.9kV and below” (the “Grid Code”) - outlines the technical requirements for the installation, or modification, of Distributed Generation (DG) projects connecting to the Barbados Light & Power Company Limited’s (BL&P) Transmission and Distribution System feeders at ≤ 24.9 kV

Connection of DG supply sources to the BL&P’s Distribution System feeders impacts the steady-state and transient voltage profiles and current distribution along the feeder in response to changing supply, load and fault conditions. These connections must:

1. Preserve acceptable safe operation of the Distribution System for the general public, customers and employees that work on the Transmission and Distribution System.
2. Maintain reliability and quality of service to BL&P customers.
3. Abide by the requirements of the Government Electrical Engineering Department (GEED), BL&P Switching and Tagging procedures, Institute of Electrical and Electronic Engineers (IEEE) 1547, National Fire Protection Association (NFPA) 70 National Electric Code (NEC) standards, Canadian Standards Association (CAN/CSA) C22.3 No. 9-08 and British Standard EN 50160.
4. Be compatible with BL&P‘s standard operating, protection, control and metering systems and practices.

To accomplish this, the design of the power equipment, protection, control and metering systems used at the DG Facility interconnection must meet specific minimum requirements. Depending on the capacity and electrical characteristics of the connecting DG Facility, specific additions and/or modifications may be required to BL&P’s equipment, protection, control and metering systems to facilitate the connection. This document has been developed with reference to the requirements of the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547 – Interconnecting Distributed Resources with Electric Power Systems, CAN/CSA C22.3 No. 9-08 Standard – Interconnection of Distributed Resources and Electricity Supply Systems, British Standard EN 50160, the NFPA NEC 2011 Code and the BL&P Switching and Tagging Procedures.

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It is imperative that these requirements are understood by those delegated or contracted by the DG Owner for the planning, design, equipment manufacture and supply, construction, commissioning, operation and maintenance of the DG Facility.

1.1 SCOPE

This document applies to single-phase or three-phase DG Facilities with aggregate capacity > 150kW interconnecting to BL&P's Transmission and Distribution System at ≤ 24.9 kV. Interconnection requirements for systems with capacities ≤ 150kW are described in the document: 'Requirements for Grid Interconnection of Renewable Generation Systems'.

This document is intended to be applied to electric power generators using all types of energy sources, energy storage and energy conversion technologies – directly connected synchronous and asynchronous rotating machines, and those connecting via inverters or static power converters which are above the threshold mentioned above. This document does not apply to generators paralleling with BL&P for less than 100ms (Momentary Closed Transition Switching) except as noted in Section 2.1.23.

Section 2 contains minimum requirements that the DG Owner is required to comply with in order to connect to BL&P's Distribution System. Depending on the size of the interconnecting DG Facility, the voltage of the interconnected distribution feeder, and whether the facility is single-phase or three-phase certain requirements may not apply. It is the DG Owner's responsibility to ensure that requirements are met for the specific system configuration. These requirements have been developed to ensure that the integrity and power quality of BL&P's Transmission and Distribution System are maintained to acceptable levels after connection of the DG Facility. Additional requirements may be necessary to address unique situations and the DG Owner shall be advised of any such requirements at the appropriate stage by BL&P. Any exemptions require written approval from BL&P. This document does not specify all of the protection requirements for the generator and equipment at the DG Facility. Minimum protection requirements for interconnection are, however, specified in Section 2.3. The DG Owner should ensure that adequate generator protections as well as protections for other equipment within the DG Facility are installed. This is to protect them from damage from faults or abnormal conditions which may originate at the DG Facility or from BL&P Transmission and/or Distribution System.

This document does not constitute a design handbook and is not a substitute for any Safety Code. DG Owners who are considering the development of a DG facility to connect to BL&P's system, shall engage the services of a professional engineer or a registered consulting firm qualified to provide design and consulting services for electrical interconnection facilities in Barbados.

1.2 OBJECTIVES

BL&P is committed to establishing the rules for connection of approved forms of generation to the Distribution System, while preserving a safe and reliable electrical supply to all of its customers. Interconnection of the DG Facilities must conform to relevant regulations in Barbados and international design standards.

The following objectives shall be integrated into the design specification, construction, operation and maintenance of the DG Facility interconnection.

SAFETY - The DG interconnection must not create a safety hazard to the general public, BL&P customers, BL&P employees who work on the Transmission and Distribution System or to personnel working in the DG Facility.

POWER QUALITY - Connection of DG Facilities must not materially degrade the power quality of the BL&P Transmission and Distribution System below acceptable levels.

RELIABILITY - Connection of DG Facilities must not compromise the reliability of the BL&P Transmission and Distribution System.

ACHIEVABILITY - The DG Facility interconnection requirements will allow fair and equitable access for all DG Owners.

OPERABILITY - The DG Facility connection must not restrict the operation of the BL&P Transmission and Distribution System. All aspects of the interconnection that can impact the BL&P Transmission and Distribution System must be compatible with BL&P standard operating, protection, control and metering systems and practices.

1.3 RESPONSIBILITIES

Connecting to BL&P's Distribution systems involves several steps and both BL&P and the DG Owner have distinct responsibilities.

BL&P is responsible for:

1. The safety, reliability, power quality and operation of BL&P‘s Transmission and Distribution System and ensuring the DG Facility connection does not adversely affect the network or BL&P‘s existing customers.

2. Maintaining the integrity of BL&P‘s Transmission and Distribution System.

3. Operating its own systems in compliance with all applicable regulatory codes in Barbados and international standards.

4. Establishing the terms and conditions for Operating and Technical Requirements consistent with the DG Facility connection “Objectives”.

DG Owners are responsible for:

1. The safety, design, construction, operation, metering, protection and control, and maintenance of the DG Facility.

2. Operating the DG facility in compliance with all applicable regulatory codes in Barbados and within the guidelines of all applicable GEED codes and international standards.

3. Ensuring that the DG Facility is compatible with BL&P‘s standard operating, protection, control and metering systems and practices.

4. Abiding by the terms and conditions of BL&P‘s Operating and Technical Requirements.

1.4 TERMINOLOGY

In this Document, “Grid Code”, the term:

1. “Shall” is used to express a requirement – i.e. a provision that the DG Owner is obligated to satisfy in order to comply with the requirements of this document.

2. “Should” is used to express a recommendation or that which is advised but not required.

3. “May” is used to express an option or that which is permissible within the limits of this document.

4. “Can” is used to express possibility or capability considering evaluation of the CIA.

Requirements may follow with a “Background Information” and “Design Considerations" section below them which do not include requirements. The purpose of these sections is to provide informative material, rationale on which the requirements in the section are based on and some design considerations. These sections are included as required and are not necessarily present for all requirements.

Appendices are designated normative, if they are mandatory or informative, if non-mandatory, to define their application.

1.5 CAPACITY LIMITATIONS ON GENERATOR INTERCONNECTIONS FEEDER LOADING LIMITS

The capacity for all sections of all feeders, the "feeder limitation," is based mainly on the distance from the BL&P's substation to the DG's Point of Common Coupling (PCC). The feeder limitation applies to all DGs connected, or connecting, to the feeder and considers the rated output capacity of each DG. Any single DG connection can affect the capacity available for all sections of the feeder. For all sections of the feeder, the total current shall not exceed:

a) 250 Amps for BL&P feeders operating at 11kVwith conductor size 1/0 AWG.AL

b) 700 Amps for each BL&P feeder operating at 24.9kV with conductor size of 795 mcm and 400 amps for feeders with conductor size of 336 mcm.

ACCEPTABLE GENERATION LIMIT AT A TRANSMISSION SUBSTATION (TS) OR A DISTRIBUTION SUBSTATION (DS)

The acceptable generation limit at a TS or a DS will be determined on a case by case basis, in conjunction with the location of the TS or DS and the connected feeders.

SHORT CIRCUIT (SC) LIMITS

The SC limits at TS low voltage bus, or at any portion of distribution feeder, shall not be exceeded by the addition of DG Facilities. The impact on SC limits will have to be assessed in the CIA.

Refer to Section 2.1.16 for requirement.

1.5.1 THREE PHASE GENERATORS

1. The individual generation limits for three-phase DG Facilities interconnecting to the BL&P Distribution System feeders are:

   a) 1 MW per connection on feeders operating at11kV; and

   b) 25 MW per connection on 24.9kV feeder. There may be only one connection on a 24kV transmission system.

2. The feeder limitation determines the total acceptable three-phase generation allowed for all sections of BL&P`s Transmission and Distribution System feeders. These limits are:

a) 5 MW for feeders operating at 11kV

b) 25 MW for transmission feeders operating at 24.9kV

These limitations are a general rule and may be modified based on the Connection Impact Assessment (CIA).

1.5.2 SINGLE PHASE GENERATORS

1. The maximum single phase generation limits for specific feeders cannot exceed:

    a) 150kW for single phase generators connecting to feeders operating at nominal voltage levels of 11kV. Where several single phase DG facilities are located on a three phase feeder, every effort must be made to balance the associated currents.

    b) No single phase generators shall be connected to feeders operating at nominal voltage levels of 24.9kV.

Note: While the absolute limits are stated above, the actual acceptable individual single phase generation limit for specific feeders, or TS/DS, will be determined by the Connection Impact Assessment (CIA).

1.6 DOCUMENT REPRODUCTION

This document may be reproduced or copied in whole or in part provided that credit is given to BL&P and it is not sold for profit.

1.6.1 DOCUMENT CREDIT

Credit is given to Hydro One Networks Inc. for reference to their interconnection document.

1.7 TERMS AND DEFINITIONS

The Term	Is defined as
ANSI	American National Standards Institute
Anti-Islanding	A protection system aimed at detecting islanded conditions (see island) and disconnecting the DG facility from the Distribution System if an island forms
AVR	Automatic Voltage Regulator
BF	Breaker Fail
Breaker	Fault Interrupting Device: this may be a breaker, circuit switcher, HVI, LVI
CEA	The Canadian Electricity Association
CIA	Connection Impact Assessment
Class 1	150kW < DG aggregate capacity at PCC < 1500kW
Class 2	1.5MW ≤ DG aggregate capacity at PCC ≤ 10MW
Class 3	DG aggregate capacity at PCC > 10MW
Clearing Time	See Trip Time
COG	Coefficient of grounding - is defined as 100% x E_{LG}/E_{LL} where: E_{LG} is the highest rms, line-to-ground, power-frequency voltage, on a sound phase, at a selected location, during a line-to-ground fault affecting one or more phases. E_{LL} is the line-to-line power-frequency voltage that would be obtained, at a selected location, with the power fault removed. COG for three-phase systems are calculated from the phase-sequence impedance components, as viewed from the fault location
Comtrade	Common Format for Transient Data Exchange
COVER	Confirmation of Verification Evidence Report
CSA	The Canadian Standards Association
Demarcation Point	The point at which the BL&P equipment ends and another party's equipment begins
DFR	Disturbance Fault Recorder
DG	See Distributed Generation (*Formerly referred to as EG – Embedded Generator)
DGEO	Distributed Generator End Open: a signal used to confirm the status of the generator breaker – used to prevent out-of-phase reclosing onto the generator
DGIT	See DG Interconnection Transformer
DG Facility	All equipment including generators, interface transformer, protections, and line on the DG side of the PCC
DG Interconnection Transformer	The transformer used to step up the voltage from the DG to distribution voltage levels.
DG Owner	The entity which owns or leases the DG facility.
Distributed Generation (DG)	Power generators connected to a Distribution System through a Point of Common Coupling (PCC).
Distributed Generator (DG	See Distributed Generation

DCA	Distribution Connection Agreement. The DG Facility is required to enter into a Distribution Connection Agreement with BL&P prior to generating onto the system
Distribution Lines	Distribution System lines that operate at nominal line-line voltages of 24.9 kV or below.
Distribution System	Any power line facilities under the operating authority of BL&P or that operate at nominal line-line voltages of 24.9 kV or below.
DNP 3.0	Distributed Network Protocol
DO	Drop Out
DS	Distribution Substation. An electrical station that is used to step down a 24kV voltage to a distribution voltage for distribution at 11kV to the end use customer.
Effectively Grounded	A system grounded through a sufficiently low impedance so that COG does not exceed 80%. This value is obtained approximately when, for all system conditions, the ratio of the zero-sequence reactance to the positive-sequence reactance, (X0/X1), is positive and ≤ 3, and the ratio of zero-sequence resistance to positive-sequence reactance, (R0/X1), is positive and < 1.
EMI	Electromagnetic Interference
Essential Loads	Part of the load that requires continuous quality electric power for its successful operation or devices and equipment whose failure to operate satisfactorily jeopardizes the health or safety of personnel, and/or results in loss of function, financial loss, or damage to property deemed essential by the user.
F Class Feeder	Distribution feeder emanating from BL&P
Ferroresonance	A phenomenon caused by the interaction of system capacitance and nonlinear inductance of a transformer, usually resulting in very high transient or sustained overvoltage
Ferroresonance Protection (59I)	Ferroresonance detection can be accomplished with a peak detecting overvoltage element (59I). Where ferroresonance is expected or found to be a problem, ferroresonance detection will be required by the local DG interface protection at the DG location to disconnect the generator.
GPR	Ground Potential Rise - IEEE defines this as the voltage that a station grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth.

Harmonics	Sinusoidal voltages and currents at frequencies that are integral multiples of the fundamental power frequency (50Hz).
High Voltage	In this document, high voltage refers to the BL&P system voltage and can be referred to as medium voltage.
BL&P	Barbados Light & Power Company Limited
HVGT	HV Grounding Transformer
HV Ground Source	Three-phase ground sources are any three-phase power transformers or grounding transformers that provide a ground-current (zero-sequence) return path to phase-ground faults on the HV side of the DGIT. That includes separate HV grounding transformers or DGITs that have star-connected HV winding with the star-point neutral connected to ground, either solidly or through a reactor.
HVI	High Voltage Interrupter – any breaker/fault clearing device that is on the BL&P side of the DGIT – voltage rating is usually at medium voltage distribution level.
ICCP	Inter-Control Center Communications Protocol
IEEE	The Institute of Electrical and Electronics Engineers
IED	Intelligent Electronic Device
Interconnection facility	Physical connection of DG to BL&P's Distribution System which allows parallel operation to occur
Interconnection Point	See PCC
Interrupting Device	The device used to disconnect generation from BL&P‘s Distribution System: this may be a high voltage interrupter (HVI) or through a low voltage interrupter/breaker (LVI).
Island	An operating condition where a DG(s) is (are) supplying load(s) that is electrically separated from the main electric utility.
Load	The amount of power supplied or required at a specific location
Load Factor	Ratio of average load during a designated period to the peak (maximum) load in the same period
Load Flow Study	Steady state computer simulation study of voltages and currents in the Distribution System.
LSBS	Low Set Block Signal – signal sent over the same channel as DGEO which blocks the Low Set Instantaneous Protections at BL&P‘s substations
LVGT	Low Voltage Grounding Transformer
LVI	Low Voltage Interrupter - any breaker/fault clearing device that is on the customer side of the DGIT – voltage rating is usually at the service voltage level.
MCOV	Maximum Continuous Operating Voltage
Medium Voltage	See High Voltage
NDZ	Non Detection Zone - range where passive anti-islanding protection may not operate within required time due to the small mismatch between generation and load
NERC	North American Electric Reliability Corporation
NEV	Neutral to Earth Voltage
MTBF	Mean Time Between Failure
OLTC	On Load Tap Changer

Parallel operation	The state and operation where the DG Facility is connected to the Distribution System and supplies loads along with the electric grid.
PCC	Point of Common Coupling. It is the point where the DG Facility is to connect to BL&P's Distribution System
Point of Connection	The point where the new DG Facility's connection assets or new line expansion assets will be connected to the existing BL&P's Transmission and Distribution System
Pst	A measure of short-term perception of flicker obtained for a ten minute interval.
PSS	Power System Stabilizer
Protection Scheme	Protection functions including associated sensors, relays, CTs, VTs, power supplies, intended to protect a Distribution System or interconnected facility.
PQ	Power Quality
PT	Potential Transformer
PU	Pick Up
Resonance	A tendency of a system to oscillate at maximum amplitude at certain frequencies, usually resulting in very high voltages and currents.
ROCOF	Rate-of-change-of-frequency
RMS	Root Mean Square
RTU	Remote Terminal Unit
SC	Short Circuit Current
SCADA	Supervisory Control and Data Acquisition
SER	Sequence of Events Recorder
Service Provider	A service Provider is an entity that provides services to other entities
SLD	Single Line Diagram
SPS	Special Protection Scheme
Stabilized	A Distribution System returning to normal frequency and voltage after a disturbance for a period of 5 minutes or as determined by the Wires Owner
Synchronized	See Parallel Operation
Telemeter	Transfer of metering data using communication systems
TCA	Transmission Connection Agreement
THD	Total Harmonic Distortion – a measurement of the harmonic distortion present. It is defined as a ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency
GC	Abbreviation for this document (DG Grid Code)
TOV	Temporary Overvoltage – oscillatory power frequency overvoltages of relatively long duration, from a few cycles to hours.

Transmission System	Any power line facilities under the operating authority of the Wires Owner usually operating at higher then 24.9kV voltages, line to line.
Transfer Trip	A signal sent over communication channels from upstream devices commanding the DG to disconnect from Barbados Light & Power Company Limited's Distribution System.
Trip Time	The time between the start of the abnormal condition to the time where the system disconnects and ceases to energize the Distribution System.
TS	Transmission Substation. An electrical station that is used to step down 69kV voltage to a sub-transmission voltage for distribution at 24kV to the end use customer and DS stations.
TT	See Transfer Trip
Type Test	Test performed on a sample of a particular model or device to verify its operation and design.
UTC	Coordinated Universal Time
VR	Voltage Regulator
VT	Voltage Transformer
Wires Owner	Utility which owns and/or operates the Distribution System.

The Grid Code

2.0 TECHNICAL INTERCONNECTION REQUIREMENTS

2.1 GENERAL REQUIREMENTS

2.1.1 SAFETY

1. The DG Facility interconnections installation and operation shall not create a safety hazard to BL&P‘s personnel, customers, the general public or personnel working in the DG Facility.

BACKGROUND INFORMATION

Safety is of primary concern and shall be the main consideration when designing the DG Facility. The primary concern of this document is to provide interconnection specifications to ensure that safety will be maintained.

2.1.2 ACTIVE POWER

1. The DG Facility shall have to restrict their active power export to the project capacity which was applied for and approved in the Connection Impact Assessment.

   [Note: Typically the Generator‘s Name Plate Capacity or Gen-Set Name Plate Capacity shall be considered as project size.]

2.1.3 REACTIVE POWER

1. The DG Facility shall comply with voltage and power factor requirements in Section 2.2.2.1 and Section 2.2.2.6 respectively.

2.1.4 EQUIPMENT RATING AND REQUIREMENTS

1. All electrical equipment and its installation shall be in accordance with GEED requirements, BL&P’s Switching and Tagging procedures and BL&P’s Information & Requirements Booklet.

2. The DG Facility shall have the electrical installation authorized by GEED, prior to establishing a Distribution Connection Agreement (DCA) with BL&P.

3. The DG Facility shall be maintained throughout the life of the assets to ensure that the DG Facility operates as designed.

4. The DG Facility interface equipment shall be compatible with BL&P's Distribution System equipment at the connection voltage which includes, but is not limited to:

    a) Maximum Voltage;

    b) Basic Impulse Limit (BIL);

    c) Short Circuit Ratings (SCR); and

    d) Capacity.

5. Connection of DG Facilities shall not cause the ratings of BL&P's Transmission and Distribution System equipment to be exceeded for all operating conditions. This includes, but is not limited to:

    a) Equipment thermal load limits; and

    b) Equipment short circuit limits.

6. Where reverse power flow is possible, all existing voltage regulating and metering devices shall be suitable for bi-directional flow.

7. Changes to BL&P`s Transmission and Distribution System equipment ratings due to the interconnection of DG Facilities shall be assessed by the BL&P's CIA.

2.1.5 POINT OF COMMON COUPLING (PCC)

1. The PCC must be identified on the single line diagram (SLD).

2. The DG Owner shall be responsible for the design, construction, maintenance and operation of the facilities and equipment on the DG side of the PCC.

3. All equipment on the DG Facility side of the PCC shall be in accordance with Section 2.1.4.

4. BL&P shall be responsible for the design, construction, maintenance and operation of the facilities on BL&P's side of the PCC.

5. When specifications and parameters (such as voltage, frequency, and power quality) are mentioned throughout this document, they must be met at the PCC unless otherwise stated.

6. BL&P, or the DG Owner, may require that their equipment be located on the other side of the PCC. In this case, the DG owner must provide the necessary space for BL&P to install such equipment and BL&P is to approve this site.

7. A 115/230V AC power service is to be available for Item (6) above.

2.1.6 NEW LINE

1. An automatic isolation device for a new line owned by the DG Owner that is ≥ 0.2 km shall be required at the PCC to disconnect the DG Owner‘s line from BL&P‘s Distribution System for faults in the DG Owner‘s line. The DG Owner shall be responsible for the installation, operation, and ownership of this device.

2. All DG facilities with more than one interface transformer are required to install an automatic isolating device at their PCC to disconnect the DG facility for faults on the DG owner‘s side of the PCC.

3. Any additional requirements shall be determined by the CIA.

2.1.7 ISOLATION DEVICE

1. A means of electrically isolating the DG Facility from BL&P‘s Transmission and Distribution System shall be provided.

2. The isolation device shall:

a) Be capable of being energized from both sides;

b) Be capable of indicating its status whether in the open or closed position locally and remotely when required;

c) Be capable of being opened at rated load (Load Break Switch);

d) Be located between the BL&P’s system and the DG Facility, upstream of all transformers, generation and HV ground sources;

e) Be readily accessible by BL&P;

f) Not be located in a locked facility, unless an arrangement is in place with BL&P;

g) Not be located in a hazardous location;

h) Have provision for being locked in the open position 3;

i) Have a manual override;

j) Have no keyed interlocks;

k) Have contact operation verifiable by direct visible means (be a Visible Break type)

l) Be capable of being closed with safety to the operator if there is a fault on the system;

m) Be capable of being operated without exposing the operator to any live parts and

n) Bear a warning to the effect that inside parts can be energized from sources on both sides when disconnecting means is open.

3. In addition to the requirements in Item (2) above, all three-phase DG Facility‘s isolation device shall:

    a) Be gang operated and disconnect all ungrounded conductors of the circuit simultaneously

    b) Be motorized if the DG Facility:

        1) is connected directly to feeders operating at 11kV and

        2) is connected to transmission lines at 24kV.

    c) Have a protection interface for tripping if used as a backup for interrupting device failure (HVI Breaker Failure or LVI Breaker Failure).

4. If the isolation device is motorized as required by Item (3) (b) above, it shall be powered from a reliable source such as a DC battery to power a DC motor or via a battery-supplied DC/AC inverter to power an AC motor.

5. If multiple generators are connected at the DG facility, one disconnect switch shall be capable of isolating all of the generators simultaneously.

6. Switching, tagging and lockout procedures shall be coordinated with BL&P.

7. The DG Owner and BL&P shall mutually agree to the exact location of the disconnect switch.

2.1.8 INTERRUPTING DEVICE RATING

1. All fault current interrupting devices shall be sized appropriately using present and anticipated future fault levels.

2. The interrupting device used to disconnect generation from BL&P's Transmission and Distribution System shall be coordinated to meet the timing requirement of the quickest protection operation and shall:

    a) Operate in no more than 160ms, which includes the protection element detection time for DG Facilities not equipped with Transfer Trip; and

    b) Operate within the required time for DG Facilities equipped with Transfer Trip as shown in Table 12 – maximum interrupting device time is dependent on the speed of Transfer Trip communications.

2.1.9 PHASING

1. The DG must connect rotating machines as required to match the phase sequence and direction of rotation of BL&P Distribution System.

2.1.10 TEMPORARY OVER-VOLTAGE (TOV)

1. Grounding of DG Facilities and interconnection systems shall be in accordance with Section 2.1.11 and not cause any voltage disturbances.

2. When connecting to BL&P's Distribution System, TOV that may be caused by the DG Facility interconnection should not normally exceed 125% of nominal system voltage (line to neutral) anywhere on the distribution system and under no circumstance shall exceed 130%.

3. BL&P may advise on action needed to reduce TOV to specified limits by outlining the requirements of a grounding transformer on the HV side.

2.1.11 GROUNDING

1. The grounding of the DG Facility shall not cause over-voltages that exceed the rating of equipment connected to BL&P's Distribution System.

2. The grounding of the DG Facility shall ensure that TOV limits in Section 2.1.10 are not exceeded.

3. The grounding of the DG Facility shall not disrupt the coordination of ground fault protection of BLP's Distribution System.

4. The DG Facility‘s grounding shall be per manufacturer‘s recommendation and the requirements in Section 2.1.11 of this document.

5. The connection of a DG Facility shall not cause the Neutral to Earth Voltage (NEV) to exceed CSA requirements (i.e., less than 10 V rms) on multi-grounded distribution system.

6. In the case of shared-use poles, voltages induced on the under-strung neutral must be minimized so as not to increase NEV.

7. If the primary HV winding of the DGIT is grounded, or a grounding transformer on the HV side of the DGIT is installed, the ground grid of the DG Facility shall be connected to BL&P‘s ground grid (neutral).

8. DG Facilities with a grounded HV DGIT, either utilizing a grounding transformer or a neutral reactor connected to the HV neutral, shall be sized as required in either Item (9) below, to ensure that TOV limits are not exceeded, or Item (10) below, to ensure the impact to ground fault protection coordination requirements in Item (3) is satisfied.

9. For interconnections to BL&P`s Distribution System, TOV is a major concern and the neutral reactor, Xn or grounding transformer, shall be sized by the DG Owner and reviewed during the Connection Impact Assessment, based on a Thevenin Equivalent of the Positive (X_{DG1}) and Zero Sequence (X_{DG0}) Reactance of the DG Facility (example: at the Point of Connection with the Point of Connection OPEN) that will result in:

    a) For Conventional (Rotating) Generators:

    $1.5<=X_{DG0}/X_{DG1}<=2.5$

    This will achieve an overall Thevenin Equivalent Positive and Zero Sequence impedance at any point on the feeder with any or all DG sources and BL&P sources In-Service of:

    $2<X_0/X_1<3$ or $R_0/X_1<0.4$ or

    b) For DG Facilities with an Inverter Interface:

    $X_{DG0}=0.6+_10\%$p.u and $X_{DG0}/ R_{DG0} >=4$

    and where 1 p.u. is based on:

1) The total MVA rating of the DG Facility (sum of DGITs MVA ratings) and high side kV rating of the DGIT(s) for Grounding Transformer sizing; or

2) The MVA and high side kV rating of the DGIT for Neutral Reactors sizing.

10. The installation of a wind farm shall not increase the lightning transfer to BL&P‘s system.

11. In wind farm installations, to limit the exposure of lightning to BL&P's distribution system, lightning protection grounding shall be electrically separated from the grounding grid of the wind tower.

12. Where the separation in Item (11) above is not possible, or practical, then the ground grids of the towers shall be electrically separated from the DG Facility Station ground grid from the point of view of transferred lightning surges. The latter can be achieved by ensuring that the wind towers are not bonded to the station's ground grid.

13. Stand-alone studies are required to ensure that Ground Potential Rise (GPR) meets step and touch potential.

14. The report in Item (13) must be submitted to BL&P.

2.1.12 INTERCONNECTION TRANSFORMER CONFIGURATION

1. The DG Interconnection Transformer (DGIT) shall not cause voltage disturbances or disrupt co-ordination of distribution system ground fault protection.

2. The DG Owner shall choose one of the allowable DGIT configuration options in Section 2.1.12.1 if interconnecting to BL&P‘s Distribution System.

3. The DG Owner shall ensure that there is no back feed from the DGIT when the generator is out of service and shall be responsible for all consequences resulting from such back-feeds.

4. The DGIT may supply unbalanced current to support the unbalanced load on the feeder even when the generator is out of service. The DG Owner is responsible to ensure the design is adequate to handle the unbalanced current. Refer to Requirements in Section 2.2.2.2.

5. Items (1), (2), and (3) apply to all DG Facilities connecting directly to BL&P's Distribution System.

2.1.12.1 DG INTERCONNECTION TO BL&P's DISTRIBUTION SYSTEM

1. The DG Facility shall connect to BL&P's Distribution System using one of the following options (see section 2.3.6 for figures):

    a) Wye-Ground:delta DGIT as shown in Figure 2;

    b) Wye-Ground:wye-Ground with a Delta tertiary DGIT as shown in Figure 3;

    c) Wye-Ground:wye-Ground (LV may be ungrounded) DGIT with a HV Grounding Transformer as shown in Figure 4; or

    d) Delta-wye DGIT with HV Grounding Transformer as shown in Figure 6;

2. In addition to the DGIT options in Item (1), the DG Facility may also connect through a Wye-Ground:wye-Ground DGIT without a HV Grounding Transformer if generators are solidly grounded and the requirements of Section 2.1.10 and Section 2.1.11 are met. The CIA shall determine whether this option is feasible.

3. In addition to the DGIT options in Item (1) and Item (2), the DG Facilities smaller than 1 MVA having generators grounded through an impedance, may also connect through a Wye-Ground:wye-Ground or a Delta:wye transformer without installing a HV Grounding Transformer, if the CIA determines that the TOV requirements in Section 2.1.10 are met.

4. For generation being added to existing critical load installations, such as hospitals and water treatment plants, existing Delta-wye load transformer can be used to connect the generation, provided that the requirements in Item (6) below are met and that an HVI is provided to isolate the HV Grounding Transformer from the Distribution System, whenever the generation is disconnected from the Distribution System.

5. A neutral reactor in the primary winding of DGIT options in (1)(a), (1)(b), (2) and (3) above may be necessary to limit the ground short circuit current and shall be sized in accordance with Section 2.1.11(4).

6. A HV Grounding Transformer on the HV side of the DGIT shall be required to keep TOV within limits for DGIT options (1)(c), (1)(d) and (4) above and shall:

    a) Be sized in accordance with Section 2.1.11(9);

b) Be located on DG side of the HVI;

c) Be a zig-zag design;

d) Be either solidly connected (not fused) to ensure that the transformer is in service at all times, or, if fused, the fuses shall be monitored and the DG Facility`s HVI shall be tripped in the event of a failure of the grounding transformer;

e) Have the neutral of the grounding transformer connected to BL&P`s neutral conductor and

f) Have adequate protection to provide an alarm when the neutral overcurrent rating of the grounding transformer is exceeded and to automatically remove the grounding transformer from service and disconnect all generation when internal phase or ground faults occur.

7. The DGIT options in Item (1), Item (2) and Item (4) above, shall require the installation of a high side interrupting device (HVI) in accordance with Section 2.1.13 to ensure that the HV Ground Source is disconnected from BL&P‘s Distribution System during abnormal conditions. The requirement of a HVI for the option in Item (3) above shall be determined in the CIA.

8. The DGIT‘s ground shall be connected to BL&P‘s neutral conductor.

9. The DGIT design and installation shall meet all other grounding requirements in Section 2.1.11.

10. The design of the DGIT shall ensure that all Power Quality requirements are adhered to.

2.1.13 HIGH VOLTAGE INTERRUPTING DEVICE (HVI)

1. The DG Facility shall be equipped with a High Voltage Interrupter (HVI), with a protection interface for tripping, upstream of all interconnecting transformers and HV ground sources if:

   a) The DG Facility is connecting to BL&P‘s Distribution System that is grounded in accordance with Section 2.1.11(9); or

2. DG Facilities at critical load installations, such as hospitals and water treatment plants, interconnecting to BL&P‘s Distribution System using the DGIT option in Section 2.1.12.1(4) shall be equipped with a HVI, with a protection interface for tripping, upstream of the HV Grounding Transformer.

3. DG Facilities < 1 MW, connecting to BL&P's Distribution System through a Wye-Ground:wye-Ground transformer may be exempt from the requirement in Item (1) above if the CIA determines that:

    a) Ground fault source contribution from the DG Facility does not cause coordination problems with BL&P ground protections and

    b) The installation does not contain HV grounding transformers.

4. If the DG Facility does not require a HVI, a low voltage interrupter(s) must be provided to disconnect the DG Facility's generation from BL&P's Distribution System.

5. The HVI status must be monitored.

6. The HVI shall be sized properly to account for present and future anticipated fault levels.

7. Breaker fail protection for the HVI shall be in accordance with requirements in Section 2.3.4.

8. The HVI's interrupting time shall be in accordance with the timing requirements in Section 2.1.8.

2.1.14 STATION SERVICE FOR ESSENTIAL LOADS

1. Wherever genuine supply diversity is possible, at BL&P's sole discretion, a second connection for AC station service from another feeder may be allowed to supply essential loads (such as station battery).

2. The station service in Item (1) above shall not be electrically connected to the DG electrical system that is associated with the power transfer from the DG Facility to the BL&P Distribution System.

3. The station service load shall not impose operating restrictions on BL&P's system when either the Motorized Disconnect Switch (Isolation Device – Section 2.1.7) or the HVI is opened.

4. The station service shall comply with all required load connection standards.

5. The station service shall be in compliance with all metering standards and regulations.

6. Station GPR shall not be transferred to the neutral of the LV system supplying station service for critical loads.

7. A backup generator may be used to satisfy Item (1).

2.1.15 BATTERIES/DC SUPPLY

1. Batteries shall be provided and shall have adequate capacity to ensure that all protection functions operate when the main source of power fails.

2. They shall remain operational for the time required for protection functions to operate properly and disconnect the DG Facility from BL&P's Distribution System. They shall be capable of sustaining continuous telemetry about the DG Facility connection status and DGEO signals.

3. Item (1) and (2) shall be implemented by using batteries and chargers connected to the main service supply, or by using an uninterruptible power supply with sufficient capacity for the application.

4. The battery voltage shall be monitored and upon failure, the protection scheme shall be considered failed and the DG Facility's generation and HV ground sources shall be disconnected from BL&P's Distribution System.

5. Relays connected to the DC supply shall not be subjected to sustained overvoltages – if there is a possibility that the DC rating of the equipment will be exceeded, steps shall be taken to ensure that DC voltage limiting devices be installed at each relay.

6. Dual station batteries shall not be required for protection and control equipment.

7. Protection systems designed to back each other up, shall be supplied by physically separated and protected (i.e. fused) DC Circuits.

8. Circuit breakers and the DG Facility's Interrupting Device shall be powered by separate and dedicated DC Circuits.

9. Separate and independent means are to be used for tripping the DG Facility's Interrupting Device and the DG Facility's Isolation Device (when motorized – See Section 2.1.7(3) (b)).

10. Upon low voltage (DC) conditions, the protections shall trip the generators and all HV Ground Sources.

11. Capacitors shall not be used as the primary means to store energy in lieu of batteries.

2.1.16 FAULT LEVELS

1. Maximum fault levels must be maintained within the limits specified by BL&P and will be revised as system changes arise. The interconnection of DG Facilities shall not cause these limits to be exceeded.

BACKGROUND INFORMATION

Maximum fault values are symmetrical fault values. Higher values may exist for short times during switching. These levels constitute ideal DG Facilities near Spring Garden generating station.

Table 1: Maximum Fault Levels

Fault Levels

Nominal Voltage (kV)	Maximum Three-Phase Fault (kA)	Maximum Single Line to Ground Fault (kA)
24.9 kV	14.4	15.5
11.0kV	8.5	11.78

2.1.17 INSULATION COORDINATION

1. The DG Facility shall be protected against lightning and switching surges.
2. Surge arresters shall be located as close as possible to the equipment they protect (BL&P Voltage Arrester MCOV ratings are shown below in Table 2).
3. Insulation coordination shall conform to ISO/ IEC 71-1 Standard (CAN/CSA C71-1-99 -1-99 and CAN/CSA C71-2-98

Table 2

BLP's Distribution System Voltage Arrester MCOV Rating	
System Phase Voltage (kV)	**Arrester MCOV (kV)**
11	9
24.9	18

2.1.18 INSTRUMENT TRANSFORMERS FOR USE IN PROTECTION SYSTEMS

1. All instrument transformers used in DG Facilities for protection shall meet the requirement of CAN/CSA-C60044-6 or ANSI/IEEE C57.13.

2.1.19 POWER QUALITY MONITORING DEVICE

DG Facilities > 150kW shall be equipped with a Power Quality (PQ) monitoring device capable of providing the reports required in Section 2.7.2.

1. The PQ monitoring device shall have the ability to perform sampling at the rate of 256 samples / cycle (~15kHz) for a minimum of 96 cycles. This will ensure that the device is capable of recording voltage and current harmonics up to the 50th harmonic (3kHz), impulsive transients in the €milliseconds range (monitoring possible to at most 7kHz), and low frequency oscillatory transients (<5kHz).

2. The instrument transformers used for PQ monitoring shall be capable of monitoring transients up to 7 kHz, and swells up to 1.2 p.u. for a period of one minute.

3. PQ monitoring applies to phase voltages, neutral to ground voltage and phase currents.

2.1.20 PROTECTION FROM ELECTROMAGNETIC INTERFERENCE (EMI)

1. EMI shall not cause the protection, control and communication functions of the DG Facility interconnection to fail, change state, misoperate or provide inaccurate information.

2. The DG Facility interconnection must have the capability to withstand electromagnetic interference (EMI) environments in accordance with:

   a) ANSI/IEEE Std. C37.90.2,— IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.; or

   b) CAN/CSA-CEI/IEC 61000-4-3 (Electromagnetic compatibility – testing and measurement techniques), using Level X, 35 V/m, in accordance with IEEE C37.90.2.

3. The DG Owner shall provide documentation to show compliance with Item (2)(a) or (2)(b) above.

2.1.21 SURGE WITHSTAND

1. The protection, control and communication equipment of the DG Facility interconnection system shall not fail, misoperate, or provide misinformation due to voltage or current surges.

2. The interconnection system shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE/ANSI Std. C62.41.2, — IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits or IEEE Std. C37.90.1, — IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus – Description.

2.1.22 DG FACILITY ACCEPTANCE

1. The DG Facility interconnecting to BL&P's Distribution System must have a registered engineer, licensed in Barbados, declare (stamp and seal) that the DG Facility has been designed, tested and constructed in accordance with the requirements of this document, BL&P's site-specific requirements, prudent utility practice and all applicable standards and codes.

2. The DG Owner shall send the design of all power equipment, protection, control, and metering systems used at the DG Facility interconnection to BL&P for review.

2.1.23 GENERATORS PARALLELING FOR 5 CYCLES OR LESS (CLOSED TRANSITION SWITCHING)

1. The generators paralleling for 5 cycles or less shall be exempt from all requirements in this document except for the requirements below in Item (2) and Item (3).

2. DG Facilities paralleling for 5 cycles or less shall have the following protection:

    a) Under-voltage protection to ensure that the generator is not capable of energizing BL&P's Distribution System if it is de-energized and

    b) A 6-cycle timer to ensure that the DG Facility will not parallel with BL&P's Distribution System for more than 6 cycles.

3. Synchronization facilities, where required, must follow the requirements specified in Section 2.4.4.

2.1.24 PROVISION FOR FUTURE CHANGES

1. The DG Owner shall be responsible to stay aware of future changes to the business environment and technical requirements.
2. The DG Owner shall make any necessary changes to the DG Facility promptly in response to:
    a) New or revised standards;
    b) New or revised codes;
    c) Legislation changes;
    d) Safety concerns and
    e) BL&P requirements
3. The DG Owner may be responsible for some or all costs associated with the changes in Item (2).

2.2 PERFORMANCE REQUIREMENTS

2.2.1 GENERAL

1. The interconnection of the DG Facility must not materially compromise the reliability or restrict the operation of BL&P‘s Distribution System.

2. The interconnection must not degrade power quality below acceptable levels listed in Section 2.2.2 (Power Quality Requirements).

3. The DG Owner shall ensure that the facility is equipped to measure, record and report on performance related events to demonstrate compliance with the applicable sections of this document.

4. If the DG Facility is found to significantly deteriorate the performance of the BL&P`s Distribution System, it shall be disconnected from BL&P`s Distribution System until appropriate measures are taken to mitigate the negative impacts.

2.2.2 POWER QUALITY

2.2.2.1 VOLTAGE

1. The DG Facility shall ensure that the operation of the DG(s) does(do) not have an objectionable impact on voltage at the PCC or the interconnected feeder and shall not cause any violation of IEEE Standard 1547, CSA Standard C235-83-CAN3 - Preferred Voltage Levels for AC Systems, 0 to 24,900V Electric Power Transmission and Distribution along the entire interconnected feeder.

2. PCC voltage shall be maintained within 0.94~1.06 p.u. and shall not be lower than pre-connection voltage.

3. The DG shall not actively regulate the voltage at the PCC. Voltage at the PCC shall be maintained within acceptable limits by following the requirements in item (8).

4. Voltage variations at the PCC shall be limited in accordance with the —Voltage Fluctuations (Flicker) Requirements in Section 2.2.2.3.

5. At the feeder level, DG shall not contribute to short-term voltage fluctuation anywhere on the feeder by more than 1%.

6. At the station level, all DGs connected to the Distribution System shall not collectively contribute to short-term voltage fluctuation at the station LV bus by more than 3-5%.

7. Tripping of all DGs connected to the station shall not cause abrupt voltage change to result in a voltage above 110% of nominal bus voltage, or less than 90% of nominal bus voltage, after a single contingency and before the station OLTC/feeder VR operates.

8. The operating power factor of the DG Facility at the PCC shall be as required in Section 2.2.2.6 (5).

9. During normal operation, the DG shall be loaded and unloaded gradually to allow adequate time for regulating devices on BL&P's Distribution System to respond and avoid excessive voltage fluctuations.

10. The DG Facility shall protect itself from abnormal voltage conditions which the distribution system is subjected to. These may include, but are not limited to:

    a) Voltage transients and

    b) Sags and swells caused by lightning, switching, faults, intermittent RE and the loss or switching of customer loads.

11. Insulation levels and protective equipment at the DG Facility shall be capable of withstanding abnormal voltages from BL&P's Distribution System.

2.2.2.2 VOLTAGE AND CURRENT UNBALANCE

1. The DG Facility shall be capable of operating under existing unbalance conditions.

2. The DG Facility shall not cause deterioration of existing unbalance voltage and current conditions at the PCC and in the Distribution System.

3. A single-phase generator shall not negatively impact the unbalance of the nearest three-phase section of the Distribution System.

4. The DG and its interconnection transformer's design shall take into consideration the unbalanced current it may supply to the unbalanced load on the feeder.

5. Single-phase generators shall not cause an unbalance of greater than 2% when connected alone.

6. If multiple single-phase generators are installed, they shall be connected so that an equal amount of generation is applied to each single phase of the distribution line, and this balance shall be maintained if one or more of the generating units go offline.

2.2.2.3 VOLTAGE FLUCTUATIONS (FLICKER)

1. The DG Facility shall not create objectionable flicker for other customers on BL&P's Distribution System.

2. The voltage dip at the PCC should not be more than 4% on connecting the single largest generation unit in the facility and should remain within 10% of nominal voltage when the entire DG Facility and all other DG Facilities on the interconnected feeder trip. These limits may be relaxed following the CIA process.

3. Item (1) above, shall include flicker caused by energization inrush.

4. The DG Owner shall take steps to make sure that flicker requirements in Item (1) and (2) are met - may need to add loss of synchronism protection, stagger generator energization, etc.

5. The DG Facility shall conform to the flicker requirements in IEEE Standard 1547, CAN/CSA-CEI/IECC61000-3-7 and meet the Pst and Plt limits shown below in Table 3.

Table 3: Pst and Plt Flicker Limits 11-24.9kV

Pst	0.9
Plt	0.7

6. Flicker measurements shall be conducted by the DG Owner using a device that conforms to IEEE Standard 1547, CAN/CSA-CEI/IEC C61000-4-15 if requested by BL&P. BL&P shall request this measurement if flicker complaints are received in the surrounding area.

7. Induction generators and inverter-based generators that do not produce fundamental voltage before the paralleling device is closed, and double-fed generators whose excitation is precisely controlled by power electronics to produce a voltage with magnitude, phase angle, and frequency that match those of the Distribution System shall be tested to determine the maximum startup current. The results shall be used, along with the Distribution System source impedance for the proposed location, to estimate the starting voltage magnitude change and verify that the unit

will not cause a voltage fluctuation at the PCC greater than ± 4% of the prevailing voltage level of the Distribution System at the PCC.

8. Induction generators may be connected and brought up to synchronous speed by direct application of rated voltage provided that they meet the requirement of voltage drop given above and/or they do not exceed flicker limits at the PCC. Otherwise, other methods such as reduced voltage starting or speed matching, using the prime mover prior to connection, must be used to respect these voltage drop and flicker limits.

9. Large DG Facilities, with multiple generator units, shall stagger the generator reconnections to BL&P's Distribution System to meet the above requirements.

2.2.2.4 VOLTAGE AND CURRENT HARMONICS

1. The DG Facility shall not inject harmonic current that causes unacceptable voltage distortion on BL&P's Distribution System.

2. The DG Facility shall follow the requirements of IEEE Standard 519 and CAN/CSA -CEI/IEC C61000-3-06.

3. The DG Facility shall operate within the voltage distortion limits as indicated in Table 4 and Table 5 below.

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Table 4: Voltage Distortion limits for Odd Harmonics

Odd Harmonics Non Multiples of 3		Odd Harmonics Multiples of 3	
	Harmonic Voltage (%)		**Harmonic Voltage (%)**
	11-24.9kV		**11-24.9kV**
5	5	3	4
7	4	9	12
11	3	15	0.3
13	2.5	21	0.2
17	1.6	>21	0.2
19	1.2		
23	1.2		
25	1.2		
>25	0.2+0.5(25/h)		

Table 5: Voltage Distortion limits for Even Harmonics Even Harmonics

Even Harmonics	
	Harmonic Voltage (%)
	11-24.9kV
2	1.6
4	1
6	0.5
8	0.4
10	0.4
12	0.2
>12	0.2

4. Total Harmonic Distortion (THD) shall be a maximum of 5% on 24.9kV systems and below 5.0% on all other systems.

5. The DG Facility shall operate within the current harmonic limits as listed in Table 6.

Table 6: Harmonic Current Limits

Harmonic Number h	5	7	11	13	
Admissible harmonic current $i_h=I_{hi}/I_i$ (%)	5-6	3-4	1.5-3	1-2.5	

6. The DG Owner and/or BL&P may be required to implement measures that will mitigate the harmonic distortions caused by the DG Facility, such as by adding harmonic filters, at the DG Owners cost.

7. The limits presented in Items (3), (4) and (5) above exclude the harmonic distortions present on BL&P's Distribution System when the DG Facility is disconnected from the Distribution System.

8. This document does not impose design limits to limit harmonic-related telephone interference problems as it is almost impossible to predict. However, the DG Owner shall make sure that the design complies with all applicable standards and shall not cause telephone interference.

2.2.2.5 FREQUENCY

1. The generators at the DG Facility shall operate at a nominal frequency of 50Hz.

2. The generators at the DG Facility shall remain synchronously connected over the frequency range presented below in Table 7.

3. The generators shall trip in the time required in accordance with Section 2.3.10 for any frequencies beyond what is presented in Table 7.

Table 7: Operating Frequency Range

Generator Size	Frequency Range (Hz)	
	Low Range	High Range
>150kW <1.5MW	47.5	50.5
>1.5MW <10MW	47.0	50.5
>10MW	45.0	50.5

2.2.2.6 POWER FACTOR

1. DG Facilities > 150 kW shall be capable of operating in constant power factors anywhere between 0.95 leading and 0.95 lagging.

2. If warranted by local distribution system conditions, (such as causing a violation of CSA C235-83-CAN3 voltage limits at the PCC), this range may be narrower or wider and will be specified by BL&P in the CIA.

3. The DG Facility shall be capable of operating within lagging and leading power factor ranges with, or without, other DG Facilities in service on the feeder.

4. BL&P shall determine the required operating power factor of the DG Facility during the CIA study and shall specify this to the DG Owner.

5. Power factor correction or reactive power compensation techniques may be required.

6. Induction generators consume reactive power and the DG Owner shall be required to provide reactive power compensation to correct the power factor at the PCC.

7. DG Facilities greater than 10 MW (Class 3 DGs) shall be assessed by BL&P to determine whether the proposed generation impacts the main transmission negatively and whether the reactive power compensation at the generator units shall be sufficient, so as not to cause any material increase in the reactive power requirements at the transmission system transformer station due to the operation of the DGs at all load conditions on the feeder.

2.2.2.7 LIMITATION OF DC INJECTION

1. The DC current injection by the DG Facility shall not be greater than 0.5% of the full rated output current at the PCC after a period of five cycles following the energization of BL&P‘s Distribution System.

2.2.3 DISTURBANCES

1. The DG Facility shall be designed, built and maintained in accordance with all applicable codes, regulations and standards, along with the requirements of this document. The design shall minimize the impact of:

    a) Over-voltages during ground faults;

    b) Electric disturbances which can cause irregular power flows;

    c) Interference – radio, television and telephone;

    d) Audible noise and

    e) Other disturbances which may reduce the reliability of BL&P‘s distribution system.

2.2.4 RESONANCE ANALYSIS

1. The prudent design of a DG Facility should include careful consideration of resonance and ferroresonance.

2. Ferroresonance or resonance studies are not mandatory.

3. If resonance problems do arise, full co-operation and data sharing on the part of the DG Owner shall be required.

2.2.5 SELF-EXCITATION ANALYSIS

1. DG Facilities with induction generators and not equipped with Transfer Trip, (Section 2.3.13), shall conduct studies to assess whether there is a possibility of self-excitation.

2. Self-excitation analysis, if required by item (1) above, shall be submitted to BL&P for review.

2.3 PROTECTION REQUIREMENTS

2.3.1 GENERAL REQUIREMENTS

1. All protective device settings and protection scheme designs must be submitted to BL&P for review.

2. Protections must not be interlocked with the position of any isolating/interrupting devices.

3. Protection settings may be required to be changed over time to maintain adequate system protection as the system configuration changes.

4. All protection operations shall ensure that the generator(s) and all HV Ground Sources are isolated from BL&P`s Distribution System within the required time from the start of the disturbance.

5. All protection designs must:

    a) Ensure proper coordination with BL&P‘s protections;

    b) Be failsafe; and

    c) Ensure that both the DG and BL&P‘s distribution system, customers and general public safety are maintained.

6. The design of the protections at the DG Facility shall be done by a registered engineer to ensure that the overall protection scheme will ensure a safe and reliable interconnection to BL&P‘s Distribution System.

7. Protection relays shall be “utility grade” and shall meet the minimum requirements specified in IEEE C37.90, “Standard for Relays and Relay Systems Associated with Electrical Power Apparatus,” latest edition, as well as meet the requirements in Section 2.1.20 and Section 2.1.21. “Industrial grade” relays shall not be permitted for interconnection protections.

8. Protection functions shall remain operational after distribution system disturbances or loss of supply from the distribution system for the required period of time needed to operate properly.

9. Communication facilities between the TS and breaker and the DG Facility may be required as a result of DG Facility interconnections.

10. The interconnection protection is required to have a dedicated device but if the DG Owner decides to combine some of the protection functions in other relays, this would be subject to BL&P‘s approval.

11. Additional protections, other than the ones listed in this document, may be required depending on the application and shall be communicated to the DG Owner at the appropriate stage.

2.3.2 SENSITIVITY AND COORDINATION

1. The DG Facilities protection shall provide adequate sensitivity to detect abnormal conditions as required in Section 2.3 and isolate its generator(s) and if present, its HV ground source, from BL&P‘s Distribution System.

2. The design of the DG Facility protection system shall coordinate with other BL&P protection system devices.

2.3.3 PROTECTION OPERATING TIMES

1. The DG Facility‘s interconnection protection shall disconnect the DG Facility`s generation and HV ground sources, if present, from BL&P‘s Distribution System within the required time as specified in the individual requirements throughout this document.

2.3.4 BREAKER FAIL (BF)

1. DG Facilities with an aggregate output > 500 kW shall provide breaker failure protection for the primary interrupting device (i.e. breaker, HVI, LVI) that is responsible for disconnecting the generation and/or HV ground sources from BL&P‘s Distribution System.

2. The breaker failure protection should have a maximum pickup time delay of 0.3s after initiation.

3. In the event of a HVI breaker fail condition, the breaker fail protection shall:

    a) Trip the next zone at the DG facility, specifically the upstream isolation device and all LV breakers shall be tripped and

    b) Remove the prime mover and excitation system as appropriate.

4. In the event of a LVI breaker fail condition, the breaker fail protection shall ensure that a fault in the DG Facility is cleared and will not affect the Distribution System by:

    a) Tripping the HVI;

    b) Initiating Breaker Fail on the HVI;

c) Opening the motorized disconnect switch (Isolation Device) as explained in Item (6) below and .

d) Removing the prime mover and excitation system as appropriate.

5. The motorized disconnect switch (see requirements in Section 2.1.7(3)(b)) shall be opened by a separate auxiliary relay in the event of a breaker fail condition to ensure that the DG Facility is properly isolated from BL&P's Distribution System.

6. The motorized disconnect switch shall be used to automatically isolate the DG Facility from the Distribution System. In the event that an alternate interrupting means (fuses or otherwise) is not provided by the DG Facility, or if such alternate interrupting means fail to coordinate with the opening of the motorized disconnect switch, then the disconnect switch may incur significant damage when attempting to interrupt a sustained fault current condition as it is not rated for breaking fault current. The design of the DG Facility shall take this into consideration when deciding on a location for the Isolation Device to ensure that safety of the DG Facility personnel, BL&P's personnel and general public will be ensured.

7. In the case of a circuit switcher being used, the interrupter and the motorized disconnect shall be specifically chosen to operate independently and no additional BF protection shall be required. If the motorized disconnect switch in the circuit switcher is not rated to break load, an additional load break switch shall be required to satisfy the requirement in Section 2.1.7.

8. The design of the BF protection for the HVI shall be submitted to BL&P for review and acceptance.

DESIGN CONSIDERATION

In normal operation, when the HVI isolates the facility, the motorized disconnect switch will follow, opening a short period afterwards. It can also be designed to open sequentially – motorized disconnect opens if HVI does not OPEN following a trip initiation.

2.3.5 SINGLE-PHASE GENERATORS

1. Minimum protection requirements for single-phase DG Facilities shall be in accordance with Table 8 below and are mandatory for all generators to which this Grid Code document is applicable.

2. Inverter type generators shall be compliant with IEEE Standard 1547 **or** CAN/CSA 22.2 No 257-06 "Interconnecting inverter based micro distributed resources to distribution system" **and** CSA Standards, C 22.2-107.1 "General use Power Supply" **or** UL 1741 **and** bear a certification mark recognized in Barbados.

3. The final design of the protection system shall be submitted to BL&P for approval in accordance with Section 2.3.19 of this document.

Table 8: Minimum Protections Required for Single-Phase DG Facilities

Protection Description	**IEEE Device #**
Interconnect Disconnect Device	89
Generator Disconnect Device	89
Over-Voltage Trip	59
Under-Voltage Trip	27
Over Frequency Trip	81O
Under Frequency Trip	81U
Over-current	50/51
Distance	21
Synchronizing Check	25
Anti-Islanding Protection	Refer to Section 2.3.12

DESIGN CONSIDERATION

Figure 1 below shows a typical protection SLD for single-phase DG Facilities and is given for information purposes only. The protection system can be designed differently than shown in this figure.

Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6, shown on the following pages, contain typical protection drawings for three-phase DG Facilities interconnecting to BL&P's Distribution System 4-Wire Distribution System.

The protection systems can be designed differently and the examples shown in this document are for informational purposes only. Additional protections may be required.

Generator protections are not the focus of this document and no requirements are set by BL&P's Distribution System. It is up to the DG Owner to ensure that the generators are protected sufficiently

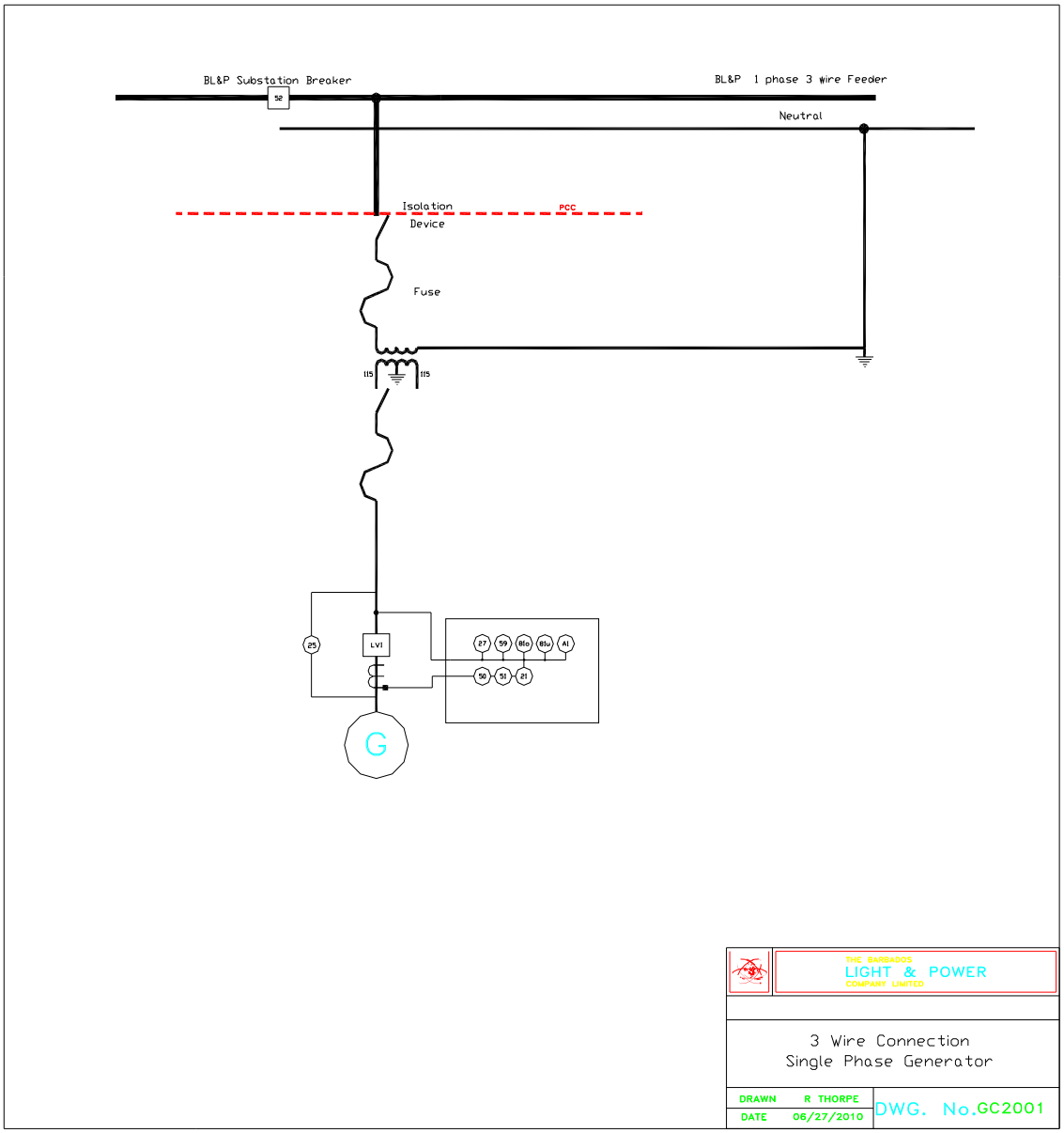

Figure 1: Typical Protection for Single-Phase 3-wire DG facility

2.3.6 THREE-PHASE GENERATORS

1. Three-Phase DG Facilities shall have the minimum protection requirements as shown below in Table 9 and are mandatory for all generators to which this Grid Code document is applicable.

2. Inverter type generators shall be compliant with IEEE Standard 1547 **or** CAN/CSA 22.2 No 257-06 “Interconnecting inverter based micro distributed resources to distribution system” **and** CSA Standards, C 22.2-107.1 “General use Power Supply” **or** UL 1741 **and** bear a certification mark recognized in Barbados.

3. The final design of the protection system shall be submitted to BL&P for approval in accordance with Section 2.3.19 of this document.

Table 9: Minimum Protections Required for Three-Phase DG Facilities

Function Requirement	Protection Element function	Device #	Synchronous	Induction	Inverter
Basic Anti-Islanding	Over voltage trip	59	Required	Required	Required
	Under voltage trip	27	Required	Required	Required
	Over frequency trip	81O	Required	Required	Required
	Under frequency	81U	Required	Required	Required
Tele-protections	Transfer trip received	TTR	Section 2.3.13	Section 2.3.13	Section 2.3.13
	DGEO/LSBS	DGEO	Section 2.3.14	Section 2.3.14	Section 2.3.14

Function Requirement	Protection Element function	Device #	Synchronous	Induction	Inverter
Other passive Anti-islanding	Rate of change of frequency	81R	<500kW	<500kW	Not required
	Vector Surge	78	<500kW	<500kW	Not required
	Directional Reactive Power Relay	32R	<500kW	<500KW	Not Required
Phase Fault Protection	Phase Overcurrent	50	Required	Required	Required
	Phase inverse timed Overcurrent	51	See note 1[1]	See note 1	See note 1
	Voltage Controlled Overcurrent	51V	See note1	See note1	See note 1
	Directional Phase Overcurrent	67	Required	Required	Required

[1] An alternative or complement to Over-current (50, 50N). Special caution is needed for selection of inverse-time characteristics that meet time constraints

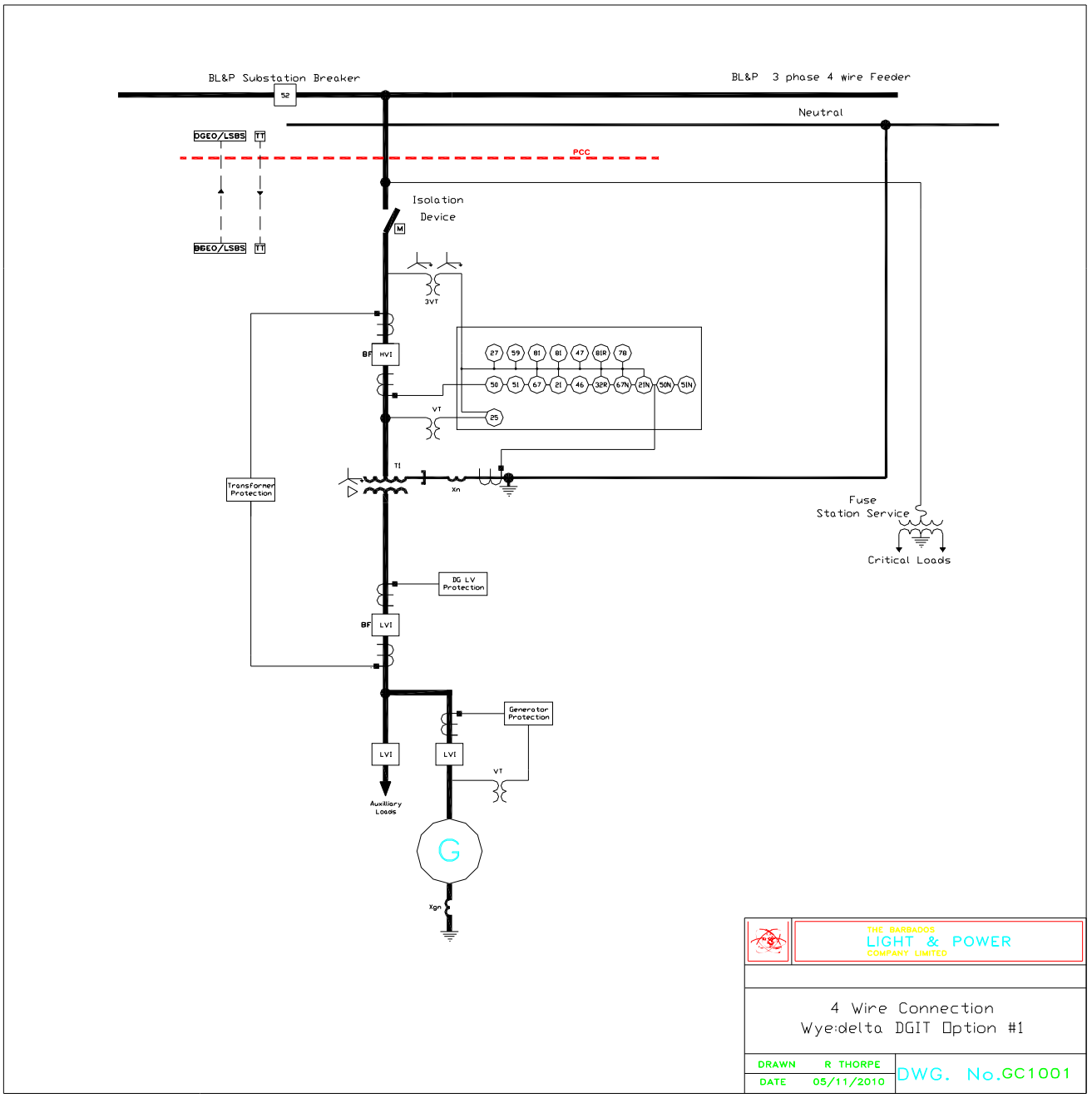

Figure 2: 4 – Wire DGIT Option #1 Typical Protection

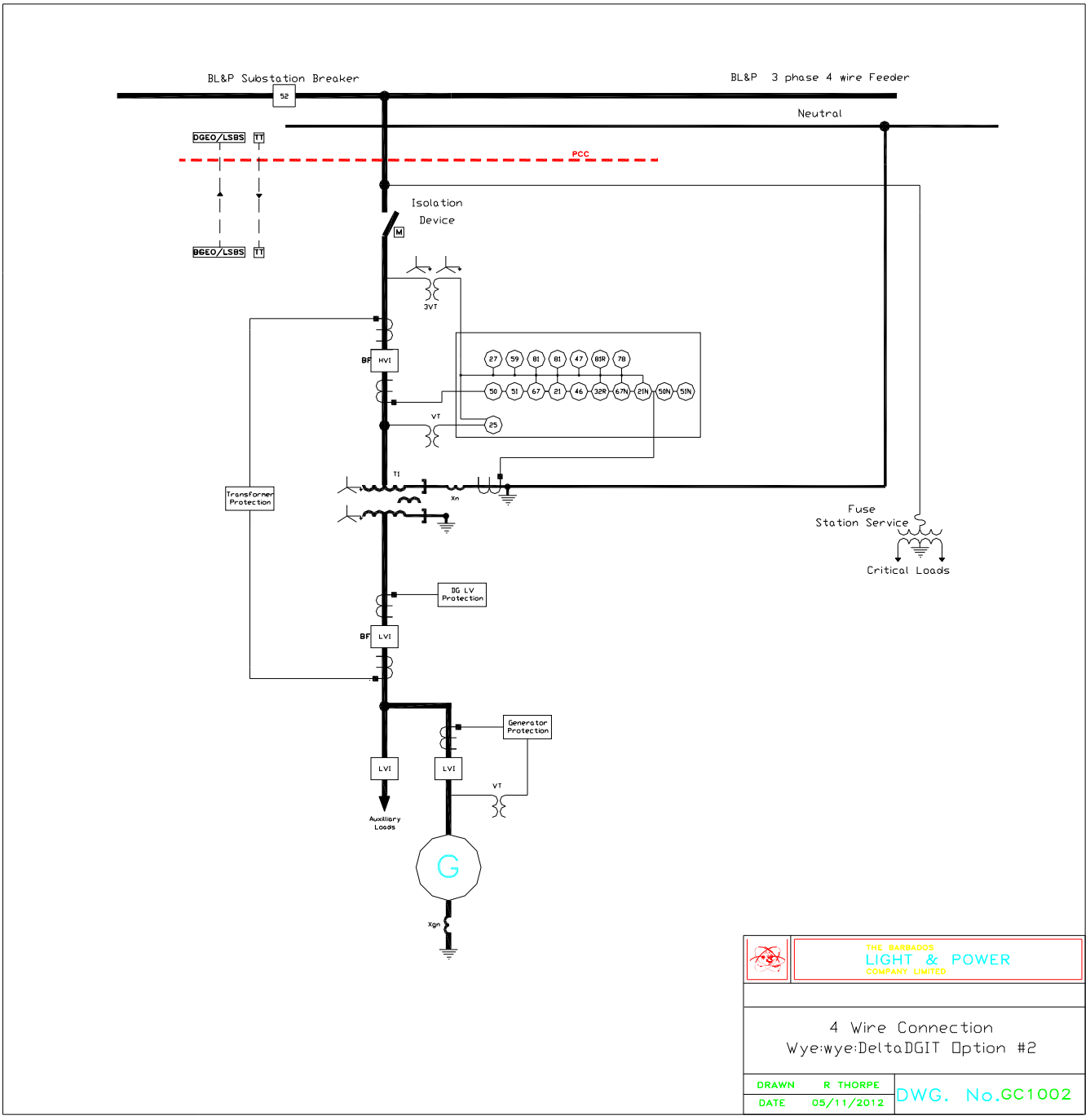

Figure 3: 4 - Wire DGIT Option #2 Typical Protection

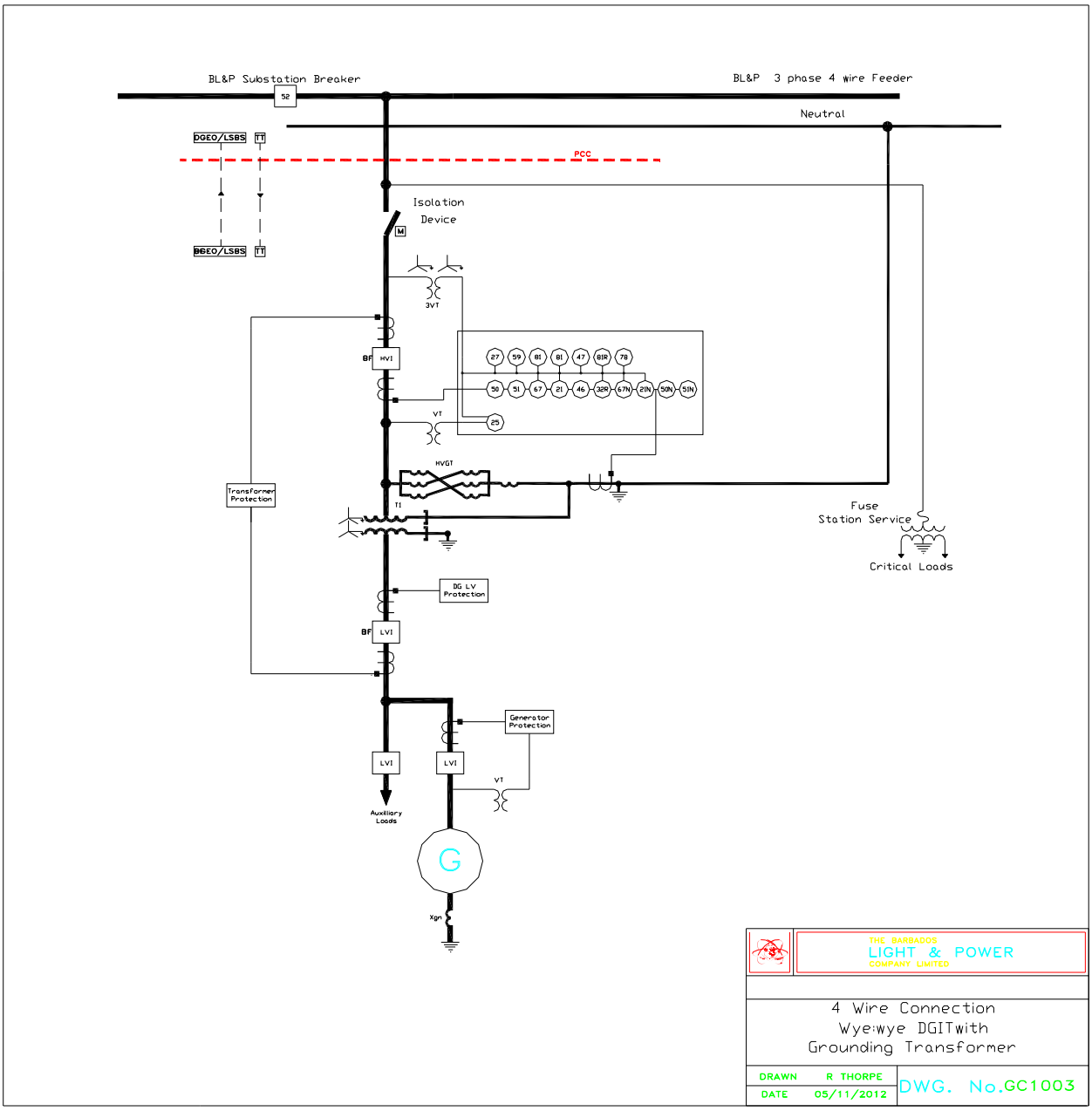

Figure 4: 4 – Wire DGIT Option 3 Typical protection

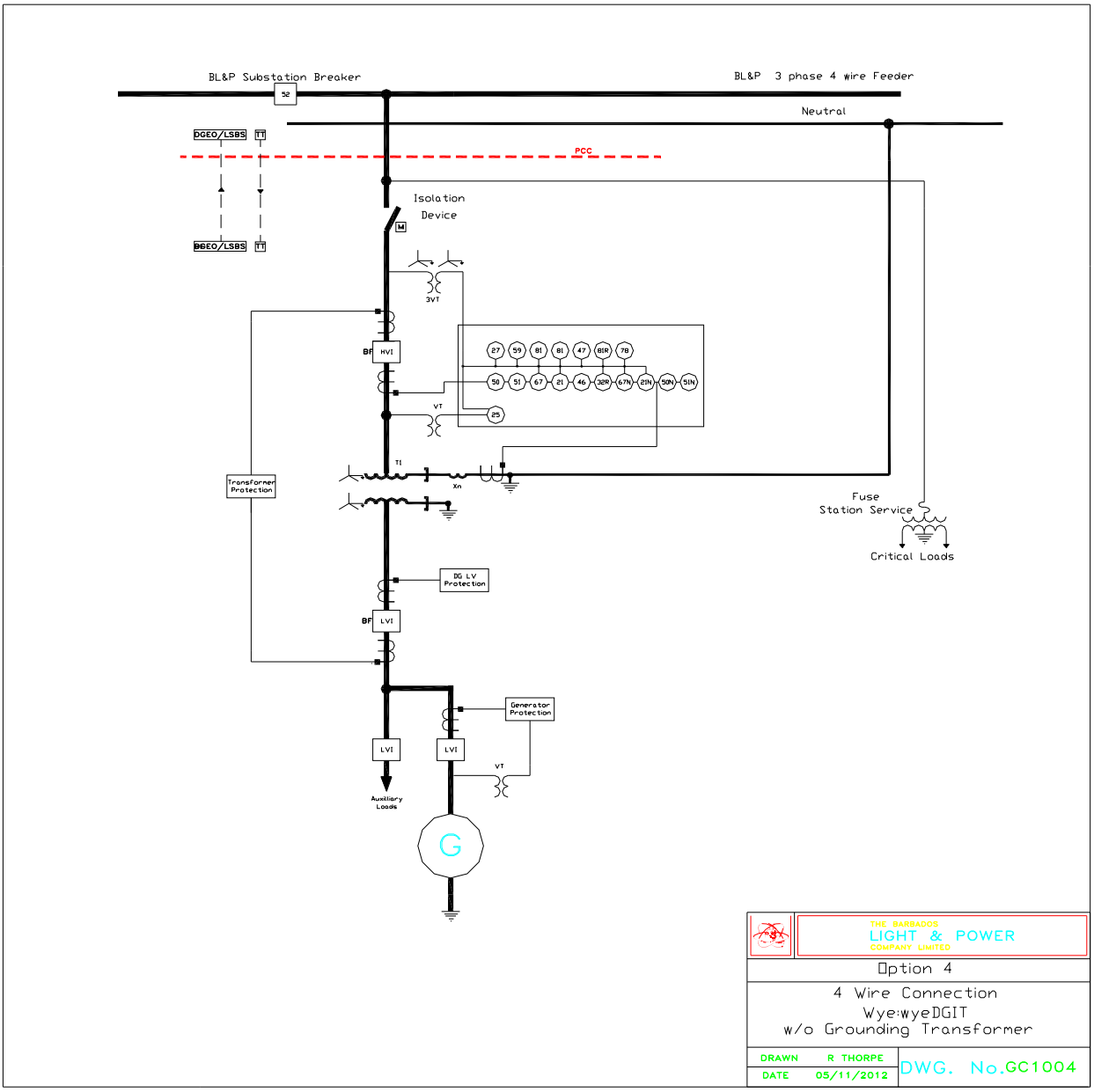

Figure 5: 4 – Wire DGIT Option #4 Typical Protection

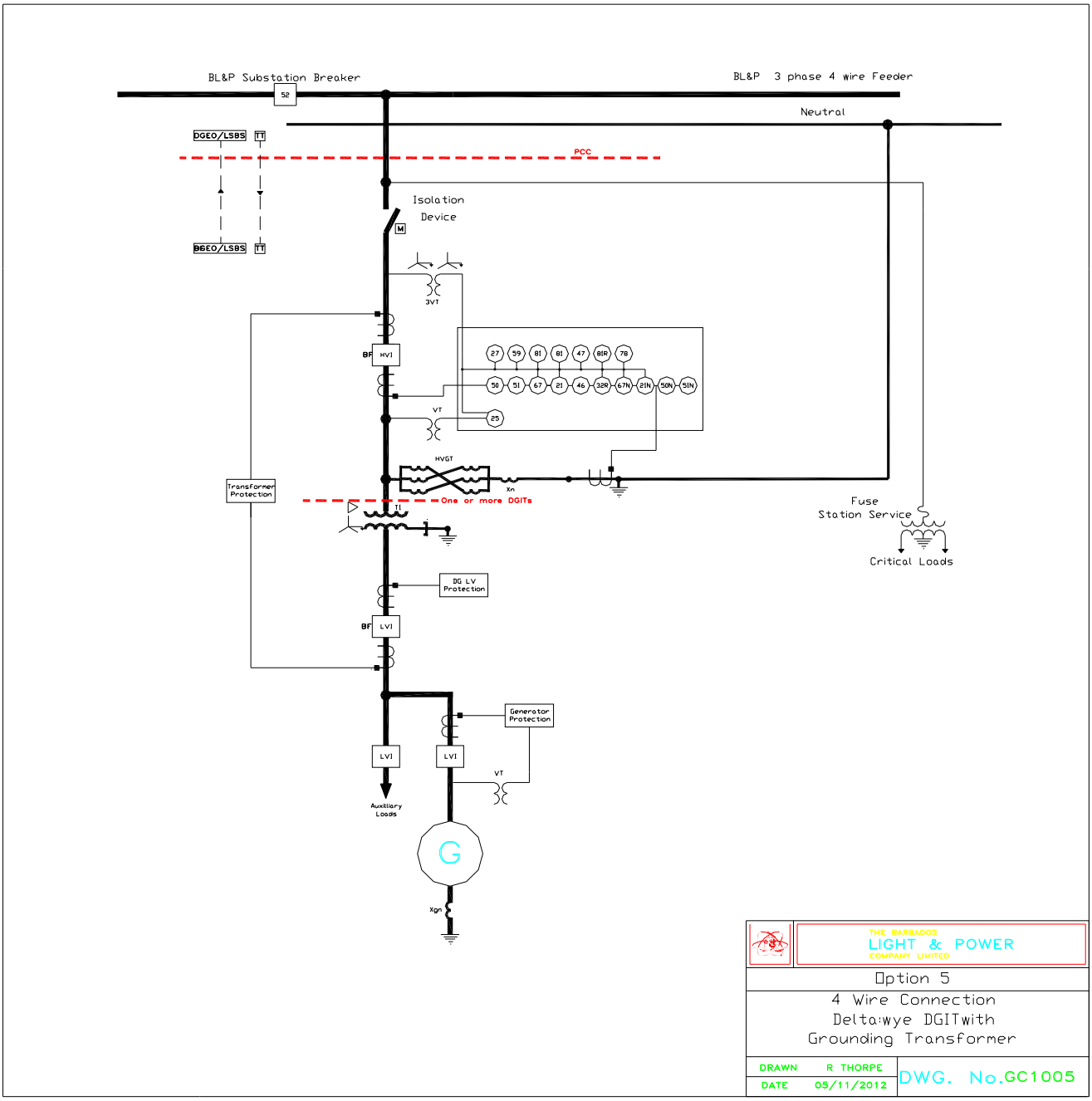

Figure 6: 4 – Wire DGIT Option #5 Typical Protection

2.3.7 PHASE AND GROUND FAULT PROTECTION

1. The DG Facility‘s protection system shall ensure that the DG Facility will detect and isolate itself and any HV ground sources from BL&P‘s Distribution System for:

    a) All internal faults within the DG Facility

    b) All external faults on the interconnected BL&P Distribution Feeder including single phase lateral spurs. This applies to all phase-phase and phase-ground faults and should be coordinated with BL&Ps protection devices.

2. Phase and ground protection shall always be operational whenever phase and ground current can be sourced from the DG Facility.

3. The protective device selectivity and sensitivity shall be maintained over the full range of minimum to maximum fault currents (present and anticipated future levels) with the DG’s infeed.

4. The DG Facility shall be capable of selectively detecting faults on the DG side of the HVI, and shall disable the HVI auto-reclosure scheme – (Refer to Section 2.4.7).

5. The total clearing time for faults on BL&P‘s Distribution System or for faults in the DG Facility shall be no more than:

    a) 500 ms for DG Facilities equipped with fast Transfer Trip; or

    b) 200 ms for DG Facilities not equipped with fast Transfer Trip. This can be relaxed to 500 ms if the DG Owner can demonstrate that the DG Facility fault contributions will not encroach on BL&P‘s Distribution System minimum fuse melt characteristic.

[**Note:** The total clearing time is measured from the start of the abnormal condition to the time that the DG Facility ceases to energize BL&P‘s Distribution System].

2.3.8 OPEN PHASE PROTECTION

1. The DG Facility‘s protections must be capable of detecting the loss of any phase to which the DG Facility is connected which occurs within the DG Facility or the Distribution System.

2. Upon the detection of the open-phase condition, the DG protection shall:

    a) Disconnect the DG from the Distribution System within 900ms and

    b) Disconnect the DGIT from the Distribution System via a HVI or a HV Motorized Disconnect Switch whenever the DGIT is three-phase with a common (shared) magnetic core.

2.3.9 FEEDER RELAY DIRECTIONING

1. BL&P feeder relay phase and ground over-current elements may need to be directional.
2. The need for Item (1) shall be specified to the DG Owner in the CIA.

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2.3.10 OVER FREQUENCY/UNDER FREQUENCY PROTECTION

1. The DG Facility interconnection protection scheme shall have the capability of detecting abnormal frequencies shown below in Table 10.
2. The DG Facility shall disconnect from BL&P's Distribution System in the clearing times specified in Table 10.
3. The clearing time in Table 10 shall be measured from the start of the abnormal condition until the time that the DG Facility ceases to energize BL&P's Distribution System.
4. More stringent clearing times may be specified in the CIA, if required.
5. DG Facilities > 150kW shall have the frequency set point field adjustable.

Table 10: Over/Under Frequency Protection Set Points and Clearing Times

Generator Size	Frequency Range (Hz)	Clearing Time(s)
> 150 kW	< 47.5 > 50.5	1.25

2.3.11 OVERVOLTAGE/UNDERVOLTAGE PROTECTION

1. The DG Facility interconnection protection scheme shall have the capability of detecting abnormal voltages shown in Table 11.

2. The DG Facility shall disconnect from BL&P's Distribution System in the clearing times specified in Table 11.

3. Voltage shall be measured:

    a) Phase-neutral for single phase installations;

    b) Phase-neutral for grounded Wye-Wye transformer configurations or

    c) Phase-phase for all other installations.

4. The voltages shall be detected at the PCC.

5. If the requirement in Item (4) above is not practical or feasible, estimated values may be used, if approved by BL&P.

6. The clearing time in Table 11 shall be measured from the start of the abnormal condition until the time that the DG Facility ceases to energize BL&P's Distribution System.

7. More stringent clearing times may be specified in the CIA, if required.

8. DG Facilities > 150kW shall have the voltage set point field adjustable.

9. Undervoltage relays should be time-delayed to avoid unnecessary tripping while over-voltage relays may be instantaneous.

10. High speed instantaneous voltage protection may be considered for detecting ferroresonance and self-excitation conditions.

Table 11: Over/Under Voltage Protection Setting and Clearing Time

Voltage Range (% of base voltage)	Clearing Time(s)*
V < 50	0.16
50 ≤ V < 88	2.0
110 < V < 120	1.00
V ≥ 120	0.16

2.3.12 ANTI-ISLANDING PROTECTION

1. Upon loss of voltage in one or more phases of BL&P's Distribution System, the DG Facility shall automatically disconnect from BL&P's Distribution System within 2 sec.

2. The DG Owner shall demonstrate to BL&P that it shall not sustain an island for longer than the time requirements in Item (1) above.

3. All DG Facilities shall have anti-islanding protection. This may involve different protection functions, however all DG Facilities shall have:

    a) Under/Over Frequency protection (Section 2.3.10);

    b) Under/Over Voltage protection (Section 2.3.11); and

    c) Transfer Trip for anti-islanding protection may be required as stipulated in Section 2.3.13.

4. DG Facilities ≤ 500 kW can be exempted from Item (3)(c), subject to item 8 below and allowed to install the following passive anti-islanding schemes, in lieu of Transfer Trip, as an interim protection until BL&P standardizes on a Transfer Trip solution for DG Facilities ≤ 500 kW:

    a) Rate of Change of Frequency (ROCOF) and

    b) Vector Jump; or

    c) Reverse Reactive Power.

5. The passive anti-islanding protection scheme in Item (4) shall be submitted to BL&P for approval.

6. The passive anti-islanding protections in Item (4) shall be set as sensitive as possible to reduce the non-detection zone and can be changed in the future if it is found to cause unjustified nuisance trips. These settings changes shall have to be pre-approved by BL&P prior to implementation.

7. If BL&P does not find a suitable low cost solution to Transfer Trip, the interim passive anti-islanding protections in Item (4) shall be changed out to Transfer Trip.

8. The DG Owner shall be aware and accept the consequences of utilizing passive anti-islanding schemes in Item (4) above as a primary anti-islanding protection and shall not hold BL&P responsible for any damage incurred due to islanded operation from events such as out-of-phase reclosing.

2.3.13 TRANSFER TRIP (TT)

1. A TT signal from the station feeder breaker(s) to the DG Facility shall be required for all DG Facilities whose aggregate capacity is >=500kW or larger.

2. A TT signal **from** the feeder breaker(s) and/or upstream recloser(s) (where the recloser is located between the DG Facility and feeder

breaker) **to** the DG Facility shall be required for any or all of the following conditions:

a) When the aggregate DG Facility capacity is greater than 50% of the minimum feeder load or the minimum load downstream of recloser(s); or

b) When the aggregate generation, comprising of existing generation, other earlier proposed DG Facilities, and the concerned DG Facility is greater than 50% of the minimum feeder load or minimum load downstream of the recloser; or

c) If the existing reclosing interval of the feeder breaker(s) and/or upstream recloser(s) is less than 1.0s.

3. A TT signal **from** upstream feeder breaker(s) and/or recloser(s) **to** the DG Facility connected at downstream of Distribution substation (DS) supplied by that feeder shall be required. This is required when the aggregate generation, comprising of existing generation, other earlier proposed DG Facilities at the feeder or at the DS, including concerned DG Facility, is greater than 50% of minimum feeder load or the minimum load downstream of breaker/recloser respectively.

4. A TT signal **from** transmission line terminal breaker(s) of an upstream Transformer substation (TS) **to** the DG Facility shall also be required if the TS where the DG Facility is being proposed is radially supplied by that transmission line and there is a possibility of islanding of the entire transmission line, or where Wide area islands could exist – aggregate generation on transmission line is greater than 50% of the minimum load on the transmission line. This signal will be cascaded onto the TT signal that will be required between the TS feeder breaker and the DG Facility in Item (2) above.

5. The DG Facility shall cease to energize BL&P‘s Distribution System with no intentional time delay and isolate all generation and HV ground sources upon receipt of a Transfer Trip signal.

6. TT communications shall meet the timing requirements in Table 12. The maximum TT time shall depend on the operational speed of the DG Facilities interrupting device.

Table 12: TT Timing Requirements

Maximum TT Communication Time (ms)	Speed of DG Facility`s Interrupting Device (cycles)
83	3
67	4
50	5
33	6
17	7

7. The DG Facility shall remain disconnected from BL&P Distribution System if the TT channel is unavailable.

8. The TT teleprotection system shall be failsafe, and

9. Upon loss of the TT communication channel, the generation and HV ground sources shall disconnect within 5 seconds of the channel failing. A controlled shutdown may be allowed and must be submitted to BL&P for approval.

2.3.14 DISTRIBUTED GENERATOR END OPEN (DGEO)

1. A Distributed Generator End Open (DGEO) real-time signal from the DG Facility to BL&P is required whenever Transfer Trip is required, as outlined in Section 2.3.13.
2. The DGEO and Low Set Block Signal (LSBS) (Refer to Section 2.3.15) signals shall be combined into one composite communications channel signal as outlined in the DGEO and LSBS Design Requirement in Section 2.3.16.
3. Upon failure of the DGEO channel, BL&P may block its feeder reclosing until the channel is repaired.
4. The DG Owner shall make repairs in the event of channel failure as quickly as possible.
5. In the event of Item (3) above, BL&P can seal in TT to the affected DG Facility until the channel is repaired to enable automatic reclosing on its feeders.

2.3.15 LOW SET BLOCK SIGNAL (LSBS)

1. A Low Set Block Signal (LSBS) from the DG to the BL&P supply source breaker or recloser, is required whenever TT is required, as outlined in Section 2.3.13.
2. The LSBS and DGEO (Refer to Section 2.3.14) signals shall be combined into one composite communications channel signal as outlined in the DGEO and LSBS Design Requirement in Section 2.3.16.

2.3.16 DGEO AND LSBS DESIGN

1. The DGEO and LSBS (Refer to Section 2.3.14 and Section 2.3.15 respectively) signals shall be combined into one composite communications channel signal.
2. This dual function signal shall be set to one [1] when the breaker is open and set to zero [0] 1s **prior** to the energization of the DGITs.

2.3.17 SPECIAL INTERCONNECTION PROTECTION

1. Other protections not specified in this requirements document may be required depending on the application.

2. The DG Owner shall be aware of site specific conditions and the nature of BL&P's Distribution System to properly assess the need for additional protections.

2.3.18 PROTECTION SCHEME FAILURES

1. The DG Facility generation and HV ground sources shall be disconnected from BL&P's Distribution System and notify BL&P's system operators if:
    a) The DG local interconnection protection system fails; Interconnection protection systems provided by Independent Electronic Devices (IED) shall have self-diagnostic (control healthy) features that detect internal relay failures;
    b) The breaker trip coil or interrupting device fails;
    c) The DC supply is lost; or
    d) The TT signal channel fails.
2. Alarm Telemetry shall be provided to BL&P directly from the DG Facility as required in Section 2.5.
3. With the exception of Item (1) (d) above, disconnection shall be automatic and immediate (no intentional time delay).
4. Disconnection following TT signal failure shall be automatic but can be delayed as outlined in Section 2.3.13(9).
5. BL&P may send TT to the DG Facility following a DGEO signal failure as outlined in Section 2.3.14(5).
6. The device(s) used to disconnect the generation shall remain open until such time when the affected system is returned to normal service condition and the DG Facility is safe for reconnection to BL&P's system.
7. The interface protection design submitted to BL&P during the implementation phase of the Connection Process, shall provide sufficient detail to ensure that the protection scheme failure requirements, outlined in Item (1) above, are addressed.
8. In designs where self diagnostic features do not trip the appropriate breakers upon failure, sufficient backup and/or redundancy protections shall be provided.
9. If electro-mechanical relays are used, the protection and control design shall be of a fail-safe nature to ensure the integrity of the protection scheme under malfunctioning conditions.

2.3.19 INTERCONNECTION PROTECTION ACCEPTANCE

1. The DG Owner shall provide BL&P with complete documentation on the proposed DG Facility interconnection protection scheme to ensure compliance with the requirements of this document and all applicable standards. Documentation shall include, but is not limited to:

    a) A detailed Single Line Diagram;

    b) An overall description on how the protection will function;

    c) A description on failure modes;

    d) Detailed engineering drawings that include design details on protection and control, teleprotection and telemetering schemes and components including manufacturer and model number;

    e) The protection element settings (pickup, timers, etc.);

    f) Details on monitoring for the protection system performance (DFR, SER, and telemetry);

    g) Details on backup supply to any critical loads;

    h) Details on the Breaker Failure protection if required by Section 2.3.4 and

    i) Details on the disconnecting and interrupting device.

2. If BL&P proposes any changes from the review in Item (1), the DG Owner shall revise and re-submit the protection information to BL&P.

3. All documentation must be submitted together.

4. The latest submissions will be filed by BL&P and MUST MATCH the documentation retained by the DG Owner.

2.3.20 PROTECTION CHANGES

1. The DG Owner shall require BL&P's approval of all:

    a) Interconnection equipment replacements;

    b) Design modifications and

c) Setting changes.

2. Any changes without prior approval shall be deemed as a violation of the Distribution Connection Agreement and may result in immediate disconnection from BL&P`s Distribution System.

2.4 OPERATING REQUIREMENTS

2.4.1 GENERAL

1. Switching that involves manual operation of air break switches shall require all connected DG Facilities to disconnect their generation from the system as directed by BL&P's SCADA control operators.

2. In the event that the source configuration changes, other than what was studied in the DG Owner's CIA, or listed in their Distribution Connection Agreement (DCA), all connected DG Facilities shall disconnect their generation from the Distribution System as directed by the BL&P's SCADA control operators. It shall be the DG Owner's responsibility to ensure that their protections are capable of detecting all external faults.

3. Any temporary feeder parallels shall require that all connected DG Facilities come off-line, as directed by the BL&P's SCADA control operators.

4. TT and DGEO communications shall be required for DGs 1 MW and larger, connecting to BL&P's Distribution System at voltages less than 24.9 kV.

5. For feeders with multiple feeder reclosers, 50% minimum feeder load calculations shall identify remaining loading levels with reclosers in open position.

6. The DG Facility shall parallel with BL&P's Distribution System without causing a voltage fluctuation at the PCC greater than ± 4% of the prevailing voltage level of the distribution system at the PCC and meet the flicker requirements in Section 2.2.2.3.

7. The DG Facility (synchronous and permanent magnet generators) shall remain in synchronism with BL&P's Distribution System while operating in parallel to BL&P's Distribution System. The DG is expected to have loss-of-field protection as part of the generator protection to quickly disconnect the generator, should the excitation to the generator fail.

8. No automatic reconnection to the system shall be allowed unless:

    a) There is always contact with the DG Owner or DG Facility operator who has the ability to immediately disconnect the DG Facility from the system if requested by BL&P's SCADA operators (24 hours/7 days per week); or

b) BL&P's SCADA operators shall have the ability to remotely disconnect the DG Facility from the system and

c) Feeder relay studies must be updated if circuit configuration is materially altered. If the source changes from the configuration studied in the CIA, the generator will not be allowed to reconnect without subsequent approval.

9. Automatic reconnection to BL&P's Distribution System shall be locked out once voltage and frequency are not within operating ranges for a period of 15 minutes on any phase for any DG Facilities limited to one connection path if stipulated in their DCA.

2.4.2 ISLANDING

1. Intentional islanding is not allowed at this time.

2. Islanding detection and protection is required as per Section 2.3.12.

2.4.3 UNINTENTIONAL ENERGIZATION

1. The DG Facility shall not energize BL&P's Distribution System when the distribution system is de-energized.

2.4.4 SYNCHRONIZATION

1. Any DG Facility that is capable of generating its own voltage, while disconnected from BL&P's Distribution System, shall require proper synchronization facilities before connection is permitted.

2. Interconnection shall be prevented if the DG and BL&P's Distribution System is operating outside the limits specified in Item (3) below.

3. Synchronous generators, self-excited induction generators or inverter-based generators, that produce fundamental voltage before the paralleling device is closed, shall only parallel with BL&P's Distribution System when the frequency, voltage and phase angle differences are within the ranges given below in Table 13 at the moment of synchronization.

Table 13: Resynchronization Requirements

Aggregate Rating of Generators (kVA)	Frequency Difference (Δ f, Hz)	Voltage Difference (Δ V, %)	Phase Angle Difference (Δ Φ,)
0-500	0.3	10	20
>500 – 1500	0.2	5	15
>1500	0.1	3	10

4. For synchronous generators, an approved automatic synchronization device shall be required if the plant is unattended (IEEE device number 25) to ensure that the DG Facility will not connect to an energized feeder out of synchronism.

5. Induction generators and inverter-based generators, that do not produce fundamental voltage before the paralleling device is closed and double-fed generators, whose excitation is precisely controlled by power electronics to produce a voltage with magnitude, phase angle and frequency that match those of the distribution system, may not require synchronization facilities.

6. Any proposed synchronizing scheme shall be submitted to BL&P prior to installation and shall be able to accommodate automatic reclosing on BL&P's distribution facilities.

2.4.5 SINGLE CONNECTION PATH

1. The requirements in Items (2), (3), and (5) below shall apply to DG Facility connections which have a restriction to only a single connection path (normal configuration) as stipulated in their DCA.

2. DG Facility generation connection shall be restricted only to the normal Distribution System supply configuration and when all required protection and control systems, required for safe and reliable connection to the Distribution System, are operational. The normal Distribution System supply configuration is considered to be when the feeder is supplied from one TS feeder breaker (the normal supply breaker) or DS recloser and all normally open line switches are open, as defined by BL&P operating diagrams.

3. DG Facility generation connection shall be restricted only to Transmission System supply configurations that have adequate minimum load connected or, have adequate TT facilities in-service to prevent a Wide-Area DG island.

4. Upon request the DG connection can be approved for Alternate Grid Connection Path if deemed acceptable by BL&P. An additional assessment on Transmission System supply configurations shall be required.

5. The CIA and DCA shall clearly identify the Distribution System and Transmission System supply configuration(s) studied and determined to be acceptable for safe and reliable DG Facility connection in accordance with Items (1) and (3) above.

6. If an alternate configuration exists and if Items (2) and (3) above apply to the DG Facility, then the DG Facility shall be disconnected until the normal configuration is restored.

2.4.6 AUTOMATIC DISCONNECTION OF GENERATION AND HV GROUND SOURCES

1. All DG Facility generation and sources of ground current shall be automatically disconnected from the Distribution System whenever the DG Facility Interconnection Protection or TT operates, as required by the other sections in this document. The timing requirements for automatic disconnection are detailed below in Items (2), (3), (5), (6), and (7).

2. For those DG Facilities that require TT, all generation shall be disconnected immediately (without any intentional delay) upon the receipt of a TT signal from BL&P.

3. For those DG Facilities that require TT, all generation shall be disconnected within 500 ms of when external faults are detected on the Distribution System by the DG Facility Interconnection Protection.

4. For those self-clearing DG Facilities that do not require TT, all generation shall be disconnected within 200 ms of the start of the abnormal condition on the Distribution System by the DG Facility Interconnection Protection.

5. All sources of DG Facility generation shall be disconnected within 500 ms when the DG Facility Anti-islanding Protection operates.

6. All three-phase DG Facility ground sources shall be disconnected within 500 ms if any of the above items (2) to (5) above operates.

7. A back-up means shall be provided for disconnecting the DG Facility generation and all grounded DGIT or HV grounding transformers that provide a ground return path for ground faults on the HV side of the DGIT, should the interrupting device fail.

2.4.7 AUTOMATIC RECONNECTION OF GENERATION AND HV GROUND SOURCES

1. Reconnection to BL&P Networks distribution system shall be a two step process as outlined below. Both steps can occur simultaneously if the DG uses HVI to synchronize generation.

2. Step 1 in Items (3) and (4) below shall apply only if the DGIT is required to be disconnected by an HVI as outlined in Section 2.1.14.

Step 1: Automatic DGIT Reconnection (HVI reclosing)

3. The DGIT may be automatically re-energized using an HVI automatic reclosing scheme provided:

    a) Automatic reclosing to the HVI is initiated only when the DG Facility Interconnection Protection or TT operates;

    b) The fault is not on the DG side of the HVI;

    c) The Distribution System feeder has successfully re-energized from the normal BL&P source and

    d) The Distribution System voltages are stable within normal limits for a continuous period of 15 seconds.

    e) Once Items (3) (a - d) are satisfied, reconnection must occur within 15 seconds, otherwise the DG may have to follow normal reconnection procedure.

4. For DG Facilities requiring LSBS, the LSBS signal shall be sent one (1) second before the DGIT is re-energized.

Step 2: Automatic Generator Reconnection

5. DG Facility generation shall not be automatically reconnected to the Distribution System until the Distribution System voltage is stabilized within 6% of nominal and the frequency is between 49.5Hz and 50.5Hz, for a definite time period defined by Item (6) below.

6. Automatic reconnection of DG Facility interconnection system shall include an adjustable delay that may delay the reconnection for 5 minutes.

7. Additional requirements listed in Section 2.2.2.3 and Section 2.4.4 shall be met for this automatic reconnection following a momentary outage to occur.

8. Should restoration attempts of BL&P supply to the Distribution System fail to re-establish stable voltages within 15 minutes, automatic reconnection of the DG Facility interconnection system shall be disabled.

9. For all DG Facilities with a limit to connect through only one normal configuration path in accordance with their DCA, BL&P's SCADA operators shall give permission to the DG Facility operators to manually reconnect when stable voltages have not been restored within 15 minutes. No automatic reconnection shall take place after the 15 minutes.

2.4.8 AUTOMATIC RECONNECTION OF DG FACILITY GENERATION FOLLOWING A SUSTAINED OUTAGE OR SHUTDOWN

1. No automatic reconnection of the DG facility shall occur following a sustained outage or shutdown - when the voltage and/or frequency out of normal operating range on any phase for more than 15 minutes for any DG Facilities limited to one connection path if stipulated in their DCA. Permission to reconnect shall be given by BL&P's SCADA operators as per the DCA.

2.5 CONTROL AND MONITORING REQUIREMENTS

2.5.1 GENERAL

1. Control and monitoring facilities shall be required at DG Facilities connected to the BL&P's Transmission and Distribution system for provision of real-time operating data.

2. The DG Owner shall provide battery backup for telemetry in the event that the DG Facility is removed from the BL&P Transmission or Distribution System.

3. Battery backup capacity shall be sufficient for the connection to be re-established.

4. Alternatives to Item (3) above are subject to approval by BL&P.

5. Under the TSC, DSC and terms of this document, DG Owners of DG Facilities connected to BL&P's Transmission and Distribution Systems shall have an obligation to provide real time data pertaining to their equipment as required by the capacity at the PCC.

6. Monitoring and control may be required as a result of Renewable Energy Supply Integration initiatives, regardless of the capacity, as will be determined by BL&P.

7. Installation capacity descriptions shall be consistent with the class definitions in this document, listed below in Table 14 for convenience.

Table 14: DG Classification

Class	Generation Capacity at PCC
1	150 kW < DG Facility Rating < 1500 kW
2	1.5 MW ≤ DG Facility Rating ≤ 10 MW
3	DG Facility Rating > 10 MW

8. The requirements for real time operating information shall apply to all customer-owned (DG Owner's) DG Facilities connected to BL&P's Transmission or Distribution network.

9. The quantities and device statuses, defined below, shall be provisioned, monitored and controlled for continuous transmission to BL&P.

10. Some, or all, of the control and monitoring requirements in this document may apply to DG Facility interconnection.

2.5.2 CONTROL FACILITIES

1. Subject to the agreement between the DG Owner and BL&P, for all DG at 11kV and 24kV, remote control of all or some of the following shall be provided to BL&P:

    a) Station breakers and switchers;

    b) Motorized disconnect switches;

    c) Transformers OLTC;

    d) 3% and 5% voltage reduction;

    e) Hold off on feeder breakers;

    f) Dynamic generator output control; and

    g) Other location specific devices.

2. At any time, BL&P's SCADA shall have remote control of the DG Facility devices as required in item 1.

3. Where the DG Owner maintains an operating centre and control of the DG Facility is handed off from the DG Owner to BL&P at scheduled times, BL&P will consider the use of an Inter Control Centre Communications Protocol (ICCP) link between the two control centers.

2.5.3 OPERATING DATA, TELEMETRY AND MONITORING

1. Quantities provided from the DG Facility shall be in SI units.

2. The quantities shall provide an overall end-to-end measurement error no greater than 2% of the nominal rating. The error shall include all primary, secondary and analog to digital conversions.

3. The resolution shall meet or exceed the accuracy rating of the device performing the analog to digital conversion.

4. Real-time data to be provided to BL&P by the DG Owner will depend on the output rating of the facility as listed below in Section 2.5.3.1 through to Section 2.5.3.4.

2.5.3.1 CLASS 1 GENERATORS

1. DG Facilities with a capacity of greater than or equal to 150 kW shall have the provision for monitoring the disconnecting device at the PCC.

2. Provisions for other quantities may be required and shall be determined by BL&P.

3. The actual implementation to install the SCADA link and modem is not required, but may be requested by BL&P at a later date to be implemented at DG's cost within 90 days.

4. DG Facilities with a capacity of greater than 300 KW but less than 1500 kW shall provide the following information:

    a) Analogue Quantities which include the following:

    - Net active power (MW) output and reactive power (MVAR) flow and direction for each unit or total for the DG Facility;
    - Phase-to-phase (preferred) or phase-to-neutral voltages and
    - Three-phase currents.

    b) Device Statuses:

    - Consolidated Connection Status at the PCC (HVI/LVI);
    - Status of individual DG units and
    - All generation rejection selections.

    c) Alarms:

    - Where facilities exist to provide independent monitoring of the interface protection fail as stated in Section 2.3.18, provision shall be made for an alarm signal to be generated and transmitted to BL&P;
    - A separate alarm shall be provided for each circuit supplying the DG Facility;
    - The alarms shall identify the name of the DG Facility and the designation of the affected circuit and
    - BL&P shall determine requirements based on controlling authority and equipment ownership.

5. Monitoring and control may be required as a result of Renewable Energy Supply Integration initiatives regardless of the capacity, as will be determined by BL&P.

2.5.3.2 CLASS 2 GENERATORS

1. Generating facilities with a capacity of greater than or equal to 1500 kW, but less than or equal to 10 MW, shall provide the same data as identified for Class 1 generators.

2.5.3.3 CLASS 3 GENERATORS

1. Generating facilities with a capacity of greater than 10 MW shall provide the same data as identified for Class 2 generators.

2.5.3.4 TELEMETRY REPORTING RATES

1. The minimum requirements for telemetry reporting rates for DG Facilities (Class 1, Class 2, and Class 3) interconnecting to BL&P's Distribution System shall be as shown below in Table 15.

Table 15: Telemetry Reporting Rates

Function	Performance
Data measurements	Less than 10s from change in field monitored quantity
Equipment status change	Less than 10s from field status change
Data skew	Not applicable
Scan period for data measurements	Minimum 4s
Scan period for equipment status	Minimum 4s

2.6 TELECOMMUNICATIONS REQUIREMENTS

2.6.1 GENERAL

1. Telecommunication infrastructure is required by Distributed Generators connected to BL&P's Distribution system for provision of protection and real-time operating data.

2. Telecommunication infrastructure shall be fast, secure, reliable, and shall meet the technical requirements for protection, control and monitoring as described in Sections 2.3 and 2.5 of this document.

3. BL&P will indicate the viable alternative technologies that may be used for Telecommunications, which may include licensed/unlicensed microwave radio, optical fiber or Carrier-based leased circuits.

4. Cellular based Telecommunication infrastructure shall only be considered for real-time control and monitoring.

5. DG owners shall provide the GPS coordinates of the DG Facility to assist in the evaluation of wireless communication alternatives.

2.6.2 TELECOMMUNICATIONS FACILITIES FOR TELEPROTECTION

1. A robust telecommunication infrastructure will support the stringent reliability and latency requirements for Teleprotection.

2. The purpose of Teleprotection is to transmit critical information about the power system conditions from one end of the protected line to the other.

3. The proposed telecommunication infrastructure for Teleprotection shall meet the requirements for TT and DGEO as per Section 2.3.

4. Telecommunication infrastructure for Teleprotection will be reviewed by BL&P to ensure the requirements for Teleprotection are met.

2.6.3 TELECOMMUNICATIONS FACILITIES FOR REAL-TIME CONTROL AND MONITORING

1. The DG Owner shall provide real-time operating information to BL&P as specified in Section 2.5 either directly from the station(s), as described in item (2), or from the DG Facility's SCADA master, as described in item (3).

2. Real time operating information provided to BL&P may be from an Intelligent Electronic Device (IED) at the DG Facility's station, to BL&P's control center, using Distributed Network Protocol (DNP 3.0 protocol):

    a) To BL&P through the gateway to BL&P's SCADA Control Centre, with the demarcation point being the wireless access point to the Service Provider's cellular network; or

    b) Where Item 2 a) above is not feasible, through a common carrier connection to BL&P's SCADA Control Centre, with the demarcation point being the DG Facility's station; or

    c) Where Items 2 a) and b) above are not feasible, BL&P will suggest communication options available to a particular site.

3. Real-time operating information provided to BL&P may be from a SCADA master through BL&P's SCADA master using Inter-Control Center Communications Protocol (ICCP) or equivalent.

4. Where modems will be used in any of the above communication methods, BL&P will determine the modem type and requirements considering communication media, site location, reliability and amount of data transfer. The DG Owner will provide all the required hardware and software and make arrangements, as needed, with a commercial provider of communication services to deliver the operating data to the demarcation point.

2.6.4 RELIABILITY REQUIREMENTS

2.6.4.1 TELEPROTECTION

The Telecommunication infrastructure shall comply with the following:

a) Provide at least an annual average availability of 99.65%.

b) Meet the Teleprotection dependability requirement defined as the probability of a missed command be less than 10 for DG application. As defined in IEC 60834-1.

c) Meet the Teleprotection security requirement defined as an unwanted command shall be less than 10 for DG application. As defined in IEC 60834-1.

2.6.4.2 REAL-TIME CONTROL AND MONITORING

1. The delivery of real-time data at the communication demarcation point shall have :

   a) MTBF (Mean Time between Failure) of four (4) years; and

   b) MTTR (Mean Time to Repair) of seven (7) days.

2. The DG Owner may be required to disconnect the DG Facility until problems are corrected, if the failure rates or repair time performance in item (1) above fails to achieve their targets by the following significant amounts:

   a) Less than 2 years MTBF; or

   b) MTTR greater than 7 days.

3. If the DG Facility is involved in a Special Protection System (SPS) or automated dispatch, the Telecommunication Mean Time to Repair (MTTR) requirement shall be 24 hours.

4. Upon loss of telecommunications, the DG Owner is required to immediately report the failure cause and estimated repair time to the Controlling Authority.

5. Mean Time to Repair time shall start from the time when the communications was lost and not from when it was discovered.

6. The DG Owner shall coordinate any planned interruption to the delivery of real time data with BL&P.

2.7 REPORTING REQUIREMENTS

2.7.1 GENERAL

1. The DG Owner shall keep a written or electronic log. This log will record the date and time, along with a description of the incident.

2. Data files names shall contain the date and time in accordance with IEEE Standard C37.232 - Recommended Practice for Naming Time Sequence Data Files.

3. The incidents recorded shall include, but are not limited to, those in the sections below.

4. The DG Owner shall make the log, or a copy of the log, available for the BL&P's review upon request, within five (5) working days of that request or as specified in the DCA.

5. The DG Facility shall monitor:

    a) Phase Voltages;

    b) Neutral to earth voltage;

    c) Frequency;

    d) Phase and neutral amps;

    e) Active Power (kW or MW);

    f) Reactive Power (kVAr or MVAr);

    g) Status of switching devices which are part of a protection and control scheme and

    h) Alarm conditions.

6. The DG Facility shall provide an alarm to the BL&P when there is a failure of recording or logging capability.

7. The recording device shall be capable of recording event time in either UTC or Eastern Standard Time.

8. DG Facilities rated greater than 300 kW and less than 10 MW, reporting protection initiated events, shall meet the following performance requirements:

a) The maximum difference in time stamps produced by different devices on the network for the same event shall be 4 ms or less.

b) The maximum difference between the time generated by the internal clock and the actual time [e.g. - Eastern Standard Time (EST) or Coordinated Universal Time (UTC)] shall be limited to 4 ms.

9. DG Facilities rated 10 MW and greater, reporting protection initiated events, shall meet the following performance requirements:

    a) The maximum difference in time stamps produced by different devices on the network for the same event shall be 1 ms or less.

    b) The maximum difference between the time generated by the internal clock and the actual time [e.g. - Eastern Standard Time (EST) or Coordinated Universal Time (UTC)] shall be limited to 1 ms.

2.7.2 POWER QUALITY RECORDING

1. Power quality recording shall be provided for facilities rated greater than 300 kW.

2. The PQ device shall generate an alarm if there is a loss of signal at an AC input terminal.

3. The PQ device shall be capable of communicating with BL&P monitoring facilities using ION 2.0, DNP 3.0 and GPSTRUETIME/DATUM protocols via RS 232/485 or Ethernet ports.

4. The PQ device shall be capable of recording impulsive transients in the milliseconds range (monitoring possible to 7 kHz).

5. The PQ device shall be capable of recording low frequency oscillatory transients (f<5 kHz).

6. The PQ device shall be capable of recording medium frequency transients (5 kHz < f <500 kHz).40

7. The PQ device shall be capable of recording sags/swells/interruptions.

8. The PQ device shall be capable of capturing voltage and current channels simultaneously.

9. The PQ device shall be capable of recording the duration of voltage sag and swell events based on programmable set points.

10. Waveforms, rms voltage variations, trends, and histograms shall be reported in IEEE P1159.3 PQDIF format.

2.7.3 DISTURBANCE FAULT RECORDING

1. Disturbance reporting shall be provided for each class of generator as specified in Items (3), (4), and (5) below.

2. Data file format shall be compatible with - IEEE Std C37.111-1999 "IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems." This format shall be used when sharing files.

3. Facilities rated greater than 300 kW shall provide waveforms from IEDs used for protection.

4. Facilities rated greater than 300 kW up to 1500 kW shall provide:

    a) A minimum rate of 240 Hz (4 samples/cycle.) at a minimum resolution of 0.05% of full scale (alternatively a 12 bit resolution is acceptable) and

    b) A minimum record duration shall be the sum of 4 cycle of pre-fault + 2 cycles post fault + total clearing time of longest time delayed protection (I.e. phase protections set at 500 ms delay and 85 ms breaker is used – total time for recording would be – 66 ms + 500 ms +85 ms + 33 ms = 685 ms)

    .

5. Facilities rated 1500 kW or greater shall provide:

    a) A minimum rate of 1 kHz (16 samples/cycle.) at a minimum resolution of 0.05% of full scale (alternatively a 12 bit resolution is acceptable);

    b) A minimum duration of (1) second; and

    c) A minimum pre-fault duration of 250 ms.

6. All reports shall provide unfiltered records. If filtered records are also available they shall be included in the report as well.

7. Multiple consecutive triggered disturbance records shall be acceptable, if required, to achieve the 1 second duration requirement.

2.7.4 SEQUENCE OF EVENTS RECORDING

1. Sequence of Event reporting shall be provided for each class of generator as specified in Items (3), (4), and (5) below.
2. Recorded points shall include:
    a) The generator connection status (individual units);
    b) The Transfer Trip signal status;
    c) The Distributed Generation End Open signal status;
    d) Which relays operated (targets & description) and
    e) Any available sequence of events records (SER) related to the above.
3. DG Facilities rated greater than 300 kW shall provide SER reporting from IEDs used for protection.
4. DG Facilities rated greater than 300 kW and less than 10 MW shall provide:
    a) SER from switching devices which are part of a protection and control scheme; and
    b) Event records with resolution of 1 msec.
5. DG Facilities rated 10 MW or greater shall also provide in addition to the requirements in Item (4) above:
    a) Events within the same facility recorded to within 1 ms accuracy, if reporting is required to a compliance authority other than BL&P.

2.8 METERING REQUIREMENTS

Metering requirements vary with the type and intent of the generation facility. BL&P has published a Metering policy for DG Facilities.

2.9 COMMISSIONING AND VERIFICATION REQUIREMENTS

1. Commissioning and Verification shall be in accordance with the BL&P's COVER Process.

2. BL&P may witness any Commissioning and Verification of DG Facilities greater than 150kW.

3. A specific Commissioning and Verification plan shall be developed that corresponds to the specific design of the DG Facility and implemented using the BL&P COVER Process as in Section 2.9.1.

4. The specific Commissioning and Verification plan in Item (3) shall incorporate the Generic Requirements as outlined in Section 2.9.2.

2.9.1 BL&P COVER PROCESS

1. The DG Owner shall use a "Confirmation of Verification Evidence Report" (COVER) to track the DG Facility's Commissioning and Verification plans and execution.

2.9.2 COMMISSIONING AND VERIFICATION GENERIC REQUIREMENTS

1. Testing of the DG Facility interconnection system shall conform to IEEE Standard 1547.1 – "*Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems*".

2. BL&P's participation in the commissioning of the DG Facility shall be limited to those protection and control systems that impact BL&P's Distribution System.

3. Commissioning of the protection and control systems shall be complete and thorough.

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

5. The expected commissioning testing and supporting documentation must include:

a) Instrument transformer checks (insulation, ratio/polarity, excitation and resistance results);

b) Breaker timing trip tests for those breakers used to disconnect the DG Facility from the Distribution System as a result of protection operations;

c) Verification of the transformer and neutral reactor impedances that impact the DG Facility's ground integration with the Distribution System and correct connection, where applicable;

d) Relay setting field work sheets (showing the measured results of the relay calibration checks). Relay element settings/directioning are to be confirmed by AC secondary injection;

e) Voltage measurements for any external power supplies used to supply the protections shall be recorded;

f) Verification that all AC and DC measurements have test equipment traceable to NRC standards;

g) Functional tests confirming the protection and control logic and timer settings;

h) Verification of test trips and alarm processing. Monitoring of breakers outputs using suitable indicators can be used to avoid repeated tripping of the same from different protections, but at least one live trip test per breaker (where the breaker is proven to open) needs to be demonstrated;

i) Verification of control interlocks in protections;

j) Verification of synchronizing system and synch-check controls;

k) Voltage phasing checks (prior to first connection);

l) Secondary load readings, voltage and current phasor checks (immediately after first connection) to prove correct magnitude and phase angle of all secondary AC voltage and current circuits correspond to primary quantities. Primary current, voltage, MW and MVAr values shall be calculated from the measured secondary values and compared to known primary quantities at adjacent locations; and

m) Verification of TT and DGEO end-end checks. This will require participation and coordination with BL&P.;

6. The DG Owner shall make modifications to correct any problems that are found during commissioning.

2.9.3 DOCUMENTATION OF TEST RESULTS

1. Documentation of Test Results shall be provided as outlined in the COVER sections as follows:

    a) All DG Owners must provide a letter signed and stamped by a registered Engineer in Barbados stating that their equipment and installation meets UL, NEC, GEED, CSA and/or other applicable electrical safety standards, prior to ready for Service Date;

    b) As-constructed drawings (single line diagram showing protection and metering, AC and DC schematics, final relay settings, testing and commissioning results for interconnection protection etc.) shall be submitted to the BL&P for its records, as stipulated in the Distribution Connection Agreement; and

    c) The completed documentations shall clearly indicate the station, 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), instrument transformer ratios. There shall be a cross-reference to the submitted design documentation (drawing numbers and revision).

2. The DG Owner shall keep the information provided in Item (1) above for a period of (7) years.

3.0 REFERENCES

A. APPENDIX A – BL&P CHARACTERISTICS *(INFORMATIVE)*

This section describes the characteristics of BL&P Distribution System and identifies aspects that must be taken into consideration when designing a generation connection. The DG owner must be able to operate within the ranges specified in this section. In this document, BL&P's Distribution System may refer to either three phase systems or single phase systems operating at voltages of 24.9kV and below – includes systems falling under the definition of distribution lines and sub-transmission lines. This section contains no requirements for the interconnection of DGs and has been provided for informational purposes only.

A.1 GENERAL CHARACTERISTICS

Most distribution circuits or feeders in BL&P's Distribution System are supplied radially from a single substation (point of supply). In some areas, some feeders may have alternate points of supply, but will be operated with more than one source of supply only momentarily during switching operations. BL&P's distribution feeders operate at the following voltages (phase-phase/phase-neutral): 24.9/14.4kV, 11/6.35kV.

A.2 SYSTEM FREQUENCY

The nominal frequency of BL&P's system is 50Hz. During normal operation (steady state), the frequency may deviate from 49.3Hz to 50.5Hz. Under contingencies the frequency deviations may be larger.

A.3 VOLTAGE

Customers supplied by a distribution feeder will nominally receive 11,000 volts but could be 2% above nominal at some locations, with and without distributed generation supplying power for minimum and maximum loading conditions. The operating voltages found on the distribution feeder vary depending on load variation, generation variation and contingency situations. BL&P standard for voltages on the Distribution System at the point of delivery during normal operation is typically in the range of +/- 6% of nominal voltage as shown in Table 16.

These values may be exceeded under abnormal conditions. Voltage transients and swells can occur on the Distribution System at any time due to lightning strikes, single phase to ground faults, and switching, among others.

Table 16: Voltage Limits 0 to 11,000V on Distribution System

Low Limit (% of nominal)	Nominal Voltage (%)	High Limit (% of nominal)
94	100	106

A.4 VOLTAGE REGULATION

BL&P utilizes voltage regulating devices throughout the distribution system to maintain an adequate voltage profile along the feeders and ensure that customers receive voltages in the range specified in CSA Standard CAN3-235-83. These regulating devices include regulating stations and transformer on load tap changers at the Transformer Station (TS) or Distribution Station (DS). BL&P operates all voltage regulating devices on its Distribution System to 115V ±6% on a 115V base. On Distribution feeders operated at 24,900 V regulation at 115V is also to 115V± 6%. On Transmission lines not directly supplying customers but connected to transmission substations (TS) the nominal voltage will be 24,900V but voltage excursions greater than ± 6% can be encountered.

A.5 VOLTAGE AND CURRENT UNBALANCE

Voltage unbalance due to unbalanced loading and single phase voltage regulation is typically under 2% but may be higher in some areas. The voltage unbalance is calculated using the root-mean square (rms) voltage levels at the fundamental frequency measured at the service entrance (Point of Connection) under no-load and no generation as in the following equation:

Voltage Unbalance (%) =100XV2/V1

Where V2 is the negative sequence voltage
V1 is the positive sequence voltage

Current unbalance is usually 10-15% of total feeder load current but may be higher in some areas. During abnormal conditions such as faults the unbalance may be very high (current unbalance may be significantly higher than 15%).

A.6 POWER QUALITY

In BL&P's distribution system, all interconnected equipment must comply with BL&P's standards for power quality. IEEE Std. 519, *IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems,* has been accepted by industry to provide guidance for appropriate performance and power quality limits such as voltage flicker and harmonic contribution limits. This standard states that the recommended practice for utilities is to limit individual frequency voltage harmonics to 3% of the fundamental frequency and the total voltage harmonic distortion (THD) to 5% on the utility side of the PCC.

A.7 FAULT LEVELS

Fault levels on BL&P's distribution system vary greatly throughout the system. Factors, such as location, generation pattern, and contingencies all contribute to varying fault levels. These fault levels may also change with time as the system expands and new generation comes online. The CIA will provide better information regarding the fault level along a specific feeder.

A.8 SYSTEM GROUNDING

BL&P's distribution facilities are typically operated as multi-grounded (for three-phase – systems). The transformer neutral at the substation is solidly grounded,
.

A.9 BL&P DISTRIBUTION SYSTEM FEEDER PROTECTION

The general feeder protection scheme utilized on BL&P's distribution system where DGs are interconnecting is described below for M Class feeders emanating from TSs. The feeder protections can be divided into two states: **High Set Instantaneous –** Instantaneous protection for close-in feeder faults is usually set to the first fuse on the feeder and traditionally employed High Set 50A/50NA elements.

The current BL&P standard for feeders with DGs interconnected is to use the High Set Instantaneous protection in addition to IDMT very inverse overcurrent and earth fault.

Timed – Directionally supervised 51/51N overcurrent elements load/fault discrimination are used for timed protection of BL&P's distribution feeders. All timed overcurrent elements on the distribution system are coordinated with each other to ensure that a minimum number of customers are affected in the case of permanent faults. For the timed overcurrent elements to function properly, all DG

sources (both positive sequence and zero sequence sources) need to be removed from the distribution

A.10 AUTOMATIC RECLOSING (FAULT CLEARING)

BL&P's Distribution System utilizes some minimal automatic reclosing to quickly clear non permanent faults on the distribution system, thus, quickly restoring supply. In general, feeder circuit breakers at Transmission Stations use non reclosing systems. One substation utilizes reclosers at Hampton Distribution Station where multi-shot automatic reclosing is used. If, after a number of preset reclose attempts the fault persists, then the recloser will lockout and stay open. The reclose —dead time (time that the distribution line is de-energized between reclose attempts) varies depending on location and type of recloser. That data can be obtained from BL&P along with all other relevant protection data.

A.11 PHASING

Conductor phasing is standardized and as such, the phase sequence and the direction of rotation can be confirmed from BL&P.

A.12 MULTIPLE SOURCE (NETWORKED) SYSTEM

In no areas of BL&P's Distribution System are there instances where portions of a distribution feeder are supplied from two different sources.

A.13 FREQUENCY OF INTERRUPTION

BL&P's distribution feeders are mainly unshielded overhead lines. They are equipped with insulation levels adequate to withstand expected voltages. Lighting strikes directly to BL&P's distribution line result in flashovers of the insulators on the feeder and result in protection systems tripping the distribution line. The faults may be temporary in which case a successful reclose will occur. Most faults on overhead distribution lines are temporary in nature. If they are permanent, and they trip the line, repair crews are dispatched and repair the feeder.

A.14 ABNORMAL CONDITIONS

Many disturbances can occur on the distribution system at varying frequencies. These disturbances can include, but are not limited to the following:

- Faults on the system;

- Frequency excursions;
- Partial or complete loss of load;
- Transient overvoltages – caused by lightning strikes or switching operations;
- Temporary overvoltages;
- Single phasing of the three phase system – caused by BL&P's protection equipment, switching or broken conductors.