Part C – Interconnection Technical Requirements

Handout

This document was excerpted from FirstEnergy Engineering Practice 02-280, approved for application throughout the FirstEnergy system on November 17, 2014.

It is intended for use by Engineers, Consultants and End Use Customers in the design and installation of Customer Owned Generation systems, acceptable for interconnection to the FirstEnergy Distribution System.

Document History

11/17/2014 EP 02-280 - Approved for use throughout the FirstEnergy system.

01/16/2015 Revision 1 - Includes corrections to minor non-substantive errata, revised Tables 6 & 7 per IEEE 1547a – 2014, Amendment 1 and corrections to regulatory citations per revisions to underlying regulations

09/12/16 Revision 2 – Corrections to page number and section number references.

4.0 PART C: INTERCONNECTION TECHNICAL REQUIREMENTS

4.1 PURPOSE

The purpose of Part C of this policy is to define FirstEnergy's technical requirements for generator interconnection in order to ensure the safety of FirstEnergy employees and the public, to protect FirstEnergy equipment from damage and to ensure the reliability of service to FirstEnergy customers[7].

These requirements will vary by mode of generator operation as explained below. In addition to the technical requirements identified in this Policy, the other Regulations, Rules, and Standards identified in Part B also apply.

4.2 GENERATORS USING OPEN-TRANSITION TRANSFER

Generators using Open-Transition Transfer (OTT) must utilize a break-before-make switch or other effective means, which prevents parallel operation with FirstEnergy's system when the generator is in operation. This requirement is identified in the FirstEnergy "Information and Guidance for Electric Customer Service," Form 115[8]. The generator installation must meet all local and NEC code requirements.

4.3 GENERATORS USING CLOSED-TRANSITION TRANSFER

Generators using Closed-Transition Transfer (CTT) must comply with the Technical Review and Technical Requirements identified in Sections 4.3.1 and 4.3.2 below. Generators using CTT, which will parallel with the FirstEnergy distribution system for a period of 100 milliseconds (6 cycles) or more, must also comply with the technical requirements specified for parallel- operated systems found in Part C, Section 4.4 of this policy.

4.3.1 TECHNICAL REVIEW

The customer shall submit an application for interconnection in accordance with the State requirements for a standard review process. These processes are located on the generator interconnection web site for each State. Follow the generation interconnection link on the homepage at: www.FirstEnergyCorp.com

4.3.1.1 Prior to parallel operation, the FirstEnergy Operating Company must review and accept all protective relay settings and/or transfer switch settings, which

[7] Note this section is intended to also serve as a stand-alone handout reference document. Consequently, some sections and references may appear similar to other portions of the Engineering Practice.

[8] This document is or will be issued & maintained for each State in the FE service territory.

shall have been provided to the Company not less than ten (10) business days prior to scheduled date for first parallel operation.

4.3.2 TECHNICAL REQUIREMENTS

4.3.2.1 The customer is solely responsible for protecting its equipment in such a manner that faults, imbalances or other disturbances on the FirstEnergy System do not cause damage to the Generation Facility's equipment. The customer is also responsible for protecting FirstEnergy's system in the event of a power system fault during transition of the generator.

4.3.2.2 The generator must not be a source of objectionable switching surges, voltage flicker, or other power quality anomalies to other FirstEnergy customers during load paralleling or transferring. The requirements listed in Part C, Section 4.4.4, of this document must be satisfied.

4.3.2.3 The protection scheme shall be designed to prevent the generator from being connected to a de-energized FirstEnergy circuit.

4.3.2.4 Following transfer to the customer's generator, resulting from loss of utility supply, the customer's facility shall remain on backup until the FirstEnergy System has recovered to within the acceptable voltage and frequency limits for a recommended period of 5 minutes.

4.3.2.5 The protection and control scheme for generators, which under agreement from the customer, are not designed to operate in parallel for more than 100 milliseconds must be designed to trip an alternate customer breaker within 200 milliseconds of the intent to transfer if the transfer scheme fails to separate the generator from the FirstEnergy system. FirstEnergy also reserves the right to require tripping of the customer's main circuit breaker if the customer's generator remains in parallel for a duration exceeding 500 milliseconds. The implementation of this system will need to be reviewed and discussed with the customer on an individual basis due to the complexity and possible variances between customer systems. This also needs to be addressed by way of a signed agreement with the customer.

4.3.2.6 The customer must provide a visibly open disconnect switch located at the point of generator interconnection that may be used to establish a safety clearance for FirstEnergy work crews. The disconnect switch must be clearly labeled, readily accessible and lockable by FirstEnergy personnel.

4.3.2.7 The customer's transfer switch must be rated for the proper operating voltage, expected ampacity, and maximum available fault current.

4.3.2.8 The generator owner shall maintain all equipment associated with the generator system according to good electrical practices and according to equipment manufacturer's recommendations and keep it in proper working condition. The generator owner shall keep a written log and test records showing the periodic testing of such equipment. These records must be available to FirstEnergy upon request.

4.4 PARALLEL-OPERATED GENERATION [9]

This section of the policy specifies the technical requirements for generators, which are intended to operate in parallel with the FirstEnergy system on a continuous basis, and for generators using closed-transition transfer, which will parallel with the FirstEnergy system for duration of 100 milliseconds or more.

4.4.1 APPLICABILITY

4.4.1.1 This section defines the technical requirements for the interconnection of parallel-operated generation to the FirstEnergy distribution system[10]. For purposes of this document, the term "generation" includes rotating and inverter-derived sources of generation.

4.4.1.2 These requirements apply to customer-owned generation used to offset energy usage and to distributed generation exporting energy on a retail or wholesale basis.

4.4.1.3 This section applies to standby generator schemes with a make-before-break transition if the duration of parallel operation is 100 milliseconds or more.

[9] Please note: There are locations on the FirstEnergy distribution system where the introduction or additions of even small amounts of generation cannot be accomplished without substantial system upgrades. The customer is strongly encouraged to complete the initial application process prior to ordering equipment or initiating construction. For proposed generation larger than 2 MW especially at lower distribution voltages, the customer is encouraged to contact FirstEnergy regarding any known limitations on the amount of generation that can be installed at the customer's proposed location.

[10] For connection to the FirstEnergy Transmission System, please see the FirstEnergy Wholesale Interconnection web page at https://www.firstenergycorp.com/content/fecorp/feconnect/wholesale.html

4.4.1.4 These requirements apply to new generator interconnections as well as existing facilities being upgraded or expanded.

4.4.2 APPLICABLE STANDARDS

4.4.2.1 Generator facilities must comply with all applicable requirements of the latest version of:

- IEEE 1547, “Standard for Interconnecting Distributed Resources with Electric Power Systems,” 28-Jul-2003,
- This standard focuses on the technical specifications for, and testing of DR connected to radial primary and secondary distribution systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. It includes general requirements, response to abnormal conditions, power quality, islanding, and test specifications and requirements for design, production, installation evaluation, commissioning, and periodic tests.
- IEEE 1547.1, “Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems,” 01-Jul-2005
- This standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that the interconnection functions and equipment of the distributed resources (DR) conform to IEEE Std. 1547™.
- IEEE 1547.2, “Application Guide for IEEE Std. 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems,” 15-Apr-2009
- The guide facilitates the use of IEEE Std. 1547-2003 by characterizing various forms of distributed resource (DR) technologies and their associated interconnection issues. It provides background and rationale of the technical requirements of IEEE Std. 1547-2003. It also provides tips, techniques, and rules of thumb, and it addresses topics related to DR project implementation.
- IEEE 1547.3, “Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems,” 16-Nov-2007
- This guide is intended to facilitate the interoperability of distributed resources (DR) and help DR project stakeholders implement monitoring, information exchange, and control (MIC) to support the technical and business operations of DR and transactions among the stakeholders. The

focus is on MIC between DR controllers and stakeholder entities with direct communication interactions.

- IEEE 1547.6, "Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks," 12-Sep-2011

  This document gives an overview of distribution secondary network systems design, components, and operation; describes considerations for interconnecting DR with spot networks and grid networks; and provides potential solutions for the interconnection of DR on network distribution systems.

4.4.2.2 Inverter based systems must demonstrate compliance with all requirements of the latest version of the UL1741, "Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources" [11] by one of the following:

- Use of an inverter(s) meeting the definition of "Certified Equipment" and providing evidence thereof: or
- Testing the system in accordance with the provisions of IEEE 1547.1. At its discretion, FirstEnergy may require FirstEnergy personnel be present to "Witness" the generator's commissioning test procedures.

4.4.2.3 Generator facilities and equipment must comply with all applicable national, state, and local construction codes and all operation and maintenance-related safety codes, such as the National Electrical Code (NEC), the National Electrical Safety Code (NESC), and the Occupational Safety and Health Administration (OSHA) regulations.

4.4.2.4 Generator interconnections are subject to applicable Federal or State interconnection rules and regulations depending upon interconnection type.

4.4.2.5 Other than where prohibited by regulation (e.g. Bidirectional Meter), the cost of any FirstEnergy system upgrades necessary to accommodate the installation of the DG shall be paid by the DG customer.

[11] Underwriters Laboratory U.L. 1741, "Standard for Inverters, Converters, Controllers, and Interconnection System Equipment for Use With Distributed Energy Resources," May 7, 1999.

4.4.3 RELAYING AND PROTECTION

4.4.3.1 The generator owner is responsible for providing adequate protection to FirstEnergy facilities for conditions arising from the operation of generation under all FirstEnergy distribution system operating conditions. The generator owner is also responsible for providing adequate protection to their facility under any distribution system operating condition whether or not their generator is in operation. Conditions may include but are not limited to:

- Loss of a single phase of supply
- Distribution system faults
- Equipment failures
- Abnormal voltage or frequency
- Lightning and switching surges
- Excessive harmonic current injection
- Excessive negative sequence voltages
- Separation from supply
- Synchronizing generator to the distribution system
- Re-synchronizing the generation after electric restoration of the supply.

4.4.3.2 Where relays are required to meet the generator protection requirements of this document and IEEE 1547, the relay(s) must trip the generator's primary interrupting device directly and without relying on the operation of other equipment to effect the interruption.

4.4.3.3 On non-certified inverters and/or on rotating equipment where relays are required to meet the generator protection requirements of this document and IEEE 1547 and where the generation system can contribute more than 5% of the available fault current or where the generation can deliver energy on to the substation bus to which it is connected, the design of the isolation and fault protection shall be based upon a single failure philosophy, i.e., the failure of any single component (primarily relays or stuck breaker protection) shall not render the protection inoperative. Regional Distribution Planning & Protection shall determine the adequacy of the proposed protection scheme."

4.4.3.4 Utility grade relays, meeting the requirements of Paragraph 4.4.3.5 shall be utilized to meet the requirements of Paragraph 4.4.3.1 and IEEE 1547 for any of the following:

- Any single non-certified inverters or rotating machines rated 300 kW or larger.
- Where multiple generators rated 300 kW or larger in aggregate are protected by a single interrupting device.
- Where multiple generators rated 2000 kW or larger in aggregate are connected to the FirstEnergy system through a single point of interconnection.
- Where multiple generators rated 2000 kW or larger in aggregate are connected to the same distribution circuit on the FirstEnergy system in close proximity.

4.4.3.5 As a minimum, utility grade relays must comply with the most current version of the following standards, or its ANSI/IEC Equivalent:

- IEEE C37.90, 2005 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE C37.90.1 – IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE C37.90.2, 1995 - IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
- IEEE C37.98, 1987 - IEEE Standard for Seismic Testing of Relays.
- IEEE C37.2, 2008 - IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

4.4.3.6 The generator protection and controls must be designed to coordinate with the reclosing practices of FirstEnergy line protective devices. The generator must cease to energize the FirstEnergy circuit to which it is connected prior to automatic re-closure of any of FirstEnergy's automatic reclosing devices.

4.4.3.7 The generator shall cease to energize the FirstEnergy distribution system for faults on the circuit to which it is connected. The generator shall not reconnect to the FirstEnergy system following a trip from a system protection device, until the FirstEnergy system has been re-energized for a period of five minutes or as close to five minutes as possible within the capabilities of the timing device.

4.4.3.8 The generator protection and controls shall be designed to prevent the generator from being connected to a de-energized FirstEnergy circuit. The generator must connect to the FirstEnergy system through an interrupting device, which has adequate fault interruption, and withstand capability, and adequate continuous current and voltage rating in accordance with latest IEEE C37 standards at the time its commissioned. Three-phase generators shall use an interrupting device that interrupts all three phases simultaneously. The tripping control of the circuit-interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the FirstEnergy supply.

4.4.4 VOLTAGE CONTROL & FLICKER [12]

4.4.4.1 The generator shall be capable of paralleling with the FirstEnergy system without causing a momentary voltage fluctuation at the point of common coupling (PCC) greater than 5% of the prevailing voltage level of the FirstEnergy system at the PCC[13].

4.4.4.2 The generator must have adequate protection and controls to ensure the requirements for frequency, voltage, and phase angle shown in Table 5 are met prior to paralleling with the FirstEnergy system.

Table 5: Paralleling requirements for generators connecting to the distribution system. [14]

Rating of Generator kW	Frequency Difference (Hz)	Voltage Difference (%V)	Phase angle Difference (degrees)
0 - 500	0.3	10	20
500 - 1500	0.2	5	15
> 1500	0.1	3	10

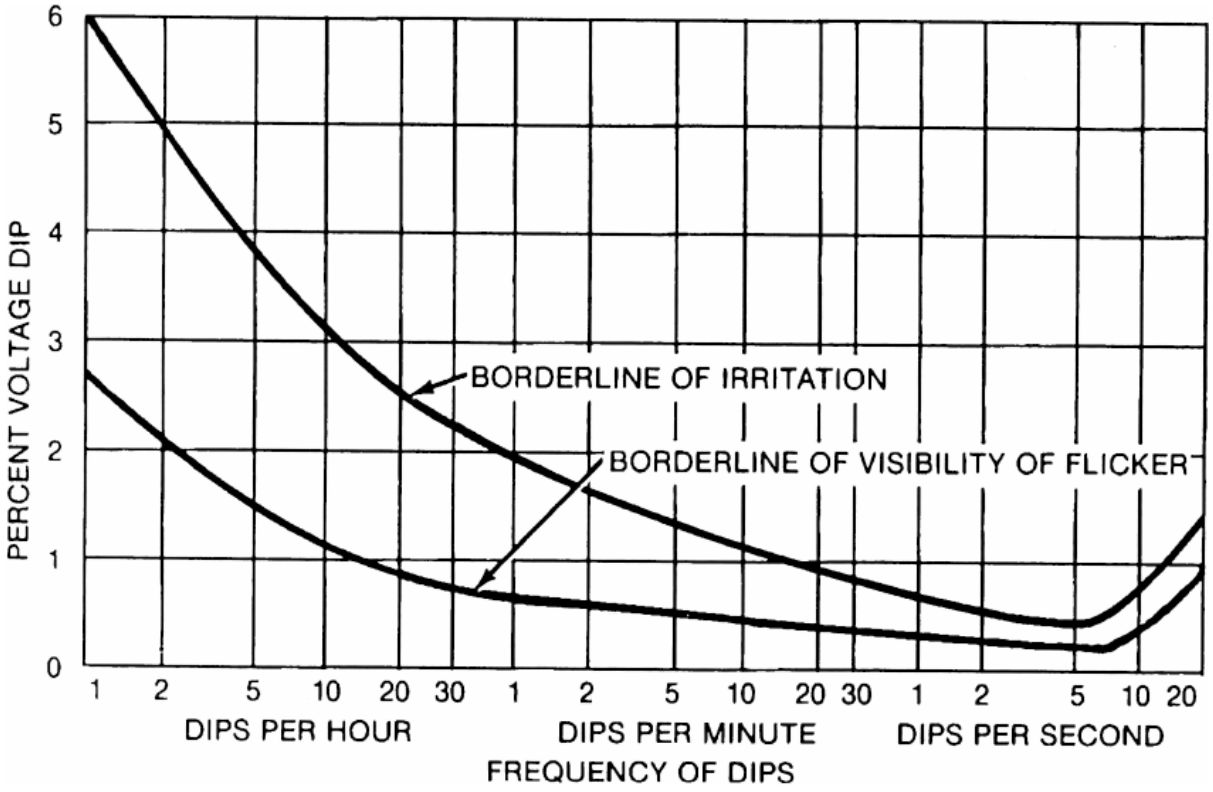
4.4.4.3 The generator shall not be a source of excessive harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including

[12] Flicker is considered objectionable when it either causes a modulation of the light level of lamps sufficient to be irritating to humans, or causes equipment misoperation. For guidance, refer to IEEE Std. 519TM-1992 [B5], IEEE P1453TM [B10], IEC/TR3 61000-3-7 [B1], IEC 61000-4-15 [B2], IEC 61400-21 [B3].

[13] The type of generation should be considered when determining the frequency of starts & stops, i.e., gas fired generation will likely parallel infrequently, whereas a solar or wind project may quickly ramp up and down several times an hour.

[14] Taken from Table 5, IEEE Std. 1547-2003, Standard for Interconnecting Distributed Resources with Electric Power Systems

inductive telephone influence factors) will be as published in the latest issues of IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems[15]." Flicker occurring at the point of common coupling serving other FirstEnergy customers shall remain below the Border Line of Visibility curve shown in fig. 10-3 of the IEEE 519 Standard. Flicker occurring at the secondary of a service transformer serving a single DG customer only shall remain below the Borderline of Irritability curve.



4.4.4.4 In the event a solar DG Customer is the only customer connected to the DG Customer's service transformer, the DG Customer shall limit voltage flicker to 3.0% of nominal at the DG customer's service entrance[16].

[15] IEEE Standard 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems," Second printing June 15, 2004

[16] Based on the solar generation varying from full output to zero & back to full output 30 times per hour. For other types of DG, the limits shall be based on the maximum variance of the generation and the maximum frequency thereof.

4.4.4.5 If one or more other customers are connected to a solar DG Customers service transformer, the DG customer shall limit voltage flicker to 1.0% of nominal at the PCC.

4.4.4.6 When there is reasonable cause for concern of the DG facilities causing flicker or other power quality issues, due to the nature of the generation and its location, FirstEnergy may require the installation of a PQ monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the generator owner's expense. Where these concerns do exist, the interconnection agreement for the project must include recognition of such and potential financial and/or other implications to the project if excessive flicker, high harmonic voltages and/or currents are detected on the distribution system.

4.4.4.7 If high voltage, low voltage, or objectionable voltage flicker arises due to the operation, frequent tripping, and/or frequent starting and stopping of the generator, the generator owner may be required to disconnect its generation equipment from the FirstEnergy system until the problem has been fully investigated and resolved.

4.4.4.8 The operation of the generator equipment must not result in harmonic currents or voltages at the point of common coupling that will interfere with FirstEnergy's metering accuracy and/or proper operation of facilities and/or with the loads of other FirstEnergy customers. Such adverse effects may include, but are not limited to heating of wiring and equipment, overvoltage, communication interference, harmonic resonance, etc.

4.4.4.9 DC injection from inverters shall be maintained at or below 0.5% of full rated inverter output current into the point of common coupling.

4.4.4.10 Normally, the generated voltage shall follow, not attempt to oppose or regulate, changes in the prevailing voltage level provided by FirstEnergy at the point of common coupling in accordance with the IEEE 1547 Standard. Generally on larger installations (>500 kVA), at the discretion of FirstEnergy, the customer generator may be required to follow a prescribed volt/var or power factor schedule, either producing or absorbing reactive power as determined by FirstEnergy. FirstEnergy reserves the right to modify the volt/var schedule after generation is operational.

4.4.4.11 When required by FirstEnergy, the generator shall be capable of maintaining a fixed or variable power factor between 0.95 leading and 0.95 lagging

(absorbing or producing VARs) as measured at the point of interconnection or at the point of common coupling as determined by FirstEnergy.

4.4.4.12 The generator must not interfere with the operation of FirstEnergy voltage regulating equipment including voltage regulators and line capacitors.

4.4.4.13 The generator must not cause the service voltage to other FirstEnergy customers to fall outside the limits specified in ANSI C84.1[17], Range A.

4.4.4.14 Voltage unbalance at the point of common coupling caused by the generator equipment under any condition shall not exceed 3% (ratio of maximum deviation from average voltage to the average voltage).[18]

4.4.4.15 A generator connected to an area network system shall not cause tripping of network protectors due to reversal of power flow.

4.4.4.16 Requirements for, and limitations on, the permissible connection to area networks are specific to the State in which the DG is connected. The DG system must meet the requirements of the applicable State regulations. The applicable regulations are available at:

- MD - **www.dsd.state.md.us/comar/getfile.aspx?file=20.50.09.08.htm** Determination of Level of Utility Review of Interconnection Request, Section D (Note: There are currently no area networks on the FirstEnergy companies' systems in MD)
- OH – **www.codes.ohio.gov/oac/4901%3A1-22-06** Level 1 simplified review procedure, Sections (A) (2) & (B)(1)(d) and,

  www.codes.ohio.gov/oac/4901%3A1-22-07 Level 2 expedited review procedure, Section (B)(1)(k)
- NJ - **http://www.lexisnexis.com/hottopics/njcode/** - § 14:8-5.5 Level 2 interconnection review, Section l
- PA - **www.puc.state.pa.us/PcDocs/630340.doc**, Section § 75.40. Level 4 interconnection review
- WV – Not Applicable – No requirement to connect generation in an area network

[17] ANSI C84.1-2006, American National Standard for Electrical Power Systems and Equipment—Voltage Ratings (60 Hertz)

[18] ANSI C84.1-2006, Annex C, Polyphase Voltage Unbalance, Paragraph C.2

4.4.5 RESPONSE TO ABNORMAL VOLTAGE

4.4.5.1 The protection functions of the interconnection system shall detect the effective (RMS) or fundamental frequency value of each phase-to-phase voltage, except where the transformer connecting the generator to the FirstEnergy system is a grounded wye-wye configuration, or single-phase installation, the phase-to-neutral voltage shall be detected.

4.4.5.2 When any voltage is in a range given in Table 6 the generator shall cease to energize the FirstEnergy system within the clearing time as indicated. Clearing time is the time between the start of the abnormal condition and the generator ceasing to energize the utility system.

4.4.5.3 For generators 30 kW or larger, different settings may be used for the under/over voltage trip levels or time delays if approved by FirstEnergy. Field-adjustable set points shall be protected against unauthorized adjustment.

Table 6 - Interconnection System Default Response To Abnormal Voltages [19]

Default settings[a]		
Voltage range (% of base voltage[b])	Clearing time (s)	Clearing time: adjustable up to and including (s)
V < 45	0.16	0.16
45 ≤ V < 60	1	11
60 ≤ V < 88	2	21
110 < V < 120	1	13
V ≥ 120	0.16	0.16

[a] Under mutual agreement between the EPS and DR operators, other static or dynamic voltage and clearing time trip settings shall be permitted

[b] Base voltages are the nominal system voltages stated in ANSI C84.1-2011, Table 1.

4.4.5.4 Where there are long conductor runs between the inverter(s) and the service entrance, there is a possibility of a voltage rise at the inverter terminals sufficient to cause nuisance tripping, even when the service entrance voltage is within normal limits. It is the responsibility of the customer generator to account for this potential in designing the interconnection facilities.

4.4.5.5 The existing service conductors originally installed to connect the customer were sized based on existing practices at the time and/or anticipated loads received from the customer and may be undersized based on the size of the

[19] Table 1 IEEE Std. 1547a-2014 IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, Amendment 1

generation. This may result in flicker at the service entrance and/or in high voltages at the inverter terminals, potentially causing nuisance tripping of the inverter. The customer generator is responsible for any costs incurred by FirstEnergy for any changes to the FirstEnergy system necessary to alleviate the problem.

4.4.5.6 Voltages shall normally be detected at the PCC to eliminate the effects of voltage drop on transformer connections between the PCC and the point of generator interconnection. However, under any of the following conditions the voltages may be detected at the point of generator interconnection:

- The aggregate capacity of the generator system connected to a single PCC is less than or equal to 30 kW,
- The interconnection equipment is certified to pass a non-islanding test for the system to which it is to be connected, and in the configuration proposed.
- The aggregate generator capacity is less than 50% of the total local electric power system minimum annual integrated electrical demand for a 15-minute period, and export of real or reactive power by the generator to the FirstEnergy system is not permitted.

4.4.6 RESPONSE TO ABNORMAL FREQUENCY

4.4.6.1 When the system frequency is in a range given in Table 7 the generator shall cease to energize the FirstEnergy system within the clearing time as indicated. Clearing time is the time between the start of the abnormal condition and the generator ceasing to energize the FirstEnergy system.

Table 7 - Interconnection System Default Response To Abnormal Frequencies [20]

	Default settings		Ranges of adjustability	
Function	**Frequency (Hz)**	**Clearing time (s)**	**Frequency (Hz)**	**Clearing time (s) adjustable up to and including**
UF1	< 57	0.16	56 – 60	10
UF2	< 59.5	2	56 – 60	300
OF1	> 60.5	2	60 – 64	300
OF2	> 62	0.16	60 – 64	10

[20] Table 2, IEEE Std. 1547a-2014 IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, Amendment 1

4.4.6.2 For generators greater than 30 kW, the frequency and time delay set points shall be field adjustable. Field-adjustable set points shall be protected against unauthorized adjustment.

4.4.7 ISLANDING PROTECTION

4.4.7.1 The generator protection and controls must be able to detect an island condition on one or more phases and disconnect all phases of the generator from the FirstEnergy system within two seconds of the formation of an island on any phase. The anti-islanding requirement can be satisfied by using any of the following methods, subject to the approval of FirstEnergy.

4.4.7.2 Direct Transfer Trip (DTT) Scheme

4.4.7.3 Use of over and under voltage and frequency relays where any remaining load on the line is significantly larger (3 times or better) than the aggregate generation.

4.4.7.4 The generator's protection package is certified to pass an anti-islanding test (i.e., certified to comply with IEEE 1547 by an OSHA listed Nationally Recognized Testing Lab (NRTL)).

4.4.7.5 The inverter is certified to pass an anti-islanding test (i.e., certified to comply with UL 1741 by a NRTL).

4.4.7.6 Non-exporting customer generator with reverse power relaying applied at the point of interconnection. Relays shall be set to pick up above the minimum import sensitivity of the relay.

4.4.8 DIRECT TRANSFER TRIP (DTT) SCHEME

4.4.8.1 FirstEnergy will make the determination if a DTT scheme is required on a case-by-case basis. A DTT scheme will typically be required when both of the following are true:

- The generator is any of the following types; a synchronous machine, a non-certified inverter, a certified inverter capable of and configured to operate in standalone mode, a certified inverter operating in any configuration whereby the anti-islanding function is disabled or a self-excited induction generator, any of which are capable of sustaining a load when separated

from the utility system, and

- The minimum load on the islanded line section connected to the generator following the opening of any automatic sectionalizing devices is not greater than 3 times the aggregate generation capacity.

Note: Where existing substation and line protective devices exist, that cannot be configured to send DTT signals (i.e., legacy breaker/recloser controls, hydraulic reclosers, sectionalizers, and fuses) these devices may need to be replaced with equipment that is capable of sourcing DTT signals at the Customer/Generator expense.

4.4.8.2 The DTT scheme design, equipment, and type of communication channel shall be proposed by the generator owner and submitted to FirstEnergy for review and acceptance.

4.4.8.3 The DTT scheme must be designed to automatically trip and separate the generator from the FirstEnergy distribution system within 2 seconds upon loss of communication channel. The generator shall not reconnect to the system until the communication channel is proven to be functioning normally for a period of five minutes or as close to five minutes as possible within the capabilities of the timing device.

4.4.8.4 Responsibilities for purchase, installation, and ownership of DTT equipment will be as follows:

- The generator owner shall own and provide a direct-transfer trip receiver(s) at their facility to receive tripping signals originating from a FirstEnergy location(s).
- The generator owner shall bear the costs to purchase and install the required DTT transmitting and associated relaying equipment at the required FirstEnergy location(s). The customer generator will perform or coordinate the installation of the equipment at the cost of the generator owner. The customer generator will own and be responsible to maintain and perform periodic maintenance and testing of this equipment.
- Where the trip signal originates inside a FirstEnergy substation, FirstEnergy will be responsible for trenching, conduit and cable installation to the customer generator's communication transmitting equipment location, at the customer generator's expense. This equipment will generally be located outside the substation fence. The connection between FE substation equipment and the Generator's equipment should be fiber or otherwise isolated to ease electric potential difference concerns under fault conditions.

- The generator owner is responsible for the design, installation, and maintenance of a dedicated, point-to-point communication channel(s) between the FirstEnergy location(s) and the generation owner's facility, including any rental, license, and attachment fees for the communications equipment and channel.
- When DTT equipment needs replacement due to age or continued unreliable performance, the generator owner is responsible for purchase and installation costs of the new equipment. This must be established in the Interconnection agreement with the generator owner.
- Customer needs to apply for service to power DTT Equipment.

4.4.8.5 If the generator owner wishes to install communications cables or equipment on FirstEnergy poles, the generator owner will be responsible to secure a license agreement or pole attachment agreement for those attachments, and assume typical licensed attachment responsibilities in terms of make-ready work costs and annual attachment fees. Cable attachment will be in the communications space on the poles.

4.4.8.6 When a DTT tripping signal originates from a FirstEnergy substation breaker, the preferred location for DTT transmitter and associated equipment is outside the FirstEnergy substation in an approved outdoor enclosure.

4.4.8.7 FirstEnergy will establish a demarcation point for any DTT communication cables leaving the substation property. FirstEnergy will perform or coordinate the installation of the cable and conduit up to the demarcation point including the box enclosure. FirstEnergy will determine the enclosure location. All material and installation costs will be borne by the generator owner. The generator owner will be responsible to install cable and conduit originating from their end up to the demarcation point. Details of the planned installation including any trenching must be approved by FirstEnergy.

4.4.8.8 The generator owner may be responsible to compensate FirstEnergy for any labor expenses involved with troubleshooting or testing of the DTT communications or protection system. This requirement is to be contractually addressed in the Interconnection Agreement with the generator owner.

4.4.9 DISCONNECT SWITCH REQUIREMENTS

4.4.9.1 FirstEnergy requires that a disconnect device with a visibly open means be provided, installed, and paid for by the generator owner, which is readily

accessible to and lockable by FirstEnergy personnel, in order to safely disconnect the generator from the FirstEnergy system.[21]

4.4.9.2 The disconnect device may be installed either at the primary voltage level or secondary voltage level at the discretion of FirstEnergy. The generator disconnect device must be clearly labeled to show its intended function.

4.4.9.3 The disconnect switch must be rated for the proper operating voltage, expected ampacity, and maximum available fault current.

4.4.9.4 The disconnect shall generally be located at or near the service entrance/utility meter. Where impractical, other accommodations may be granted upon prior request by customer and approval by FirstEnergy. The disconnect must be on the AC side of the inverter.

4.4.10 INTERCONNECTION TRANSFORMER REQUIREMENTS

4.4.10.1 All generation must be isolated from the FirstEnergy primary distribution system by a transformer in order to properly integrate the grounding scheme of the generator to the grounding scheme of the distribution system. In most cases, the preferred transformer configuration is wye grounded - wye grounded. However, depending on line configuration, other transformer connections may be preferred and will be determined by FirstEnergy. Please contact the appropriate FirstEnergy interconnection contact prior to specifying and ordering a new transformer.

4.4.10.2 The grounding scheme of the interconnection transformer shall not cause overvoltages on the un-faulted phases during ground-fault conditions that exceed the rating of equipment connected to the FirstEnergy distribution system.

4.4.10.3 The ground-source contribution current of the interconnection transformer shall not disrupt the coordination of the overcurrent devices of the distribution circuit whether or not the generator is in operation.

[21] Exception: In New Jersey and West Virginia, an outdoor disconnect switch is not a requirement for Level 1 interconnection review per regulations. See NJ Administrative Code, NJAC 14:8-4.1 et seq.(2008) and West Virginia PSC, Title 150, Series 33, Rules Governing Electric Utility Net Metering Arrangements and Interconnections

4.4.10.4 Where service is supplied to the DG customer through a FirstEnergy-owned transformer, the aggregate nameplate rating of the generator or generators shall not exceed the kVA rating of the transformer.

4.4.11 MAINTENANCE REQUIREMENTS

4.4.11.1 The generator owner shall maintain all equipment associated with the generator system, including DTT communications equipment, according to good utility practices and according to equipment manufacturer's recommendations and keep it in proper working condition.

4.4.11.2 The generator owner shall keep a written log and test records showing the periodic testing of such equipment. These records must be available to FirstEnergy upon request.

4.4.12 ACCEPTANCE TESTING

4.4.12.1 Test results or equipment pre-certification shall be supplied by the generator owner, that verify, to the satisfaction of FirstEnergy, compliance with the IEEE 1547.1 Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

4.4.12.2 The generator owner must provide FirstEnergy the opportunity to perform an inspection prior to interconnection to verify correct protective settings and wiring connections.

4.4.12.3 Acceptance testing shall be performed on all generators and generating equipment not pre-certified by a nationally recognized testing laboratory as suitable for utility interconnection meeting the intent of these technical requirements. A qualified third party testing organization shall perform these tests at the expense of the generator owner.

4.4.12.4 Acceptance testing of the protective schemes, where required, must be completed on new or modified installations. The company shall have the option of reviewing commissioning test procedures for non-UL 1741 listed generator/inverters and witnessing any commissioning tests.

4.4.13 COMMUNICATIONS AND CONTROL

4.4.13.1 FirstEnergy may require the generator owner to provide a listing of two or more persons and their telephone numbers such that the FirstEnergy dispatching office can contact the generator owner for emergency switching operations 24 hours a day. This is a necessary safety requirement.

4.4.13.2 Generator interconnections rated 2000kW or larger, individually or in aggregate shall provide access to their Supervisory Control and Data Acquisition (SCADA) Remote Terminal Unit (RTU) which will be connected via an appropriate, Connecting Party supplied, dedicated digital cellular circuit to FE's Transmission System Control Center. Details of the communication requirements begin in Section 4.13.5. The RTU must communicate with the FirstEnergy EMS via DNP 3.0 protocol. The following control, status, and metering points will be required:

- Control
  - Tripping control of generator or interconnection breaker.
- Status
  - Indication that a direct-transfer trip operation has occurred, where DTT is required. (see Section 4.4.8 for DTT requirements)
  - DTT communication channel status (where required)
  - Open/close indication of the interconnection breaker
  - Status of SCADA control switch, if available (used to isolate control function at RTU)
  - Meter communication trouble alarm; used to indicate if the customers operational data meter has failed
  - Open close indication of the low side generator step up transformer breaker
  - Other points may be identified as needed on a case by case basis
- Operational metering
  - Total generator real and reactive power output measured at the high-side of the generator step-up transformer.
  - Generator voltage (all phases) measured at the high side of the generator step up transformer.

- Generator amps (all phases) measured at the high side of the generator step up transformer.

4.4.13.3 In situations where the existing aggregate generation is approaching the minimum loading on the FirstEnergy substation transformer or where the aggregate generation on a distribution circuit is approaching the maximum generation for the circuit, at the discretion of FirstEnergy, generators rated less than 2,000 kW may be required to furnish a SCADA remote terminal unit (RTU) in order to connect and provide access to this data by FirstEnergy.

4.4.13.4 Where tripping control of generator breaker is required, the tripping command originating from the FirstEnergy dispatching office must also activate a closing lockout function, which must be manually reset before the generator breaker, can be re-connected to the system.

4.4.13.5 For the customer to interface to the FirstEnergy CDMA network the customer is required to acquire and install an Encore Networks Bandit II IP Legacy Router equipped with a cellular modem. The router is configured to encapsulate frame relay over dual IPsec tunnels in order to provide redundant communications to FirstEnergy head-end routers located at geographically diverse network control centers. An RS-232 serial interface is used for the connection between the Bandit II and the Interconnection Customer RTU.

4.4.13.6 The Interconnection Customer can select the cellular carrier of their choice. A 5 Gb/Month plan is recommended. The cellular signal at the customer site must be stable, with minimum RSSI of -85dBm. FirstEnergy can conduct comparative RSSI testing at the customer site, if requested. Once the carrier is selected, the customer will place the order for the Bandit II, specifying the carrier so that the correct modem is installed. Encore Networks will provide the customer with the IMEI and/or ESN number associated with the modem, and a SIM card may be required, depending upon the carrier selected. The customer will use this information in order to activate the modem in the carrier's network.

4.4.13.7 Encore Networks can pre-configure the Bandit II IP Legacy Router for operation within the FirstEnergy system prior to delivery to the customer. Encore Networks can be reached at:

Encore networks, Inc.
Office: 703-318-7750
3800 Concorde Parkway, Ste 1500
Chantilly, VA 20151
www.encorenetworks.com

4.4.14 METERING REQUIREMENTS

4.4.14.1 Metering instrument transformers are to be protected from the distribution system by a fuse or other protective device such that failure of an instrument transformer does not cause a distribution protection device to open.

4.4.14.2 In the case of an existing retail customer that is adding generation to their facility, the retail-billing meter will need to be replaced with a bi-directional meter. A review of the wiring and current transformers may need to be performed to verify the ampacity ratings are sufficient for the size of the generator. Cost responsibilities for meter replacement are defined in the retail net metering tariffs. The cost of most other metering upgrades required to accommodate the addition of the generation are the responsibility of the customer generator.

4.4.14.3 Wholesale generation facilities must comply with the metering requirements of PJM and with the FirstEnergy requirements specified in the document entitled "FirstEnergy Revenue Metering Requirements for Generation Facilities Connected 46 kV and Lower."

4.4.14.4 Generators with an aggregate capacity of 1000 kW or larger may require the installation of an interval metering system, which will transfer metering data to the FirstEnergy MV-90 system[22]. The meter will be provided by FirstEnergy. The generator owner will be responsible to provide at their cost a dedicated communications channel, which will interface with FirstEnergy's MV-90 system.

4.4.14.5 Cost responsibilities associated with the purchase, installation, and testing of revenue-metering equipment will be determined on a case-by-case basis under the direction of the FirstEnergy Corporate Metering Department and in accordance with the rules found in filed tariffs. These details are to be addressed in the facilities study.

4.4.15 BATTERY STORAGE FREQUENCY REGULATION ("FR") SYSTEMS

Frequency response systems participating in the PJM Ancillary Services Market respond to an automatic signal from PJM in order to correct for short-term changes in electricity use that might affect the stability of the power system by

[22] MV-90 is FirstEnergy's system for collecting interval metering data.

matching generation and load to maintain system frequency. Consequently, because of the magnitude and frequency of load changes, additional analysis is required during the review process.

4.4.15.1 FR systems must be analyzed at full potential load change, i.e. not less than twice the aggregate inverter rating.

4.4.15.2 Inasmuch as all FR systems are sent the same raise or lower signal, multiple FR systems on a distribution circuit or substation transformer must be analyzed in aggregate. Maximum ramp rates & staggered responses may be required.

4.4.15.3 Because of the frequency & magnitude of load changes, Flicker Curve considerations should be part of the analysis.

4.4.15.4 In addition to the voltage flicker limits discussed in Section 4.4.4, aggregated FR should be limited to an amount creating voltage fluctuations to less than ½ the dead band of any voltage regulation device.

4.4.15.5 Presence of FR may significantly increase costs to reconfigure system to accommodate future load growth or inhibit/prevent system reconfiguration. Additional costs to reconfigure system because of FR may be passed on to customer or FR may be required to cease interconnected operations.

4.4.15.6 FR operation may only be permitted while system is configured as originally studied (i.e., not during restoration / maintenance),

4.4.16 DEFINITIONS

Area Network System - A type of electric distribution system served by multiple transformers interconnected in an electrical network circuit, which is generally used in large metropolitan areas that are densely populated, in order to provide highly reliable service. Area network has the same meaning as the term “distribution secondary grid network” found in Institute of Electrical and Electronics Engineers (IEEE) standard 1547.

Automatic Sectionalizing Device - means any autonomous circuit-opening device, which can detect fault current & remove the faulted section of the circuit from the upstream circuit and allow restoration of service to the upstream sections of the circuit.

Certified Equipment – Equipment which has been submitted by a manufacturer to an OSHA-approved nationally recognized testing laboratory, and has been tested and listed by the laboratory for continuous interactive operation with an electric distribution system

in compliance with the applicable codes and standards listed in the IEEE 1547 and UL 1741 Standards.

Distributed Generation (DG) - Electric power generation facilities connected to an EDC through a PCC. DG systems are generally connected an EDC's distribution system and not directly to a bulk power transmission system. DG may be connected behind a retail customer's meter or may be connected directly to the EDC's system.

Distributed Resources (DR) - For the purposes of this technical requirements document shall have the same meaning as DG.

Direct Transfer Trip (DTT) - The immediate separation of all sources of generation at a DG customer's location initiated upon the operation of an automatic upstream protection device (substation breaker or line recloser) by means of a dedicated communication channel between the upstream device and the DG location.

Electric Distribution Company (EDC) - shall mean the electric utility entity that owns the electric distribution system serving the DG.

Flicker – A variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity.

Harmonic Distortion – Continuous distortion of the normal sine wave; typically caused by nonlinear loads or by inverters.

Inverter – A device or system that changes direct current power to alternating current power. Inverters that are self-commutating can be configured for stand-alone service. Inverters that are line-commutated cannot be configured for stand-alone service.

Microgrid - Is a localized grouping of electric generation sources, electrical loads, and may include an electrical storage system that normally operate connected to and in parallel with the electric utility's system (macrogrid), but can disconnect and function autonomously as physical and/or economic conditions dictate. A microgrid will typically involve only one customer, such as a building level or campus level microgrid, but may, in the future, be expanded to include localized groupings of interconnected customers.

Nationally Recognized Testing Laboratory (NRTL) - shall mean a qualified private organization that meets the requirements of OSHA regulations. NRTLs perform independent safety testing and product certification. Each NRTL must meet the requirements as set forth by OSHA in the NRTL program.

Point of Common Coupling (PCC) – The point at which the generator facility is connected to the shared portion, or potentially shared portion of the FirstEnergy system. The IEEE 1547 standard establishes this point as the location where voltage and harmonic limits are measured and applied.

Point of interconnection - The point of distributed resources connection (point of DR connection): The point where a DR unit is electrically connected in an EPS.

PURPA - Public Utility Regulatory Policies Act of 1978 - A United States Act passed as part of the National Energy Act. It was meant to promote energy conservation and promote greater use of domestic energy and renewable energy.

Qualifying Facility (QF) - is a generating facility, which meets the requirements for QF status under PURPA and which meets certification and registration requirements for QF status.

Regional Transmission Organization (RTO) – An independent, FERC-approved organization of sufficient regional scope, which coordinates the interstate movement of electricity under FERC-approved Tariffs by operating the transmission system and competitive wholesale electricity markets, and ensuring reliability and efficiency through expansion planning and interregional coordination.

Single Phasing Condition – Occurs when one or two phases of the three-phase supply line are disconnected.

Unintentional Island - An unplanned condition where one or more generator's and a portion of the FirstEnergy system remain energized solely through the point of interconnection.

4.5 TABLE OF FIGURES & ILLUSTRATIONS

Figure 1: Effect of Interconnection Transformer Configuration On Fault Detection

Interconnection Transformer Connections		Disadvantages	Advantages
Primary Side	Gen. Side		
△	△	Can provide an ungrounded source after substation breaker A trips, which can cause overvoltages on the distribution system.	Provides no ground fault contribution for fault at F1 & F2. No ground current from breaker A for a fault at F3.
△	Y		
Y	△		
Y	△	Provides an unwanted ground current for supply circuit faults at F1 and F2, and reduces ground current at breaker A for faults at F1	No ground current from Breaker A for faults at F3. No overvoltage for a ground fault at F1.
Y	Y	Allows source distribution circuit relaying at A to respond to a secondary ground fault at F3.	No overvoltage for ground fault at F1.
Y	Y with resistance	Can supply the distribution circuit from a resistance grounded source, after substation breaker A trips, causing overvoltage	Provides reduced ground fault contribution for fault at F1 & F2. Reduced ground current from breaker A for a fault at F3.

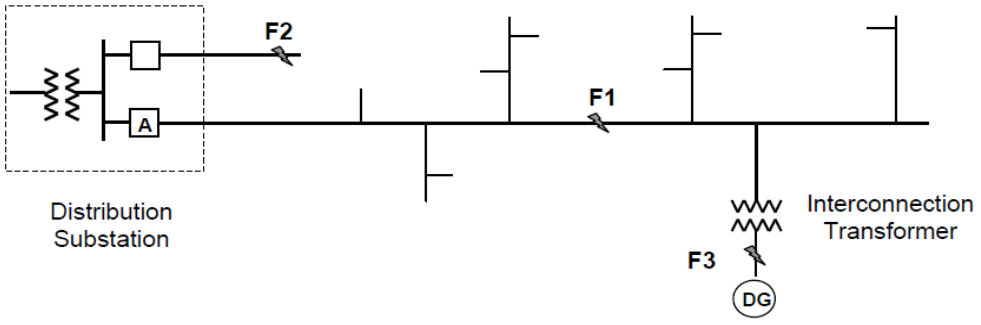
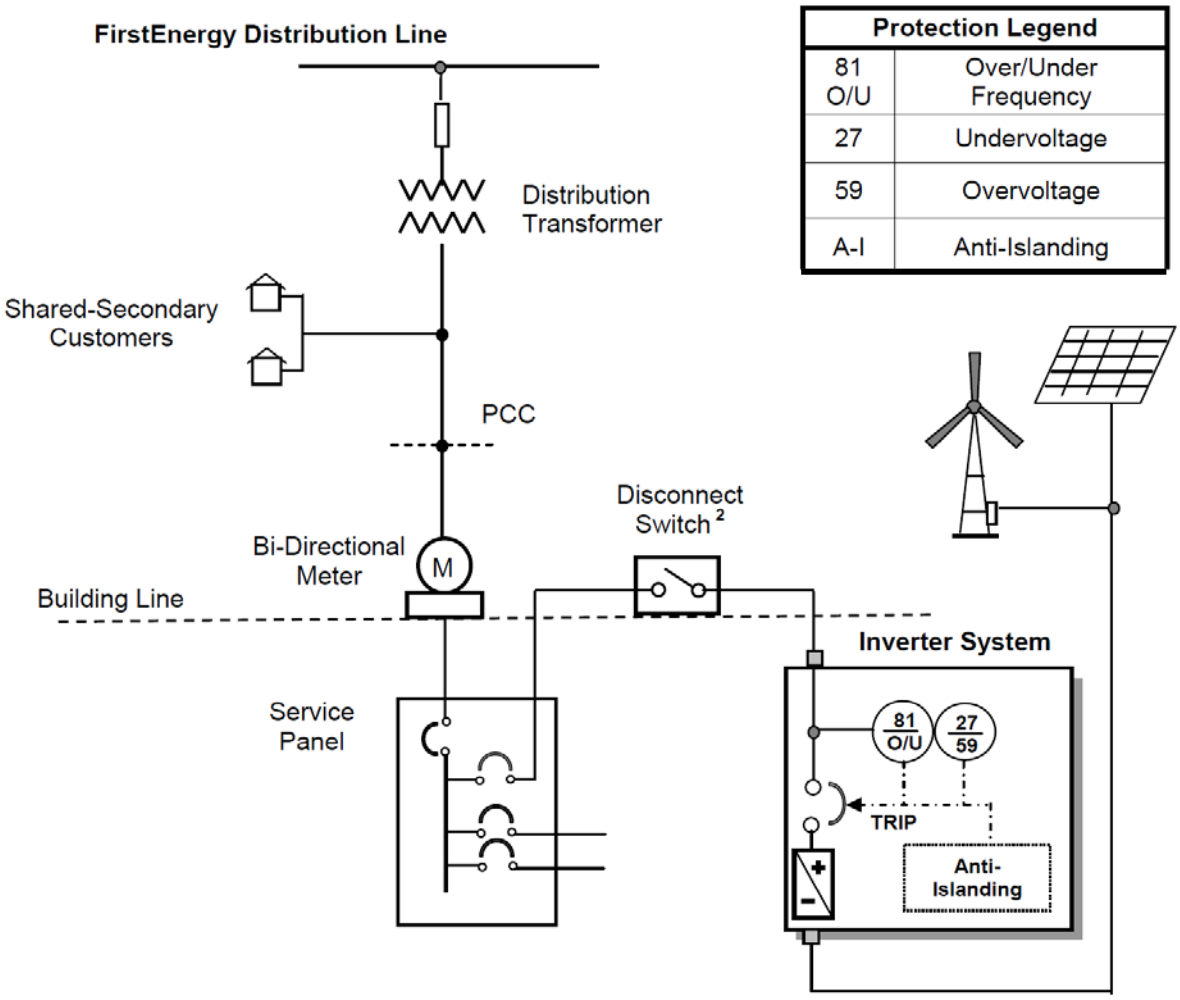


Diagram 1: Possible Fault Locations

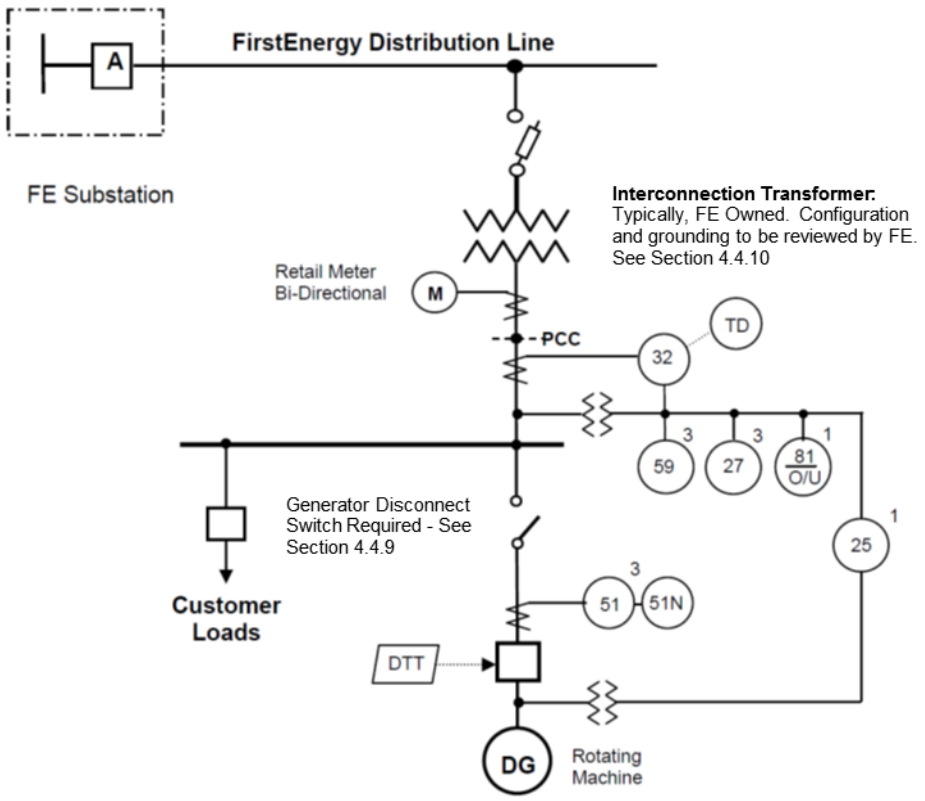
Figure 2: Interconnection Requirements for Net Metered Customer – 30 kW or Less



Notes:

1. U.L 1741 Certified Inverter meets the requirements of IEEE 1547. Inverter includes built-in short-circuit, under/over voltage, under/over frequency and anti-islanding protection.
2. Lockable disconnect switch, clearly marked and readily accessible to FE personnel, except in the state of New Jersey.
3. All components of installation must meet NEC, NESC and local building code requirements.

Figure 3: Interconnection Requirements for Secondary-Connected Generator

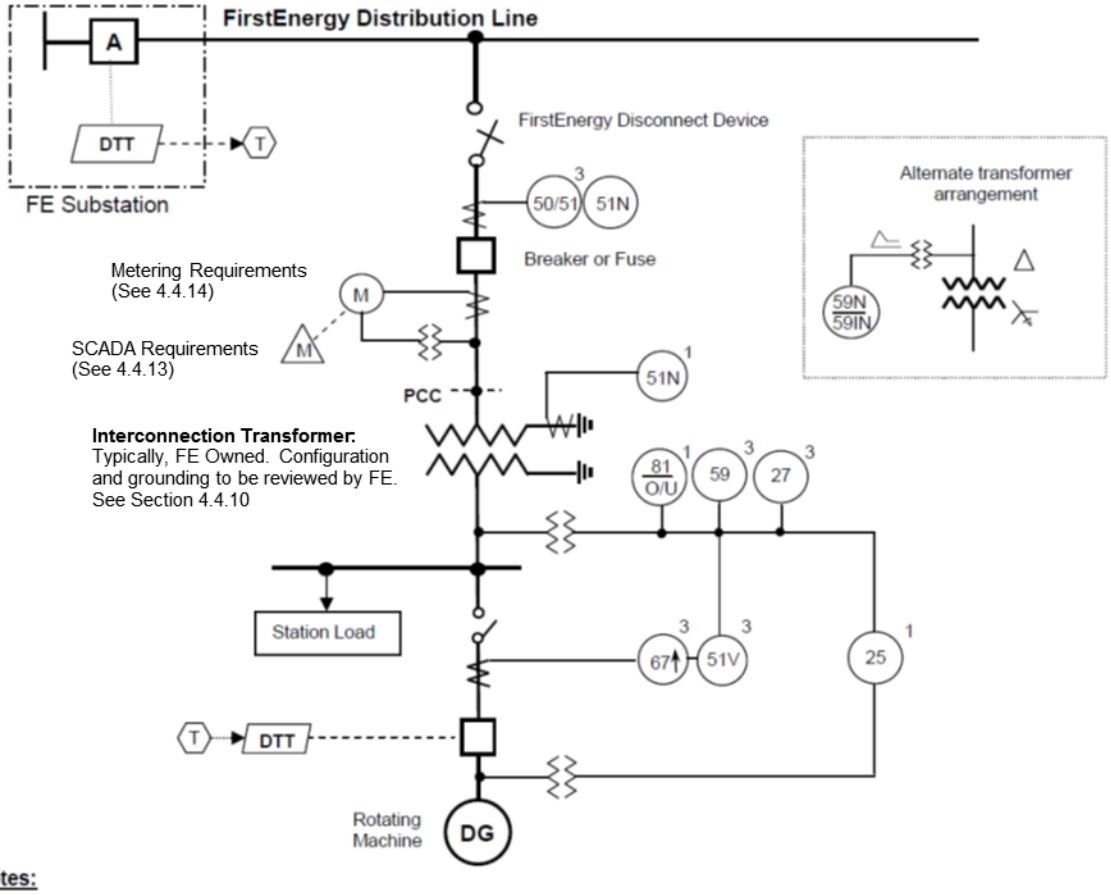


Notes:

1. Utility grade relays may be required - See Paragraph 4.4.3.4
2. Generator Protection not shown - Customer responsibility - See Paragraph 4.4.3.1

Relay	Function	When Required
27	Undervoltage Detection	All Installations
59	Overvoltage Detection	All Installations
81O/ 81U	Over / Under Frequency	All Installations
25	Synchronizing	For Synchronous machines
51G	Detect system ground faults	When DG will supply ground fault current
59G	Detect system ground faults	When interconnection transformer HS winding is ungrounded
32	Reverse Power Relaying	Islanding protection for non-export customer see Section 3.5
51/51N	Phase/Neutral Overcurrent	All Installations
DTT	Direct Transfer Trip	Protection Study Required - See Section 4.4.8 for requirements

Figure 4: Interconnection Requirements for Primary-Connected Generator

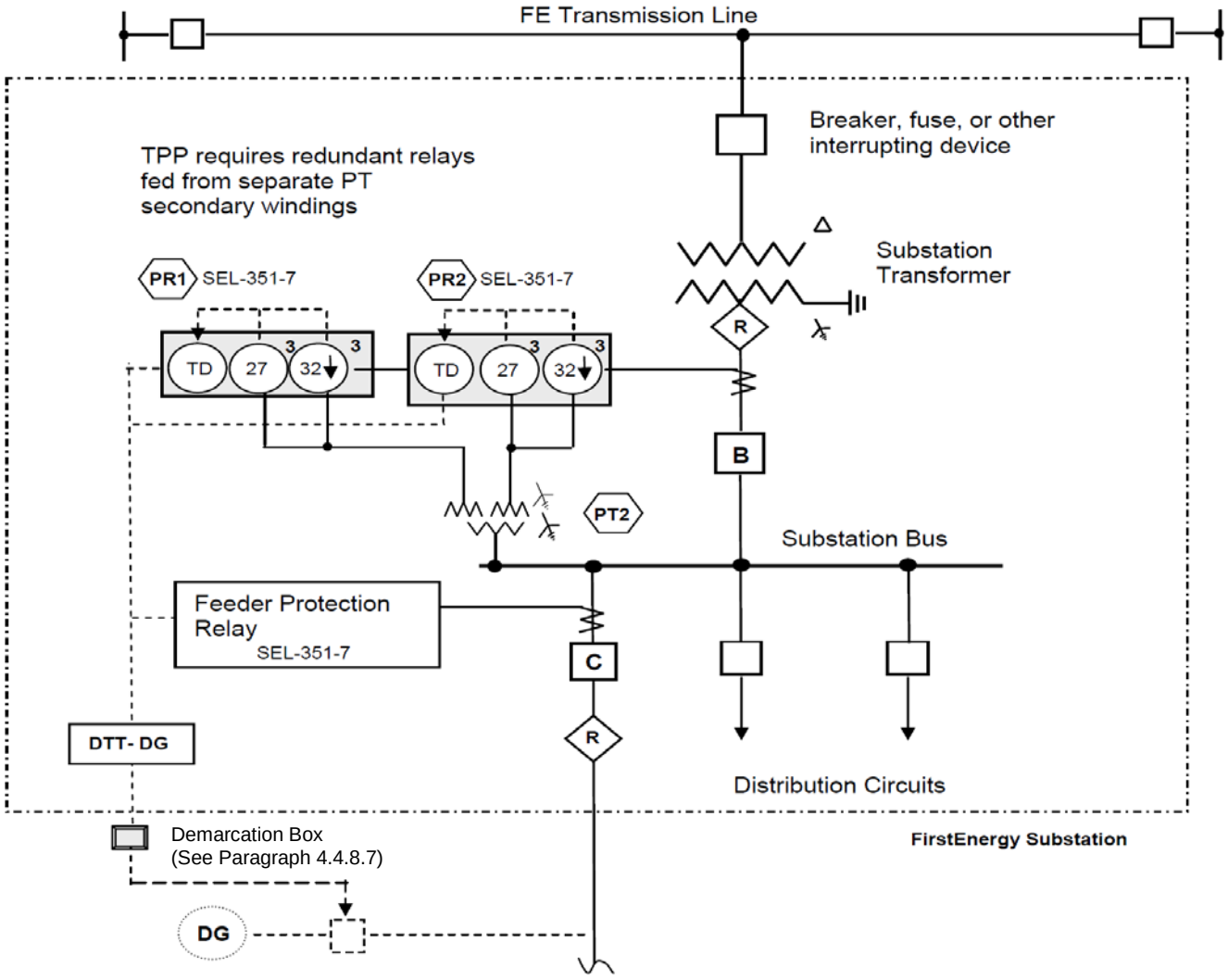


Notes:

1. Utility grade relays may be required - See Paragraph 4.4.3.4
2. Generator Protection not shown - Customer responsibility - See Paragraph 4.4.3.1

Relay	Function	When Required
27	Undervoltage Detection	All Installations
59	Overvoltage Detection	All Installations
81O/ 81U	Over / Under Frequency	All Installations
25	Synchronizing	For Synchronous machines
59N / 59IN	Ground Fault detection –Time / Inst	When interconnection transformer HS winding is not effectively grounded
67	Detect system phase faults	Generally required for all synchronous machines - Protection study required
51V	Detect system phase faults	May be needed when 67 not able to detect remote faults
51/51N	Detect system phase and ground faults	All Installations
DTT	Transfer Trip Receiver	May be required when 81O/U / 27/59 relays may not adaquately detect an islanding condittion. See Section 4.4.8

Figure 5: FE Substation Protection Requirements: DG will not cause transmission back-feed

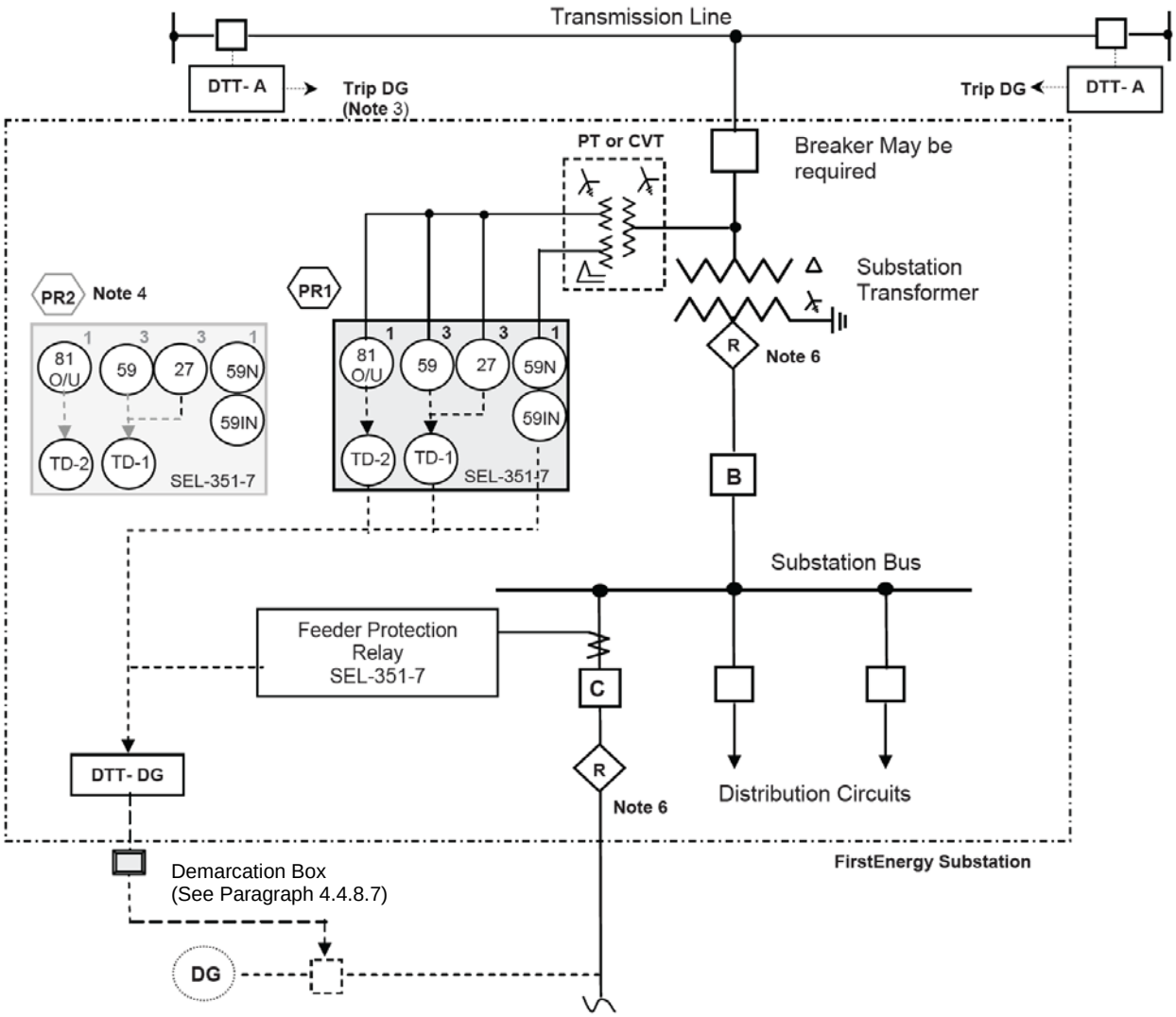


Notes:

1. This protection scheme functions to detect transformer high-side faults and applies when the DG is potentially capable of sustaining the substation transformer load upon loss of transmission source.
2. The DG will not be able to back feed power to transmission system with this protection scheme. This scheme offers a lower-cost protection solution to DG owner as compared to the design shown in Figure 6.
3. The DG will trip via DTT if transformer's power flow in the forward direction is lost or reverses; it will also trip for Undervoltage condition from 27 relay. 27 Time delay allows for transient under-voltages.
4. This protection scheme prevents the DG from permanently supplying a fault on the high voltage side of the transformer, but relies on high side relaying to detect and clear fault.

Figure 6: FE Substation Protection Requirements

Distributed Generation is allowed to Back-feed Transmission



Notes:

1. This protection scheme functions to detect transformer high-side faults and applies when the DG is capable of sustaining the substation transformer load upon loss of transmission source.
2. Use when DG will be permitted to back feed transmission.
3. DTT-A scheme requirement will be determined on case-by-case basis by TPP. This determination is a function of DG capacity relative to potentially islanded load if transmission source is lost. (2:1 load/gen. ratio is typically used by ED TPP)
4. If DTT-A scheme is not used, redundant PR1 and PR2 relays are required.
5. 59N/59IN required to detect ground faults on transmission side.
6. Tap Changer Controls may need to be replaced to allow for reversed power flow.

Figure 7: Interconnection Process for Parallel-Operated Generation