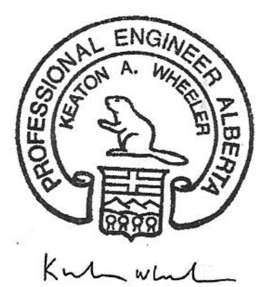
FortisAlberta – Effective Grounding Study Requirements for DER Interconnections

DER-02B

Version No: 5.0

2025 / 01 / 15	2025 / 01 / 15		
Prepared	**Approved**	**Owner**	**Authentication**
Keaton Wheeler **Principal Engineer Advanced Power Systems**	**Michael Simone** **Manager Operations Engineering**	**Operational Engineering Services**	 Authenticated original filed with the Engineering Department
Additional Reviewers and/or Contributors	**Shane Harbourne, Sr. Lead Engineer Protection & Control**		

Validation

APEGA PERMIT NUMBER: P07387

Responsible Member (RM) to sign and date authenticated original file

RM Name: Michael Simone

RM Signature:______________________

Date:______________

FORTIS ALBERTA

Copyright © 2025 FortisAlberta. All rights reserved. No modifications or reproductions are allowed without written permission.
Printed on Jan. 16, 2025 at 9:31 AM. The current version is on FortisAlberta Standards Database.

LIMITATION OF LIABILITY AND DISCLAIMER

This document is not a replacement for electrical codes or other applicable standards.

This document is not intended or provided as a design specification or as an instruction manual.

The DER owner, employees or agents recognize that they are, at all times, solely responsible for the generator plant design, construction and operation.

FortisAlberta Inc. (FAI), and any person employed on its behalf, makes no warranties or representations of any kind with respect to the DER requirements contained in this document, including, without limitation, its quality, accuracy, completeness or fitness for any particular purpose, and FAI will not be liable for any loss or damage arising from the use of this document, any conclusions a user derives from the information in this document or any reliance by the user on the information it contains. FAI reserves the right to amend any of the requirements at any time. Any person wishing to make a decision based on the content of this document should consult with FAI prior to making any such decision.

Revision History

Version	Date	Revision Details
5.0	January 2025	Clarity added on EMT model requirements including inverter inner control loops. Clarity added on fault locations and exclusion of system neutrals. Clarity added on supplemental grounding requirements including 59G relays. Simulation list for high ratio sites updated. Removed 40Ω fault impedance consideration from TOV study only (does not include relay de-sensitization). Clarity added on use of utility breakers of reclosers for LROV and GFOV simulations.
4.0	December 2023	Clarity added to relay de-sensitization with a diagram. Guidance on inverters certified to UL1741 SB updated. Added simulation option for machine-based DER TOV conformance. Added clarity to supplemental grounding use for inverter-based sources and secondary screening. Additions to sign off section for EMT models.
3.0	November 2022	Updated LROV requirements for UL1741 SB certified inverters Updated Fig. 3 TOV graph 3.1: Clarity added to relay de-sensitization with a diagram.
2.0	5 November 2021	Version 2 released
1.0	26 August 2021	New Standard Issued

PURPOSE

This document is to serve as an aid for completing effective grounding studies for DER facilities and assess any supplemental grounding devices.

1.0 Resources

The following documents should be understood for the purposes of reviewing DER grounding studies.

- EPRI – Effective Grounding for Inverter-Connected DER (Report: 3002020130)
- DER-02 – FortisAlberta Technical Interconnection Requirements
- DER-02A – FortisAlberta Engineering Study Requirements for DER Interconnections
- IEEE Std C62.92.1 IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems—Part I: Introduction
- IEEE Std C62.92.6 IEEE Guide for Application of Neutral Grounding in Electrical Utility Systems, Part VI—Systems Supplied by Current-Regulated Sources
- IEEE 1547-2018 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

2.0 Glossary

coefficient of grounding (COG): The ratio of the greatest unfaulted phase-to-ground voltage during a ground fault divided by the line-to-line voltage without the fault.

transient overvoltage (TOV): An electrical impulse of short duration but high energy that is induced onto the electrical system by external sources.

ground fault overvoltage (GFOV): The TOV that occurs on the unfaulted phases during a phase-to-ground fault.

load rejection overvoltage (LROV): The TOV that occurs when a sudden loss of load is experienced by the power system.

relay desensitization: The reduction in short circuit current experienced by existing protective devices following DER integration.

generation to load ratio (GEN/LOAD): The ratio of the sum of the existing generation and new generation divided by the minimum feeder load.

transformer configuration (Primary-secondary): When transformer configurations are referred to in this document it is in the form HV – lv where HV (uppercase) and lv (lowercase) are the high voltage (HV) and low voltage (LV) winding configuration, respectively. Delta windings are referred to as D and wye windings are referred to as Yg (for grounded wye) or Y (for ungrounded wye). E.g., Yg-d is a wye grounded HV and delta LV configuration.

3.0 Review Methodology

This section is to serve as a guide to determine anticipated impacts to the distribution system. These impacts are largely driven by the size of the DER facility, the minimum load of the feeder or protective segment, and the configuration of the DER interconnection transformer.

The three main factors to consider in effective grounding studies are:

- Transient Overvoltage (TOV)
  - Load Rejection Overvoltage (LROV)
  - Ground Fault Overvoltage (GFOV)
- Relay Desensitization
- Exceeding Distribution Equipment / System Ratings

3.1 GENERATION TO LOAD FACTORS AND CRITERIA

For inverter-based generation, the TOV behaviors are dependent on the control system of the specific inverter. According to EPRI's report on Effective Grounding for Inverter-Connected DER, contrary to traditional understandings with rotating machine-based generation, TOV susceptibility has a relation to feeder loading. The generation to load ratio is a key factor to consider for mitigating TOV concerns.

The generation to load (GEN/LOAD) ratio is defined as:

$$GEN/LOAD = \frac{Generation\ (kVA) + Existing\ Feeder\ Generation\ (kVA)}{Minimum\ Feeder\ Load\ (kVA)}$$

where:

- *Generation (kVA)* is the rating of the DER site.
- *Existing Feeder Generation (kVA)* is the rating of each DER site that is already present on the FAI feeder that the DER site is connecting to.
- *Minimum Feeder Load (kVA)* is the minimum loading of the feeder where the DER facility is connected.
  Note: The minimum feeder load and the percentage that is grounded will be provided by FortisAlberta.

The subsequent tables provide a summary of the DER classifications, concerns, and requirements.

Table 1 – Generation to Load Criteria

Inverter-based Generation				
	Low		*Medium	High
Generation to Load Ratio	$GEN/_{LOAD} \leq 0.6$	$GEN/_{LOAD} \leq 0.8$	$0.6 < GEN/_{LOAD} \leq 1.4$	$GEN/_{LOAD} > 1.4$
Minimum Line to Ground (LG) Feeder Loading	-	$LG\ Min\ Load >$ 33% *of the total feeder load*	-	-
Machine-based Generation				
No GEN/LOAD criteria				

*Note: If the DER meets the criteria of both a medium and low ratio site then the DER will be classed as a low ratio site.

Table 2 – Low GEN/LOAD Ratio Summary (Inverter-Based Generation)

Low GEN/LOAD	
Concerns	
LROV	*No*
GFOV	*No*
Relay Desensitization	*May be a Concern for Yg-d Transformer Configurations*
Protection Requirements	
Supplemental Grounding	*May be Required for Yg-d Transformer Configurations. Required for transformers with high voltage delta windings. Not required for Yg-yg transformer connections.*
59N Protection	*Required for Floating Neutral (Delta or Wye-ungrounded primary) Transformer Configurations*

Table 3 – Medium and High GEN/LOAD Ratio Summary (Inverter-Based Generation)

	Medium GEN/LOAD		High GEN/LOAD	
Concerns				
Transformer Configurations	**D-Yg, D-Y, Y-D, Yg-Yg, Y-Y, D-D, Y-Yg. Yg-Y**	**Yg-D**	**D-Yg, D-Y, Y-D, Yg-Yg, Y-Y, D-D, Y-Yg. Yg-Y**	**Yg-D**
LROV	*No*	*No*	*Yes*	*Yes*
GFOV	*Yes*	*Yes*	*Yes*	*Yes*
Relay Desensitization	*Maybe (Needs Review)*	*Yes*	*Maybe (Needs Review)*	*Yes*
Protection				
Electromagnetic transient (EMT) Study	May be Required	May be Required	Required	Required
Supplemental Grounding	May be Required	Required	Required	Required
DER Facility Arresters (minimum class)	Intermediate Class	Intermediate Class	Intermediate Class	Intermediate Class
Commissioning	LROV performance Testing Required	-	LROV performance Testing Required	LROV performance Testing Required

Table 4 – Machine Based Generation Summary

Machine-Based Generation Facilities	
Concerns	
LROV	*No* *Note: Only when facility meets effective grounding definition for machine-based generation*
GFOV	*No* *Note: Only when facility meets effective grounding definition for machine-based generation*
Relay Desensitization	*May be a Concern*
Protection Requirements	
Supplemental Grounding	*May be Required to meet effective grounding definition for machine-based generation*

3.2 INVERTER-BASED GENERATION – TOV MITIGATION METHODS

Two approaches are possible to meet the effective grounding requirements to mitigate TOV concerns for medium to high ratio DER sites.

1) Supplemental grounding (grounding transformer)
2) Fast inverter detection/response

3.2.1 Supplemental grounding (grounding transformer) for TOV mitigation:

For inverter based DERs the following equations are used to define an effectively grounded system where supplemental grounding is installed:

$$0.01 \leq \frac{X_0}{R_0} \leq 0.3$$

$$1 \leq \frac{Z_0}{Z_{1load}} \leq 2$$

Where: Z_0 (R_0+jX_0) is the impedance of the supplemental grounding and Z_{1load} is the equivalent impedance of the grounded load in the network.

For medium ratio sites, if the DER meets the above effective grounding definition, then GFOV is not a concern.

For DER owners utilizing supplemental grounding for inverter-based sources, the TOV solution is subject to secondary screening from FortisAlberta. Sites that do not pass secondary screening will be required to either change the supplemental grounding parameters and submit for approval again or the site may be mandated to conduct EMT simulations to demonstrate effective grounding compliance.

For high ratio sites that are inverter based DERs it is uncommon that both criteria (TOV and desensitization) can be met with supplemental grounding. In some cases, the GFOV can be mitigated but LROV concerns will remain and cannot be mitigated through supplemental grounding.

If TOV cannot be mitigated through supplemental grounding, then fast inverter detection/response may be explored as an option to restrict the TOV to an acceptable level (note: alternate methods may be available but would be subject to FAI approval).

3.3 SYNCHRONOUS / INDUCTION GENERATION - TOV MITIGATION METHODS

To meet the effective grounding requirements to mitigate TOV for a synchronous or induction generator, the DER shall meet the effective grounding definition below:

The effective grounding criteria for a synchronous or induction generator (machine-based generation) such that the COG is less than 0.8 is defined as:

$$0 < \frac{X_0}{X_1} < 3 \qquad 0 < \frac{R_0}{X_1} < 1 \qquad \frac{X_0}{R_0} > 3$$

Note that X_1 is the Thevenin equivalent impedance seen from the DER PCC while X_0 and R_0 are the impedances associated zero sequence impedances seen from the DER PCC.

Where applicable, for cases where the above equations are not adhered to for synchronous and induction generators, the graphs in Annex A of IEEE Std. C62.92.1 may be used to demonstrate effective grounding.

In lieu of the calculations above, simulations may be conducted in EMT or phasor domain software packages to demonstrate the system is effectively grounded with a COG below 0.8. At minimum, the following simulations are required:

1. All simulations are to be done with a three-phase system voltage of 26.36kV.
2. DER at 3 different outputs (full output, generation to load ratio of 1.4, generation to load ratio of 1) and a line-to-ground fault occurs (GFOV) (for a fault impedance of 0Ω only). Fault locations should be at the DER PCC.

3. Note: All studies that are conducted that have additional DERs on the feeder will be required to model all sources. FAI will provide the details of each site greater than 1 MVA that are to be integrated into the model. For sites smaller than 1 MVA, an aggregated value will be provided which will be modelled at the DER PCC.
4. Notes for modelling:
    a. The minimum load shall be modelled as a combination of single and three phase loads. The maximum voltage unbalance of the FAI network is up to 3% during steady state conditions. Note: it is acceptable to model the system at no load in lieu of the minimum load.
    b. If a system neutral is installed going to the DER at the PCC from FortisAlberta, the neutral shall be excluded from all simulations.
    c. Voltage measurement points shall be identified for the generator and PCC relay protection.
    d. The DER shall be modelled using a power factor of 90% lagging (exporting VARs).

As mentioned in the definitions, COG is defined as:

$$COG = \frac{V_{LG(fault)}}{V_{LL(unfault)}}$$

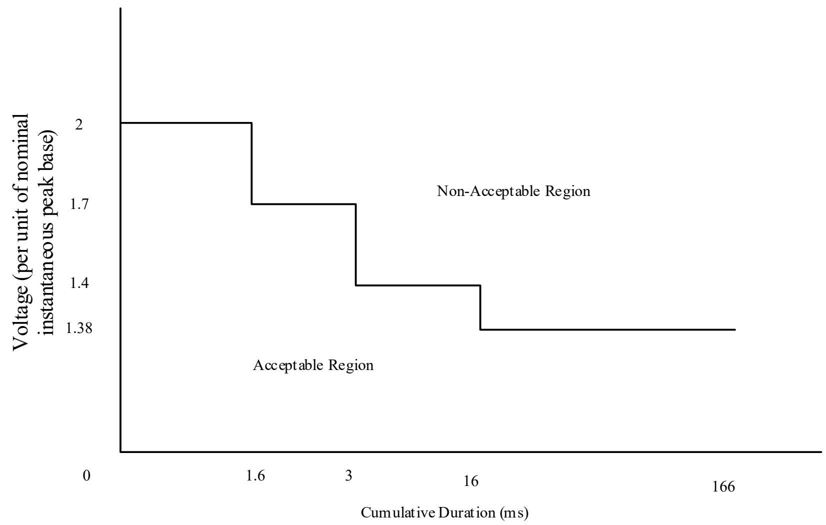
Where it is the ratio of the greatest unfaulted phase-to-ground voltage during a ground fault divided by the line-to-line voltage without the fault.

4.0 Engineering Study Requirements

The following information is designed to aid DER owners in meeting the requirements set out by FAI to connect to the distribution network. Tables 2/3/4 provide a high-level summary of the concerns and requirements that will need to be met for both inverter and machine-based generation.

In general, to allow for DER connection to the FAI network, the following supplemental grounding related requirements are relevant:

1. The DER is required to limit the load rejection overvoltage (LROV) and ground fault overvoltage (GFOV) to the limits prescribed in the figure below. This figure is modified version of Fig. 3 in IEEE 1547-2018 which confirms to FAI system limits.



The DER shall not contribute to instantaneous or fundamental frequency overvoltages with the following limits:

I. The DER shall not cause the fundamental frequency line-to-ground voltage on any portion of the distribution system that is designed to operate effectively grounded, as defined by IEEE Std C62.92.1, to exceed 138% of its nominal line-to-ground fundamental frequency voltage for a duration exceeding one fundamental frequency period.

II. The DER shall not cause the line-to-line fundamental frequency voltage on any portion of the distribution system to exceed 138% of its nominal line-to-line fundamental frequency voltage for a duration exceeding one fundamental frequency period.

2. The DER is required to limit the desensitization of the utility ground fault protection to 10% or less.

These requirements are met differently based on how the DER site is defined. Regardless of definition the above criteria are still required, however, the options to meet these criteria may vary. The subsequent sections outline the criteria and mitigation options in greater detail.

4.1 TOV STUDY REQUIREMENTS FOR INVERTED-BASED GENERATION:

4.1.1 Medium Ratio Sites

Supplemental grounding (grounding transformer):

1. Complete an effective grounding study to meet the definition in Section 3.2.1.
2. Install a supplemental grounding device as required by the effective grounding study to meet the definition in Section 3.2.1.

Fast Inverter Detection/Response for TOV mitigation:

See Section 4.1.2

4.1.2 High Ratio Sites

Fast Inverter Detection/Response for TOV mitigation:

Where supplemental grounding is unable to limit the TOV, the alternative method to meet the TOV requirements is through meeting the definitions of IEEE Std. 1547-2018 in the context of the inverter self-trip. The following is required:

1. If the inverter is certified to UL1741 Supplement B or more recent and has opted for the LROV test during certification may have the LROV EMT simulations may be waived. DER owners looking to have the LROV simulations waived shall submit certification results to FortisAlberta for evaluation. It is up to the sole discretion of FortisAlberta whether to waive the LROV EMT simulations.
2. An EMT study is required to determine the performance of the inverter self-trip for TOV. The inverter will need to be modelled in detail and, at minimum, the following case studies will be required (Note: additional case studies may be required):
   a. All simulations are to be done with a three-phase system voltage of 26.36kV.
   b. DER at 3 different outputs (full output, generation to load ratio of 1.4, generation to load ratio of 1) and the grid source is suddenly lost (LROV). This is not required for medium ratio sites. This shall be performed by opening the closest upstream breaker and substation breaker during individual simulations.
   c. DER at 3 different outputs (full output, generation to load ratio of 1.4, generation to load ratio of 1) and a line-to-ground fault occurs (GFOV) (for a fault impedance of 0Ω only). The fault location shall be at the DER PCC.
   d. Note: All studies that are conducted that have additional DERs on the feeder will be required to model all sources. FAI will provide the details of each site greater than 1 MVA that are to be integrated into the model. For sites smaller than 1 MVA, an aggregated value will be provided which will be modelled at the DER PCC.
   e. Requirements for modelling:
      i. The minimum load shall be modelled as a combination of single and three phase loads. The maximum voltage unbalance of the FAI network is up to 3%

during steady state conditions. Note: it is acceptable to model the system at no load in lieu of the minimum load.

ii. If a system neutral is installed going to the DER at the PCC from FortisAlberta, the neutral shall be excluded from all simulations.

iii. Voltage measurement points shall be identified for the inverter and PCC relay protection.

iv. The DER shall be modelled using a power factor of 90% lagging (exporting VARs).

v. For the LROV simulations: The closest upstream utility owned main line breaker or recloser shall be opened to simulate a loss of grid.

vi. For the GFOV simulations: Any utility owned circuit breaker or recloser shall not be used in simulation (unless otherwise authorized by FortisAlberta). If a DER owned breaker is used, it shall not trip faster than 2 seconds after the fault occurs.

vii. The inverter model shall represent the full detailed inner control loop of the power electronics[1] and shall be provided by the manufacturer of the inverter. Constant current sources are acceptable for preliminary studies only, but the final study shall be completed using the vendor specific model of the inverter specified for the DER.

3. If the result of the EMT study demonstrates non-conformance to IEEE 1547-2018 with regards to TOV, then the inverter is not suitable for the application.
4. Note: commissioning tests shall still be performed to confirm the LROV performance.

4.1.3 Additional/Backup requirements for TOV mitigation:

For medium and high ratio DER sites the following additional requirements shall be met:

- Overvoltage protection will be required to be installed at the DER facility.
- Intermediate class surge arresters (at a minimum) are required. It is preferred that station class arresters are installed.
- For medium ratio DER sites that have opted to use supplemental grounding: additional EMT studies are NOT required. However, protective relaying that senses if the supplemental grounding has failed will be required. If the supplemental grounding has failed, the DER site will be required to disconnect until repairs/replacements are made.
- For high ratio sites that have installed supplemental grounding: additional EMT studies are required: The studies outlined in Section 4.1.2 Note 2 shall be repeated without the supplemental grounding device. Protective relaying that senses if the supplemental grounding has failed shall be installed (59G relay). If the supplemental grounding fails, the DER site shall disconnect until repairs or replacements are completed, provided

[1] The model cannot use the same approximations classically used in transient stability modelling, and should fully represent all fast inner controls, as implemented in the real equipment. It is preferred and recommended to create models which embed the actual hardware code into an EMTP-RV/PSCAD component whenever possible. If the model is assembled using standard blocks available in the EMTP-RV/PSCAD master library, approximations are usually introduced, and specific implementation details for important control blocks may be lost. In addition, there is a risk that errors will be introduced.

TOV simulations show that the inverter's fast protection cannot effectively ground the DER without the supplemental grounding.

4.1.4 High Ratio EMT Simulation List:

For medium (only if EMT simulations are selected or required) and high ratio DER sites the following simulations shall be performed based on requirements in Sections 4.1.2 and 4.1.3.

1. For simulations the following shall be submitted to FortisAlberta at a minimum:
    a. Full output with the final DER configuration and a sudden loss of grid (LROV). This configuration includes the inverter fast tripping response, site arresters and supplemental grounding (Note: supplemental grounding will not affect this simulation). This is not required for medium ratio sites. This shall be performed by opening the closest upstream breaker and substation breaker during individual simulations.
    b. DER output corresponding to a GEN/Load ratio of 1.4 with the final DER configuration and a sudden loss of grid (LROV). This configuration includes the inverter fast tripping response, site arresters and supplemental grounding (Note: supplemental grounding will not affect this simulation). This is not required for medium ratio sites. This shall be performed by opening the closest upstream breaker and substation breaker during individual simulations.
    c. Full output with the final DER configuration and a 0Ω single line-to-ground fault at the DER PCC. This configuration includes the inverter fast tripping response, site arresters and supplemental grounding.
    d. Full output with the final DER configuration and a 0Ω single line-to-ground fault at the DER PCC. This configuration includes the inverter fast tripping response, site arresters and <u>excludes</u> supplemental grounding. If the DER fails to be effectively grounded in this case, the DER shall be disconnected from the FortisAlberta network if the supplemental grounding has failed or is out of service.
    e. Repeat simulation Section 4.1.4 Note 1. c. for a DER output corresponding to a GEN/Load ratio of 1.4.
    f. Repeat simulation Section 4.1.4 Note 1. d. for a DER output corresponding to a GEN/Load ratio of 1.4.
    g. Repeat simulation Section 4.1.4 Note 1. c. for a DER output corresponding to a GEN/Load ratio of 1.0.
    h. Repeat simulation Section 4.1.4 Note 1. d. for a DER output corresponding to a GEN/Load ratio of 1.0.
    i. Simulations e-h are not required if zero-sequence continuity between the PCC and DER units is maintained. Note: FortisAlberta will only accept that zero-sequence continuity is maintained for Yg-yg interconnection transformers without supplemental grounding. If the DER wishes FortisAlberta to recognize that zero-sequence continuity is not broken and is not using a Yg-yg configuration without supplemental grounding, it must submit proof for review. FortisAlberta reserves the right to accept or reject the DER's reasoning at its sole discretion.

4.2 TOV STUDY REQUIREMENTS FOR MACHINE-BASED GENERATION:

1. Complete an effective grounding study to meet the definition in Section 3.3.
2. Install a supplemental grounding device as required by the effective grounding study to meet the definition in Section 3.3.

Note: If the effective grounding criteria is met, TOV is not an issue.

4.3 STUDY REQUIREMENTS FOR RELAY DESENSITIZATION:

Relay desensitization may be a concern when there is a ground source on the high voltage winding or side of the PCC transformer. FAI requires that any DER connected to the network does not desensitize the ground fault protection by more than 10%. This can be defined by:

$$DI\ (\%) = 100 \times \left(1 - \frac{I_{SC_{after}}}{I_{SC_{before}}}\right)$$

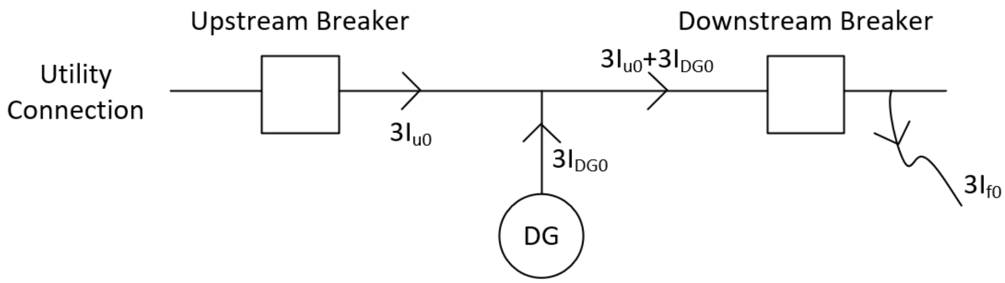
Where $I_{SCafter}$ is the short circuit current seen by the utility protective relay with the DER connected to the system with its output at full capacity and $I_{SCbefore}$ is the short circuit current seen by the utility protective relay without the DER connected to the system. Note: the relay detects ground fault currents using $3I_0$ where I_0 is the zero-sequence current associated with the short circuit.

A study is required to confirm that the DER will not desensitize the ground fault protection by more than 10%. The minimum number of fault locations that are required to be studied for desensitization of protective devices are:

- Line-to-ground (LG) fault at the substation (for fault impedances of 0Ω and 40Ω)
- LG fault at the DER PCC (for fault impedances of 0Ω and 40Ω)
- LG fault at the upstream protection location (for fault impedances of 0Ω and 40Ω)
- LG fault at the downstream protection location (for fault impedances of 0Ω and 40Ω)
- Note: additional case studies may be required when further protective devices are identified as being vulnerable to desensitization or improper operation.

For all locations, the short circuit current shall be determined at each main line protective device.

For clarity, an example system is given below:



The de-sensitization of concern is the fault flow currents designated $3I_{u0}$ in the diagram above.

Where the desensitization is greater than 10%, supplemental grounding is required to mitigate the effects of the DER connection. Protective relaying that senses if the supplemental grounding has failed shall be installed (59G relay). If the supplemental grounding fails, the DER site shall disconnect until repairs or replacements are completed.

5.0 Commissioning

On-Site commissioning will be required to verify LROV protection performance where fast inverter detection/response is used. Facilities larger than 500 kVA are classified as a DER-Composite system, which is a system that consists of partially compliant DER components and supplemental DER device(s). DER-Composite systems require detailed design evaluation, installation evaluation, and commissioning tests to determine full compliance to IEEE 1547.1-2020 requirements.

Commissioning of DER-Composite systems shall comply with the DER-02 requirements, the completed IPSC document as well as full compliance with Section 8.5 of IEEE 1547.1-2020.

110 Days prior to the in-service date, the DER facilities commissioning plan shall be submitted to FAI for review. The commissioning plan shall be aligned with DER-02 commissioning requirements as well as Section 8.5 of IEEE 1547.1-2020. Table 75 in IEEE 1547.1-2020 summarizes the requirements that shall be verified in the commissioning plan as well as those requirement commissioning tests.

5.1 LOAD REJECTION OVERVOLTAGE VERIFICATION

This test is conducted by opening the facility PCC breaker (all 3 phases) at generation outputs of 33%, 66% and 100% where the voltage on the high voltage side of the transformer shall meet the TOV requirements in Section 7.4 of IEEE 1547-2018.

6.0 Approval / Sign-off

The initial Effective Grounding Study shall be submitted to FAI with the detailed level study application. A revised Effective Grounding Study shall be submitted prior to the construction of the DER facility when the issued for construction (IFC) SLD is submitted. Both the initial and revised studies shall be authenticated by a professional engineer accredited to APEGA and submitted to FAI for review and approval.

All DERs that are considered high ratio are required to submit a copy of the following:

1. For inverter-based sources: an EMT model of the inverter that includes the detailed inner control loop of the power electronics, provided by the inverter manufacturer, in both EMTP-RV and PSCAD formats.
2. For wind turbines (DFIG): an EMT model of the turbine in EMTP-RV and PSCAD formats.
3. For Synchronous or induction generators: DER owner shall provide detailed modelling data including governor settings, exciter settings and generator electrical data sheets (including time constants, impedance information etc.).