



**INTERCONNECTION REQUIREMENTS FOR PARALLEL OPERATION OF GENERATION GREATER
THAN 50 KW CONNECTED TO THE PECO DISTRIBUTION SYSTEM**

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I. INTRODUCTION

A. Purpose of this manual

This document is intended to provide technical requirements to customers that operate generators, rated greater than 50 kW, in parallel with the PECO distribution system. The purpose of this document is to provide an assurance that generators operated by customers connected to PECO distribution lines will not adversely impact quality of service to other customers, will not jeopardize PECO employees, will not jeopardize PECO equipment, and will not remain connected to PECO distribution lines after PECO circuit opening devices have operated.

This document is for use with radial distribution systems. GIC's desiring to connect to networked 33 KV lines need to arrange for the development of additional studies, such as load flow studies, in order to provide an assurance that the GIC will not negatively impact system operation.

NOTE: For facilities sized 50 kW and below, please refer to the document entitled "**Requirements for Parallel Operation for Customers with Generation Not Exceeding 50 kW**".

A generator satisfying PECO requirements and/or PJM Interconnection, L.L.C. (PJM) requirements, may operate in parallel with PECO distribution facilities.

PECO shall be permitted to implement any reasonable modifications to the requirements set forth in this manual, without notice, if these modifications are consistent with the primary function of this manual and with good utility practice. Said modifications can only be implemented after PECO has provided notice to GICs or other parties affected by these modifications. All modifications to these requirements will be applied by PECO to GICs or other parties affected by these requirements on a fair and non-discriminatory basis.

B. Definitions

CERTIFIED A designation that the interconnection equipment to be used by a customer-generator complies with the following standards, as applicable:

- (i) **IEEE Standard 1547**, "Standard for Interconnecting Distributed Resources with Electric Power Systems," as amended and supplemented.
- (ii) **UL Standard 1741**, "Inverters, Converters and Controllers for use in Independent Power Systems" (January 2001), as amended and supplemented.

"CONSTRUCTION SERVICE AGREEMENT" (CSA) shall mean that certain agreements between the GIC and PECO and/or PJM covering all of the terms, conditions and requirements regarding the design, purchase, construction and installation of those facilities needed to interconnect the generator with the PECO distribution system and/or the PJM transmission system.

ELECTRIC SERVICE REQUIREMENTS (ESR) Current version of the PECO Electric Service Requirements handbook.

"GENERATION INTERCONNECTION CUSTOMER" (GIC) is an entity that submits an interconnection request to interconnect a new generation facility or to increase the capacity of any existing generation facility that will operate in parallel with the PECO distribution system.



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“GENERATOR” is any electrical generation facility, which is, or may be in the future, interconnected with the PECO distribution system including: Small Power GICs, Exempt Wholesale Generators, Independent Power GICs.

“INTERCONNECTION AGREEMENT” is the contract between the GIC and PECO that defines the conditions and requirements under which a generator may export power to the PECO-owned distribution system.

“INTERCONNECTION SERVICE AGREEMENT” (ISA) is the contract between the GIC, PJM and PECO that defines the conditions and requirements under which a generator may export power to the PECO distribution system.

“PECO” or “THE COMPANY” – PECO, PECO Energy Co., or PE.

“PED” shall mean the facilities owned and/or controlled by PECO for the purpose of providing distribution service.

“PJM” Pennsylvania, Jersey, Maryland Interconnection LLC (Regional Transmission Organization)

“POINT OF COMMON COUPLING (PCC)”: The point where a GIS electrical service is connected to PECO’s distribution system (typically the service voltage)



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II. INTERCONNECTION PROCESS

This section provides an overview of the processes involved with interconnecting a generator to the PECO distribution system. The process will vary depending on whether the GIC desires to net-meter with a new or existing PECO electric service account or to sell the output to a third party marketer through PJM.

A. **PJM Process**

GIC installations that sell their electrical energy output must apply through the PJM process. Applications are submitted directly to PJM with appropriate application fees. PJM will coordinate the electrical interface requirements with the PECO distribution system. PECO requires the GIC to submit a Service and Meter Request Form to provide cost estimates and establish metering points for the GIC interconnection

B. **PECO Process**

GIC installations that net-meter their electrical energy output in conjunction with a new or existing PECO electric service account, in accordance with PAPUC Net Metering regulations as detailed in the PA Code Title 52, Chapter 75, shall submit a PECO Service and Meter Request, a Level 2, 3, or 4 application to operate in parallel, and appropriate application fee to the PECO Regional New Business office that services the property.

All GICs must comply with the procedures and requirements of this manual, and the PECO *Electric Service Requirements* handbook.

III. GIC RESPONSIBILITIES

This section describes the PECO process only and it does not apply to PJM requirements. The customer's design shall be approved by PECO and PJM, where appropriate, before the customer is granted permission to connect or commence construction on any necessary interconnection facilities. The GIC shall be responsible to pay for any PECO distribution system studies and or modifications before PECO review or construction begins.

A. **Initial Design Package** – The customer is responsible for submitting the initial design package to PECO. The complete design package should be mailed to the appropriate regional New Business Services Office. See the PECO Electric Service and Meter Application Form for the appropriate address. The design package shall include the following:

- i. **Electric Service and Meter Application** – The GIC customer shall submit a Service and Meter Request to PECO, stating the corporate name of the facility owner, its recognized incorporated name, location as an official street address, capacity of generation, size of expected loads and requested service voltage meeting the requirements of the PECO electric service tariff currently filed with the State of Pennsylvania.
- ii. **Single Line Diagram of the service and the proposed generating facility interconnection**– The GIC shall submit a detailed single line diagram of the entire facility. Appendix II contains examples of single line diagrams and Section IV contains PECO's technical standards. If the interconnection application is for a new service, the GIC is required to include a site plan along with the single line diagram. The single line diagram shall include the following items, if applicable:
 1. The PECO service interconnection, connections to generators and generator facility load.
 2. Existing and proposed PCC and synchronizing circuit breakers, with ratings, as applicable.
 3. Existing and proposed disconnect switches
 4. Proposed relays and the connection points required by PECO for the Generator. Relays must be of a type acceptable by PECO. (See Appendix 1, Section E)
 5. Voltage transformers, including voltage rating and type of connection.
 6. Current transformers, including all tap ratios and taps used.



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7. Power transformer MVA ratings, impedance and connections, including the neutral grounding arrangement.
 8. Generator type (solid state or rotary – synchronous or induction). MVA / kW ratings, transient reactance, power factor, sub-transient reactance, synchronous reactance, zero-sequence impedance and winding configuration, including the neutral grounding arrangement.
 9. Inverter UL-1741 certification
- iii. **Application for Parallel Operation Form (Level 2, 3, or 4)** – The GIC must apply in writing for permission to operate a generating facility in parallel with the Company by providing the required information on the Level 2, 3 or 4 Interconnection Application form, available on PECO's Net-Metering and Interconnections Web Site
- iv. **Application Fee**– The GIC shall pay fees according to the fees posted on PECO's Net-Metering and Interconnections Web Site

Note - No fee is required for momentary parallel operation with interconnection equipment meeting UL1008, or transitional paralleling (2 minutes or less) to transfer load to and from an electrical generating source.

B. REVIEW PROCESS

- i. **CERTIFIED INTERCONNECTION SYSTEMS** - Customers must meet the following requirements to be eligible for the simplified approval process for parallel operation:
1. The aggregate generator capacity, at the point of interconnection, must be rated 2 MW or less
 2. The generator and interface equipment, including protection systems, must be certified by an independent third party laboratory, i.e., UL. Customers meeting the above requirements, who desire approval through the simplified approval process for parallel operation, should check the appropriate boxes on the application form and include pre-certification paperwork in the initial design package. In cases where the application requires utility construction to the distribution system or creates distribution system limitations, then the application is not eligible for the simplified approval process and will continue to be processed as a standard application.
 3. Inverter Testing - Inverter Witness Testing – At PECO's discretion, GIC installations with certified utility interactive inverters shall prove the anti-islanding protective feature of the inverter by monitoring the AC inverter output voltage and disconnect the inverter from the grid. The monitoring device shall provide wave forms to determine the time required for the inverter to cease operation when the grid is interrupted. This test shall be witnessed by a PECO employee and a copy of the inverter waveforms from the test submitted for PECO's records.
- ii. **NON CERTIFIED INTERCONNECTION** – Generator systems that are not Certified_ will be required to provide PECO with the following information upon completion of the final design:
1. **Detailed AC Schematic** – The GIC must submit an acceptable schematic and connection diagram (AC Three Line Diagram and Control Schematic) after the initial plans are accepted by PECO and before manufacturer of the equipment. This information must include the following:
 - a. Relay information, including manufacturer, catalog and style numbers and range of operation.
 - b. Complete power transformer specifications, including winding configuration, MVA rating, voltage rating, impedance values and tap changer ranges with the no-load fixed tap position.
 - c. Complete generator specifications, including type (synchronous or induction), voltage rating, synchronous, transient and sub-transient reactance values and zero-sequence impedance.
 - d. Detailed AC and control schematics showing relay connections and proper polarity marks on all relay voltage transformers and current transformers.



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2. **Bill of Material** – The bill of material for the service substation must be provided if applicable.
3. **Equipment Test Data** – Certified test data for the generator(s) and transformer(s) shall be provided to the appropriate PECO New Business Services office at least sixty days prior to the desired service date.
4. **Protective Relay Settings** - GIC shall submit proposed settings – pickup, time delay, and trip curve - for relays that trip the PCC circuit breaker and for each generator. Supporting documents that explain the criteria for each set point selection shall be submitted along with the proposed settings. This may include settings for the following:
 - a. Time overcurrent relays
 - b. Voltage controlled overcurrent relays
 - c. Instantaneous overcurrent relays
 - d. Overvoltage relays
 - e. Undervoltage relays
 - f. Overfrequency relays
 - g. Underfrequency relays
 - h. Breaker failure relays
 - i. Impedance relays
 - j. Differential relays
 - k. Loss of Field relays
 - l. Reverse power relays
5. **Voltage Schedule** – PECO may provide Voltage and VAR operating requirements. The GIC shall operate their interconnected power source in a manner to avoid creating voltage issues on the PECO distribution system.
6. **Protective Relay Testing** - GIC shall submit certified test reports – pickup, time delay, and trip curve - for relays that trip the PCC circuit breaker and for each generator. This may include certified test reports for the following:
 - a. Time overcurrent relays
 - b. Voltage controlled overcurrent relays
 - c. Instantaneous overcurrent relays
 - d. Overvoltage relays
 - e. Undervoltage relays
 - f. Overfrequency relays
 - g. Underfrequency relays
 - h. Breaker failure relays
 - i. Impedance relays
 - j. Differential relays
 - k. Loss of Field relays
 - l. Reverse power relays



7. **Circuit Breaker Trip Testing** - GIC shall submit certified trip test reports for the PCC circuit breaker and for each generator circuit breaker. This shall include trip tests with battery chargers turned off and AC power supplies to tripping capacitors turned off (The intent is to simulate circuit breaker tripping for a three phase fault with near zero AC voltage). During completion of these certified trip tests, at least one trip shall be through a protective relay trip circuit, that is, not by local or remote control switch.

IV. TECHNICAL STANDARDS

A. Determination of Interconnection Voltage Level

1. **Voltagess Available For Generators** – GICs are eligible, under appropriate circumstances, to access the same voltages available to customers listed in the Definitions section of the Rules and Regulations of the PECO Electric Service Tariff. Representative sizes of generators that may be connected to existing Company distribution circuits are listed in the table below with corresponding minimum service voltages. In some cases, larger generators may be installed after formal review by PECO of the GIC's proposed interconnection.

2. **Generator Size vs. Available Voltage**

Maximum Generator Size (kW)	Minimum Service Voltage * (Volts)
50	All PECO Service Voltages
200	208Y/120 Volts 3 Phase 4 Wire
400 **	480Y/277 Volts 3 Phase 4 Wire
3,000	13,200 Volts 3 Phase 4 Wire ***
10,000	33,000 Volts 3 Phase 4 Wire ***

* All voltages are not available in all parts of the system. A generator should contact PECO to obtain the distribution voltage available at specific sites. PECO reserves the right to review interconnection request for services supplied at 4,160 Volts ***.

** Limited to PECO pad mounted transformer installations

*** Limited to services greater than 600 Volts with customer owned transformers

3. **Compatibility** – A GIC connecting a Generator to an existing PECO circuit must be compatible to existing and projected requirements for that circuit. Therefore, a Generator meeting the above voltage guidelines may not be permitted to connect to a given circuit if such interconnection is not compatible with future Company system arrangements. In that case, the GIC will be required to pay either the cost to connect to a higher voltage circuit or the cost for additional circuit facilities. If additional circuit facilities are required for the Generator, larger generation installations may be possible for a specific service voltage.



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B. Applicable Power Quality Requirements

The GIC must design its generation facilities and appurtenant equipment to operate within the following specifications.

1. Harmonic distortion limits (as a percent of distortion of 60 Hz fundamnet) for an individual Generator shall conform to the current IEEE 519 revision.
2. Voltage distortion contributed by a Generator may be further restricted so as not to raise the single frequency or total harmonic distortion levels above system limits at the point of common coupling or any system point in resonance.
3. PECO will review the effects of current distortions on an individual basis. Where distortion limits are exceeded, the Generator will be required, at its own expense, to make correction such as adding filters.
4. Flicker, voltage variations and fluctuations must be controlled as described in Rule 13.2 of the **Rules and Regulations** of PECO's Electric Tariff.
5. Pennsylvania Public Utility Commission Electric Regulations, 52 Pa. Code §57.14, allow voltage variations from the Company's nominal service voltages. Where service is primarily for lighting, the allowable variation is $\pm 5\%$. Where service is primarily for power, the allowable variation is $\pm 10\%$. The GIC must design its equipment to operate satisfactorily within the $\pm 5\%$ voltage limits at the PCC and not subject other PECO customers to voltage variations outside these limits during both operating and shutdown conditions. A GIC, at its own expense, must provide voltage regulators or load tap changing transformers, if needed to maintain these voltage limits for other customers. A GIC may operate their system within the $\pm 10\%$ voltage range as long as this mode of operation has no deleterious impact on other customers. A GIC shall operate within the $\pm 5\%$ voltage limits unless PECO provides written permission to operate outside of these limits.

C. PECO's Design Criteria for Generator Interface Equipment

1. **GIC Service and Interconnection Requirements** – The GIC shall design, provide, install, own, operate and maintain all facilities on its property, except for the PECO retail meters and metering transformers described in Section V below and distribution transformers for customer's served at voltages below 600 volts. The installation shall be in accordance with PECO's **ESR** handbook, the **National Electrical Code**, the **National Electrical Safety Code** and any other codes that apply. The installation shall include a service entrance disconnect and over-current protection that meet the requirements of Article 230 of the National Electrical Code. The service entrance circuit breaker or switch and fuse must coordinate with the PECO line or circuit protection, protect the Generator's electrical equipment from over-current conditions and be capable of disconnecting the Generator from the PECO circuit in the event of an interruption of service. The Generator's protective system control power source must be reliable and not subject to interruption during fault periods. Storage batteries or capacitor trip devices are examples of equipment that meet this requirement. Where multiple generators are connected in parallel to the PECO system through a single connection point, the rating of the Generator will be the sum of the ratings of the individual generators.
2. **Generator Compatibility** – A Generator connected to PECO's system shall match the service voltage, number of phases, wires and grounding of the distribution system supplying the Generator, at the point of common coupling.
 - (a) **3 Phase, 4 Wire System Solidly Grounded** – Generators connected to 3 phase, 4 wire solidly grounded systems shall present a solidly grounded Wye source at the service delivery point. Generators supplied at 4 kV or higher, Where the generator does not have a solidly grounded Wye connection, the GIC shall interconnect to the Company's facilities through an isolation transformer (typically grounded-wye primary, delta secondary) designed to match PECO's distribution system. A Generator must also supply sufficient ground fault current to stabilize phase-to-neutral voltages during PECO distribution system faults, and incorporate overcurrent protection to disconnect the generator from the Company lines during multi-phase, or phase -to-ground fault conditions.



Exceptions

- a. Generators may be connected through a delta primary winding where the items 1 and 3 and 4 or 5 below, or 2 and 3 and 4 below or 5 are satisfied
 1. Where the customer's annual minimum 30 minute interval KW demand is at least twice the aggregate KW nameplate capacity of all interconnected generation sources connected to the service.
 2. Where 30 minute interval data is not available, the aggregate KW nameplate capacity of all interconnected generation shall not exceed 10% of the customer's annual maximum monthly KW demand.
 3. A zero-sequence over-voltage relay and its appropriate voltage transformers are connected to monitor the service voltage and trip the generator(s) upon sensing a supply circuit phase-to-ground fault.
 4. A directional power relay will trip the generator(s) in the event that export of power PECO's system is detected.
 5. The Generator is certified inverter per UL 1741 and IEEE 1547.

- (b) 3 Phase System with Resistor Neutral within the Boundaries of the City of Philadelphia**
– Generators connected to 3 phase, resistor-grounded systems shall present an un-grounded or impedance-grounded Wye source at the service delivery point. A zero-sequence over-voltage relay and its appropriate voltage transformers shall be connected to monitor the service voltage and trip the generator(s) upon sensing a supply circuit or line phase-to-ground fault. Transformers shall have a Wye primary connection with a neutral bushing, which can be solidly grounded if PECO converts the line to a grounded-wye source.

D. Fault Protection in Generator's Interface Equipment

The general guidelines for fault protection are included below. Generators that will only momentarily parallel with the PECO system should review Appendix 1 for different protection requirements that apply. All GICs shall:

1. Protect PECO's electrical system from the generator's internal phase or ground faults. Protective relay requirements depend on the size and type of the generator and the generator transformer connections. (See Appendix I for General Protection Requirements.)
2. Protect its own equipment from faults on the Company's system, including phase and ground faults.
3. Protect its generator from ground faults, under-frequency, over-frequency and reclosing of Company circuits. It is also recommended that GICs should protect against negative phase sequence (single phasing), over-current and motoring.
4. Design the coordination of its internal relays and submit the proposed settings of service protection relays for PECO review.
5. Separate its generator from the Company system whenever the Company's service line is de-energized.

E. Exceptions

GICs connected to PECO circuits that serve no other customers and are dedicated to the GIC connection may, at the discretion of the Company, be excused from some of the requirements of this manual. PECO's relaxation of any one requirement does not relieve the Generator of its obligation to meet all other requirements of this manual or to meet the requirements of the **National Electrical Code**, the **National Electrical Safety Code** and any other codes that may apply. The GIC, by taking exception to a requirement, is responsible for all damages or injuries that may be associated with that exception.



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V. METERING REQUIREMENTS

This section describes metering for PECO net-metering. It does not apply to PJM ISA's and CSA's.

A. Metering

Service connections at 120, 208, 240 or 480 volts, and all services over 600 volts, with transformers operating independently from generation, must be metered for power supplied to the customer by PECO. The metering instruments shall be owned and maintained by PECO. The customer is responsible to provide enclosures to mount PECO metering transformers per Section 8 of the ESR. PECO will provide, own and maintain the IN meters (sales to customer) and the OUT meters (deliveries to PECO) for Net-Metering interconnections, at its expense. For transformer-rated meters, the meter transformers will be owned and maintained by PECO. Any additional costs resulting from non-standard work will be charged to the GIC.

VI. TELEMETERING REQUIREMENTS

A. Monitoring of Generators

PECO reserves the right to require GICs to install communications equipment, such as telemetering or telephone connections, at each Generator location. This equipment must allow PECO to monitor the Generator's operation and output, the position of breakers and any other information needed to ensure safety, reliability and stability of PECO's electric system. Costs of design, installation, operation, testing and inspection of the communications equipment shall be paid by the GIC. In general, all Generators over 5 MW shall require telemetering, but PECO retains the discretion to require smaller Generators to install such equipment.

VII. REQUIREMENTS FOR TESTING AND ACCEPTANCE

The following typical testing requirements shall be performed on service entrance equipment and PECO required GIC relay elements. The GIC shall have this equipment inspected and tested by the GIC, or an independent testing company. All testing is at the GIC's expense. GIC shall submit a written report from the testing agency to PECO for review. PECO shall have the right to attend and observe the testing.

- A. Current Transformers** – Perform primary current injection to prove ratio, polarity, and the integrity of the CT network. Single point safety ground shall be proved by megohm testing the ground lifted and re-connected. Primary current tests may be required to verify proper operation of protective relay circuits, particularly when multiple CTs are paralleled, and differential circuits.
- B. Voltage Transformers** – Verify ratio, polarity, and the integrity of the VT network. Single point safety ground shall be proved by mega-ohm testing the ground lifted and re-connected. Additional tests may be required to verify proper operation of protective relay circuits.
- C. Protective Relays** – As specified, in other parts of this document; are to be calibrated and tested by secondary current and voltage injection to prove pick-up values and time response appropriate for the relay's time curves.
- C. Witness Test** – PECO reserves the right to require all generating sources greater than 50 kW to perform a Witness Test of the generating system's protection. Inverters shall record time to trip when isolated from the electric grid. Systems with relays shall demonstrate that the relays trip a protective device with secondary current and or voltage injection, as appropriate.



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VIII. OPERATIONAL REQUIREMENTS

A. Operation of Generator in Parallel with Company System

From time to time, PECO must remove its circuits from service for maintenance. These planned outages are for the purpose of testing relays, rearranging, modifying or constructing lines and maintaining lines or station equipment. The GIC must cooperate with these planned outages.

Also, from time to time, a Generator may not be permitted to operate in parallel with the PECO system or, in the case of a Generator with multiple services, may be permitted to operate only in parallel with specific circuits so that PECO can perform "Live-Line Maintenance" on facilities serving the GIC.

At any and all times that a GIC is operating in parallel with PECO's system, the GIC shall have personnel available to respond to PECO's needs and to promptly resolve any operational issues that arise. For example, if high system voltage is detected, the GIC must be able to reduce their generator terminal voltage promptly, when requested by PECO.

If PECO is unable to contact the GIC within a reasonable amount of time or the GIC is unwilling or unable to implement PECO's request, PECO reserves the right to interrupt service to the GIC facility until system conditions improve.

The GIC must cooperate with the following conditions and requests.

- (1) During planned outages, or emergency conditions, PECO may require the generation source to be disconnected, locked, and tagged to prevent its closing into the PECO line. A GIC with rotating generation or systems not meeting UL 1741, must notify PECO before bringing a Generator on line. PECO may require the GIC to delay synchronizing to allow parallel operation with the system when the Company is experiencing circuit trouble or system disturbances.
- (2) A GIC must not energize supply circuits interconnecting with the Company's facilities or continue to maintain supply to Company circuits after PECO has de-energized its circuits.
- (3) The Company may require the GIC to discontinue parallel operation during emergencies and under abnormal operating conditions.
- (4) A GIC is responsible to evaluate the potential effect of the Company's reclosing practices on the Generator and to provide suitable protection.

B. Reactive Requirements

When a Generator draws excessive reactive power from the Company the GIC shall correct the Generator's power factor to values according to the Company's Electric Tariff and/or the PJM Operating Agreement.

C. Minimum Generation

During certain low-load periods, PECO, acting in conjunction with PJM, may require a GIC to reduce output of its Generator(s) so as not to exceed its own internal needs and export power. A GIC must be capable of reducing the output of its Generator(s) so as not to export any energy to PECO during such light load conditions.

D. Distribution System Back-Up Capacity

- (1) GICs with dual service who must operate in a regular/reserve mode after installing parallel generation may create line capacity problems. All costs to provide additional capacity for this purpose are the responsibility of the GIC



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E. Parallel Operation with Dual or Regular/Reserve Service

GICs with dual service shall maintain a 50% - 50% load split between both services with the generator(s) in normal operating configuration. GIC with lines from different sources may be unable to operate generation in parallel with both lines. The GIC is responsible for payment of all costs to provide compatible sources.



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Appendix I

General Relay and Other Protection Requirements for Parallel Operation of Generation Facilities

This Appendix provides prospective GICs with a guide on the protection systems required by PECO. PECO's goal is to operate its electric system safely and reliably, while maintaining the quality of service and considering the needs of the GIC, PECO and any other customer whose service might be affected.

The amount and type of relay protection required is normally determined based on generator type, size and service supply line. However, circumstances where another Generator is already on the service supply line could require the GIC to install a higher level of relay protection than the amount specified under the following protection requirements. These situations will be analyzed on a case-by-case basis.

This section is broken down as follows:

- A. General Requirements**
- B. Synchronous Generator Protection**
 - 1. Distribution System Protection – Continuous Parallel
 - 2. Distribution System Protection – Momentary Parallel
 - a. Instantaneous Parallel
 - b. Transitional Parallel
- C. Induction Generator Protection**
- D. Utility Interactive Inverters**
- E. Acceptable Relay Types**

A. General Requirements

- 1. All service entrance protection relays and generator interconnection relays required by PECO must be set and calibrated.
- 2. In addition to normal service entrance over-current protection relays and the relay protection required for the GIC's equipment, the GIC shall provide the following relay protection per IEEE 1547.
 - a. **Over-/Under-Frequency Relays (81 O/U)** – Relay specifications and settings shall comply with the current revision of IEEE Standard 1547, as shown below. [See Section B of the Appendix for specific requirements for synchronous generators.] Frequency may be monitored at either the point of common coupling or at the point of connection.

Generator Size	Frequency Range (Hz)	Clearing Times (Seconds)
≤ 30 kW	> 60.5	0.16
	< 59.3	0.16
> 30 kW	> 60.5	0.16
	< (59.8 – 57.0) (adjustable set point)	Adjustable 0.16 to 300
	< 57.0	0.16



- b. **Over-/Under-Voltage Relays (59 and 27)** – Three phase (grounded-wye / grounded-wye VTs) voltage shall be monitored. Relay specifications and settings shall comply with the current revision of IEEE Standard 1547. Voltage shall be monitored at the service voltage (point of common coupling) unless any of the following conditions exist:
- i. The aggregate capacity of GIC systems connected to a single point of common coupling is less than or equal to 30 KW.
 - ii. The interconnection equipment is certified (UL-1741) to pass a non-islanding test for the system to which it is to be connected.
 - iii. The aggregate GIC capacity is less than 50% of the total GIC annual minimum integrated electrical demand for a 30 minute time period, and export of real or reactive power by the GIC to PECO's system is not permitted (directional power relay protection required) or in any other case where export of real or reactive power to PECO's system is not permitted.

Voltage Range (% Of Base Voltage)	Clearing Times (Seconds)
$V < 50$	0.16
$50 \leq V < 88$	2.00
$110 < V < 120$	1.00
$V \geq 120$	0.16

3. The required protection and list of recommended relay types is included in Section E. If the GIC desires another relay type, it should submit the specifications and instruction books to PECO for review/acceptance. All relays must meet the following requirements:
- a. Must use nominal 120-Volt inputs.
 - b. Can accept the required settings within the tolerances specified.
 - c. To facilitate testing, the protective devices shall be connected to test switches providing access to each phase and neutral current, voltage (when applicable), control power and tripping contacts. Acceptable test switches are those manufactured by Meter Devices, Superior and General Electric (Type PK Test Plugs). Relays equipped internal General Electric test plugs or ABB flexi-test switches are exempt from the external test switch requirement (i.e., General Electric type IAC, IFC, DIAC, MDP relays; ABB relays and Basler 50/51B relay)
 - d. Microprocessor-Based Relays also require the following:
 - 1. A self-diagnostic failure feature that provides an alarm contact to be used by the customer to annunciate the condition.
 - 2. A reliable power source that is not dependent on the primary service voltage during the time the relay is sensing a fault.
 - 3. Multi-function, digital- and microprocessor-based relays with 3 phase and neutral over-current protection contained in a single enclosure are considered one protective device. A redundant relay with the same over-current protective characteristics and settings, with separate test switches, must be installed to meet PECO reliability requirements.
 - 4. The GIC must program and/or set all useable and desired functions of the relay and provide a certified test report to PECO. PECO reserves the right to conduct its own tests on the relays.



B. Synchronous Generator Protection

1. **Distribution System Protection – Continuous Parallel** – The following generator interconnection relays must provide three-phase sensing and be connected to monitor the PECO service voltage supplying the GIC’s facility. The interconnection relays must isolate the generator from the PECO system.

a. **Over-/Under-Frequency Relays (81 O/U) –**

1. Synchronous generators connected to a PECO distribution circuit, in parallel with other customer loads, shall have over-/under-frequency settings as follows

Frequency (Cycles)	Clearing Time (Seconds)
59.5	0.16
60.5	0.16

2. Synchronous generators rated over 1000 kW, connected to a PECO circuit with no other distribution load, will have an over/under-frequency settings as shown below. This requires the generator(s) to be capable of continued operation at frequencies at and above the 57.5 Hz setting. Exceptions may be specified at the time of installation.

Frequency (Cycles)	Clearing Time (Seconds)
57.5	5.0
60.5	0.16

- b. **Over-/Under-Voltage Relays (59 and 27)** – See Appendix I, General Requirements section A.2 (b) for requirements

c. **Ground Fault Protection**

1. **Relay 51G** – If the interconnection transformer has a grounded-Wye high-side connection.

Settings: Specified at time of installation

2. **Relay 59G (Zero-Sequence)** – If the interconnection transformer has a Delta high-side connection.

Settings: Specified at time of installation

- d. **Voltage-Controlled (Restrained) Over-Current Relays (51V)** – Required on each synchronous generator rated above 1,000 kW. The type, setting and calibration of these relays shall be the responsibility of the customer.

2. **Distribution System Protection – Momentary Parallel** – Upon notice to PECO, at an acceptable time, a generator may momentarily parallel with the PECO system to provide for a disturbance-free transfer of load to and from a generator for the purpose of testing, peak shaving, load curtailment or returning load to a PECO-supplied service. Interconnection requirements will be determined by the length of time the generation is paralleled with the PECO system

- a. **Instantaneous Parallel [< 10 cycles (0.167 seconds)]** – The generation interconnection relays, identified in the above sections of this appendix, are not required where the transfer system meets UL1008 and the following conditions apply:

- i. The Generator does not have to present a grounded-Wye source to the PECO system.



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- ii. The parallel and disconnecting operation must be automatic, instantaneous (switching time only) and less than 10 cycles (0.167 seconds) duration
- iii. A paralleled transfer must be blocked if the normal PECO source to the load is not within $\pm 10\%$ of nominal voltage.
- iv. The transfer scheme must be acceptable to PECO.
- v. The parallel operation must be monitored by a timing relay that will trip the generator's main breaker if the parallel lasts longer than 0.5 seconds. The tripping voltage must be from a reliable source, i.e., battery or a capacitor trip device.
- vi. The GIC may transfer load to and from generators rated less than 600 volts without providing notice to PECO.

b. Transitional Parallel (< 2 Minutes)

- i. The Generator does not have to present a grounded-Wye source to the PECO system. If the Generator does not present a grounded-Wye source, zero-sequence over-voltage relays (59G) must be installed to monitor the service voltage.
- ii. The parallel, generator loading and disconnecting operations, must be automatic. Parallel time must be kept to a minimum and never exceed two (2) minutes.
- iii. A paralleled transfer must be blocked if the normal PECO source to the load is not within $\pm 10\%$ of nominal voltage.
- iv. The transfer scheme must be acceptable to PECO.
- v. The parallel operation must be monitored by a timing relay that will trip the generator's main breaker if the parallel lasts longer than 2 minutes. The tripping voltage must be from a reliable source, i.e., battery or a capacitor trip device.
- vi. The GIC must receive permission from the PECO OCC before paralleling the generator with the PECO system.

C. Induction Generator Protection

Induction generators shall comply with the same Over/Under Voltage and Frequency requirements as synchronous generators as defined in IEEE 1547, and noted in the Synchronous Generator Protection section above.

D. Utility Interactive Inverters

Utility Interactive Inverters shall provide verification of manufacture to UL-1741 standard and meet the IEEE-1547 over/under voltage, frequency, and anti-islanding protection requirements.



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E. Acceptable Relay Types

PECO has accepted the following relays and recognizes that other relay types may be acceptable for use on the PECO system. If the GIC desires another relay type, it should submit the relay specifications and instruction books to PECO for review/acceptance. All such relays must meet the requirements noted in Section A (3) of this Appendix. Forward this information to the appropriate PECO New Business Services Customer Engineer.

Note: Relays listed with (*) require installation of an acceptable test switch.

1. Over-/Under-Voltage Relays: (59/27)

Relay Manufacturer	Relay Type
ABB	SV (Under-Voltage Only)
	SSVT
	CV (Under-Voltage Only)
	CVQ (Under-Voltage Only)
	ITE-59D (*) (Over-Voltage Only)
	ITE-27D (*) (Under-Voltage Only)
	ITE-47D (*) (Under-Voltage Only)
	ITE-27/59 (*)
	DPU-2000R
Beckwith	PRIDE (*) (Below 1000 kW
Basler	BE1-27/59
	BE1-951
General Electric	NGV, Multilin SR-750
	IAV (Under-Voltage Only)
	ICR (Under-Voltage Only)
	IFV (Under-Voltage Only)
Schweitzer	SEL-251
	SEL-311
	SEL-321
	SEL-351



2. Over-/Under-Frequency Relays: (81 o/u) – Some of these relays require timers to provide for adjustable time delays.

Relay Manufacturer	Relay Type
ABB	MDF
	KF (Under-Frequency Only)
	ITE-81 (*)
	DPU-2000R (*)
Beckwith	PRIDE (*) (Below 1000 kW)
Basler	BE1-81 (o/u)
	BE1-951
General Electric	SFF
Schweitzer	SEL-351

3. Over-Current Ground Relays: (51G)

Relay Manufacturer	Relay Type
ABB	DPU-2000R
	CO-8
	ITE-51Y (*)
Basler	BE1-951
General Electric	IFC-VI
	IAC-VI
	SFC
	Multilin SR-750
Schweitzer	SEL-251
	SEL-311
	SEL-321
	SEL-351

4. Timing (Associated with Under-Voltage Relays):

Relay Manufacturer	Relay Type
ABB	TD-5
Agastat	7000 Series
General Electric	SAM



5. Zero-Sequence Over-Voltage Relays: (59G)

Relay Manufacturer	Relay Type
ABB	ITE-59 (*)
	CV
	SV
	SSVT
	DPU-2000R
Basler	BE1-59
	BE1-951
General Electric	NGV
	IAV
	IFV
	Multilin SR-750
Schweitzer	SEL-311 (Definite Time Using Timer)
	SEL-321



Appendix II

Typical One-Line Diagrams

The following diagrams are included herein as references for typical installations where energy sources operate in parallel with services supplied by PECO's Distribution System:

Diagram A Services 600 Volts and Less – Synchronous & Induction Generators

Diagram B Services 600 Volts and Less – Utility Interactive Inverters

Diagram C Switch/Fuse Services Over 600 Volts – Synchronous & Induction Generators

Diagram D Switch/Fuse Services Over 600 Volts – Utility Interactive Inverters

Diagram E Services Over 600 Volts – Impedance Grounded Generators on 3p 4w Systems

Diagram F Services Over 600 Volts – Delta Utility Interactive Inverters on 3p 4w Systems

Diagram G Services Over 600 Volts – Impedance Grounded Generators on 3p 3w Systems

Diagram H Services Over 600 Volts – Delta Utility Interactive Inverters on 3p 3w Systems

Diagram X AC Schematic – Y Connected Inverter / Generator Interconnection to 3p 4w Solidly Grounded Service

Diagram Y AC Schematic – Delta Connected Inverter / Generator Interconnection to 3p 4w Solidly Grounded Service

Diagram Z AC Schematic – Impedance or Ungrounded Y Connected Inverter / Generator Interconnection to 3p 4w Solidly Grounded Service

Interconnection Diagram – Generator/Inverter Connection to 3 phase, 4 wire Solidly Grounded Service

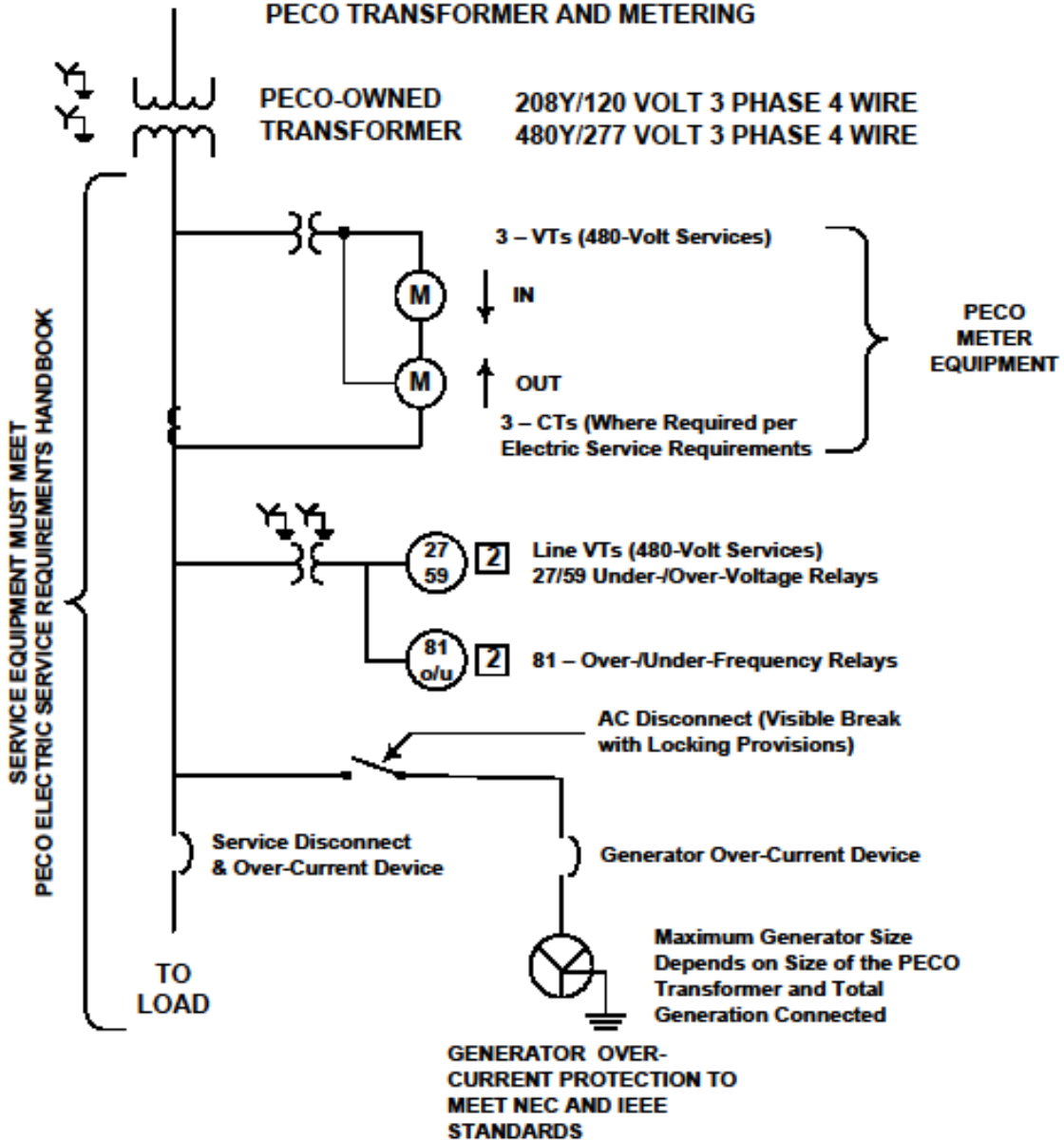


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DIAGRAM A
PECO SECONDARY 3-PHASE SERVICES
(600 VOLTS AND LESS)
(APPLIES TO SYNCHRONOUS & INDUCTION GENERATORS)

CUSTOMER OWNS, OPERATES AND MAINTAINS ALL EQUIPMENT EXCEPT PECO TRANSFORMER AND METERING



2 SETTINGS PER IEEE 1547 SPECIFICATION

NOTE: ALL GENERATION SOURCES TO BE CONFIGURED AS A SOLIDLY GROUNDED-WYE CAPABLE SUPPLYING CUSTOMER SINGLE-PHASE LOADS CONNECTED PHASE TO NEUTRAL. SEE AC SCHEMATIC FIGURES X, Y & Z.

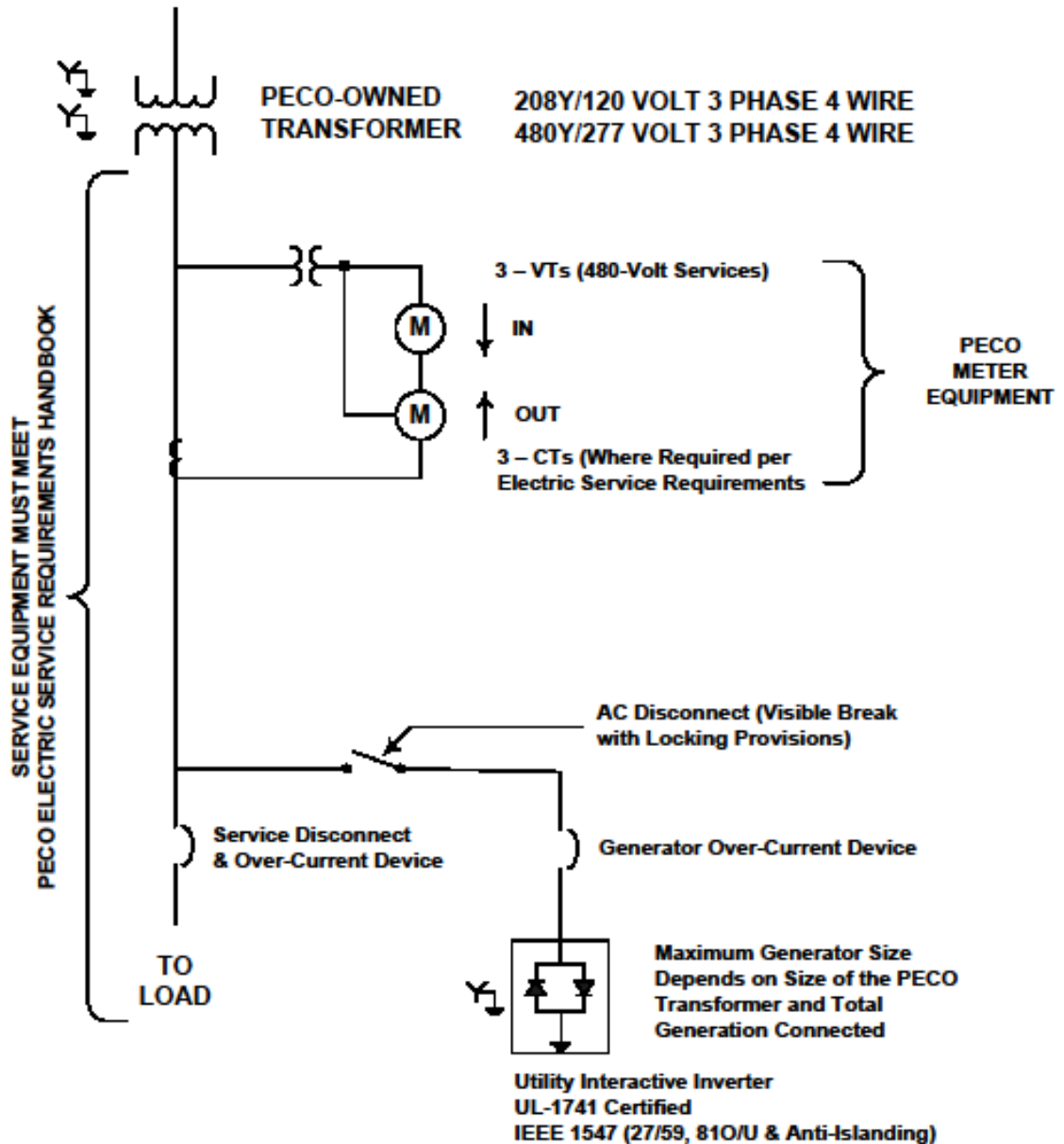


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DIAGRAM B
PECO SECONDARY 3-PHASE SERVICES
(600 VOLTS AND LESS)
(APPLIES TO UTILITY INTERACTIVE INVERTERS)

**CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO TRANSFORMER AND METERING**



NOTE: ALL GENERATION SOURCES TO BE CONFIGURED AS A SOLIDLY GROUNDED-WYE CAPABLE SUPPLYING CUSTOMER SINGLE-PHASE LOADS CONNECTED PHASE TO NEUTRAL. SEE AC SCHEMATIC FIGURES X, Y & Z.

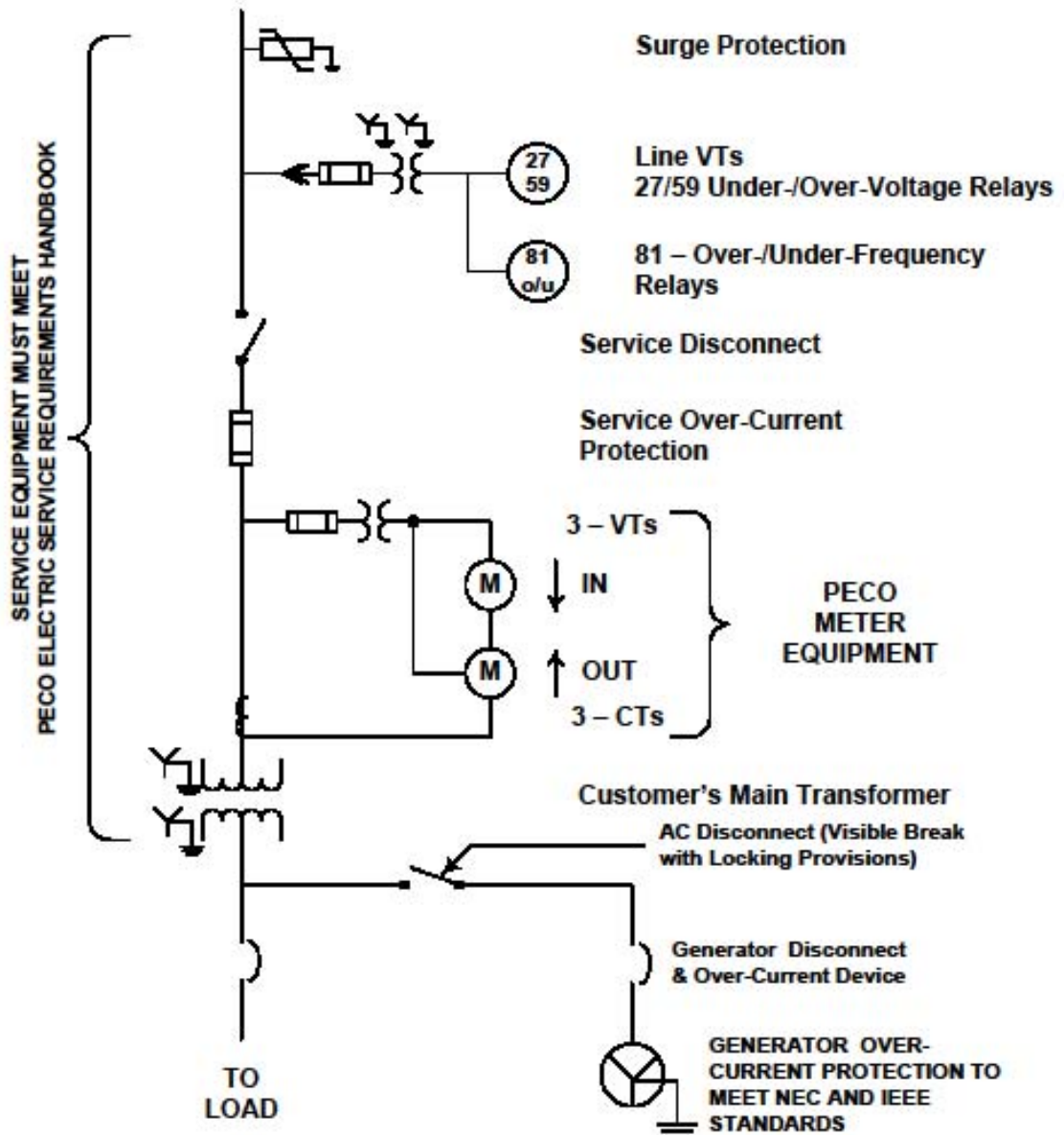


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DIAGRAM C
SWITCH & FUSE SERVICES OVER 600 VOLTS
(4,160, 13,200, 33,000)
THREE-PHASE FOUR-WIRE SYSTEM
(APPLIES TO SYNCHRONOUS & INDUCTION GENERATORS)

CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO METERING



NOTE: ALL GENERATION SOURCES TO BE CONFIGURED AS A SOLIDLY GROUNDED-WYE CAPABLE SUPPLYING CUSTOMER SINGLE-PHASE LOADS CONNECTED PHASE TO NEUTRAL. SEE AC SCHEMATIC FIGURES X, Y & Z.

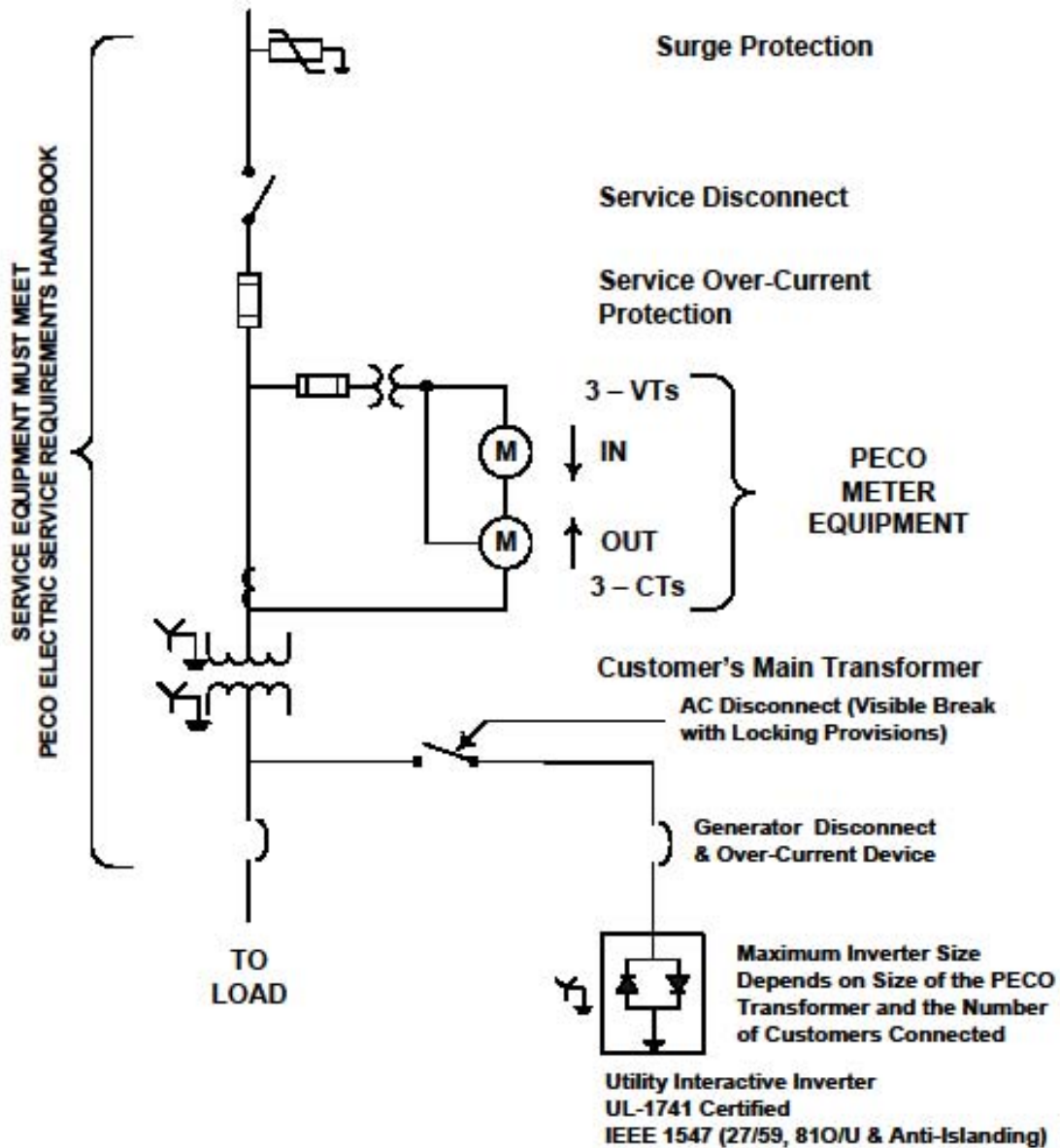


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DIAGRAM D
SWITCH & FUSE SERVICES OVER 600 VOLTS
(4,160, 13,200, 33,000)
THREE-PHASE FOUR-WIRE SYSTEM
(APPLIES TO UTILITY INTERACTIVE INVERTERS)

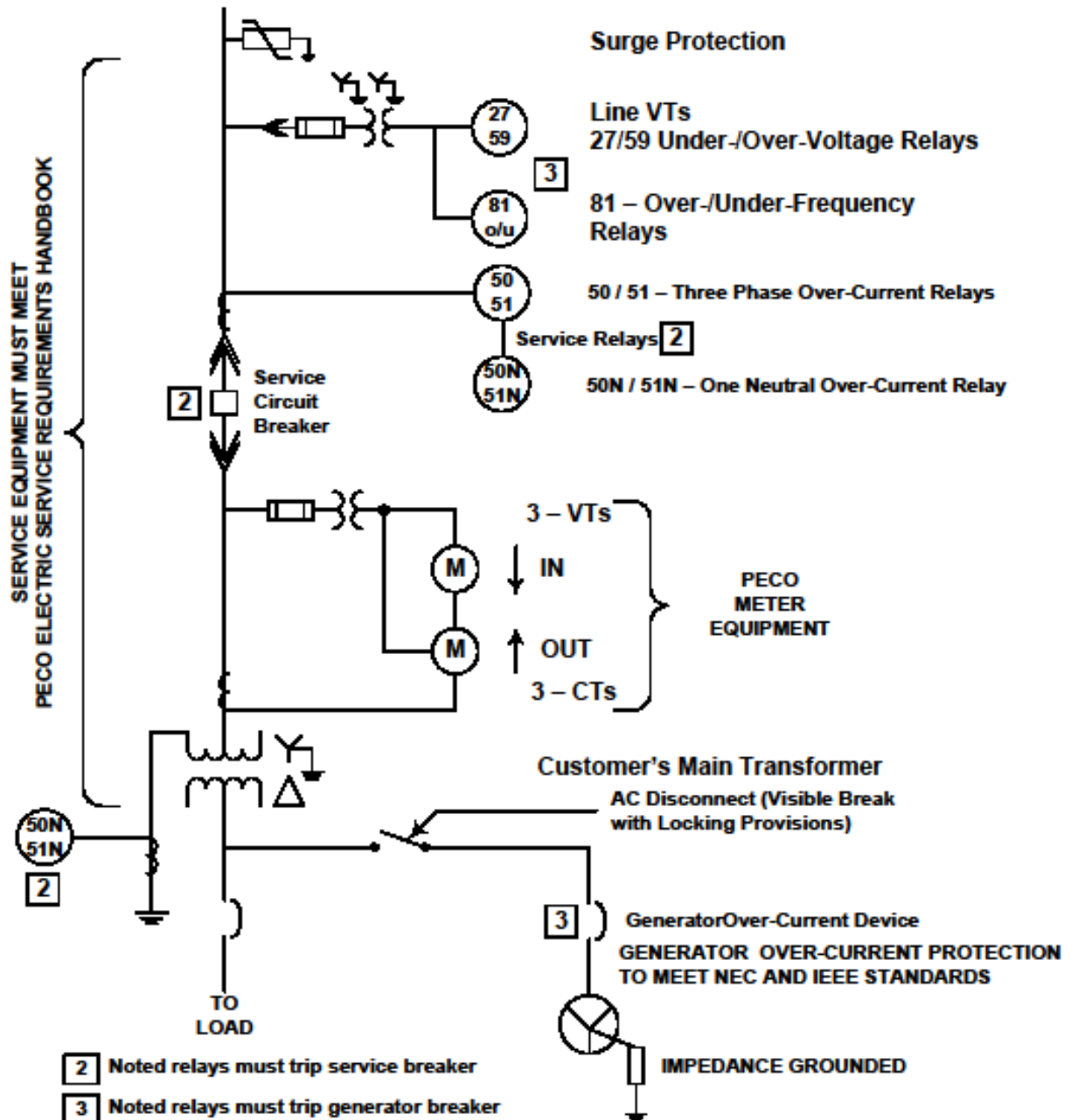
CUSTOMER OWNS, OPERATES AND MAINTAINS ALL EQUIPMENT EXCEPT PECO METERING



NOTE: ALL GENERATION SOURCES TO BE CONFIGURED AS A SOLIDLY GROUND-WYE CAPABLE SUPPLYING CUSTOMER SINGLE-PHASE LOADS CONNECTED PHASE TO NEUTRAL. SEE AC SCHEMATIC FIGURES X, Y & Z.

DIAGRAM E
BREAKER SERVICES OVER 600 VOLTS
(4,160, 13,200, 33,000)
THREE-PHASE FOUR-WIRE SYSTEM
(APPLIES TO SYNCHRONOUS & INDUCTION GENERATORS)

**CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO METERING**

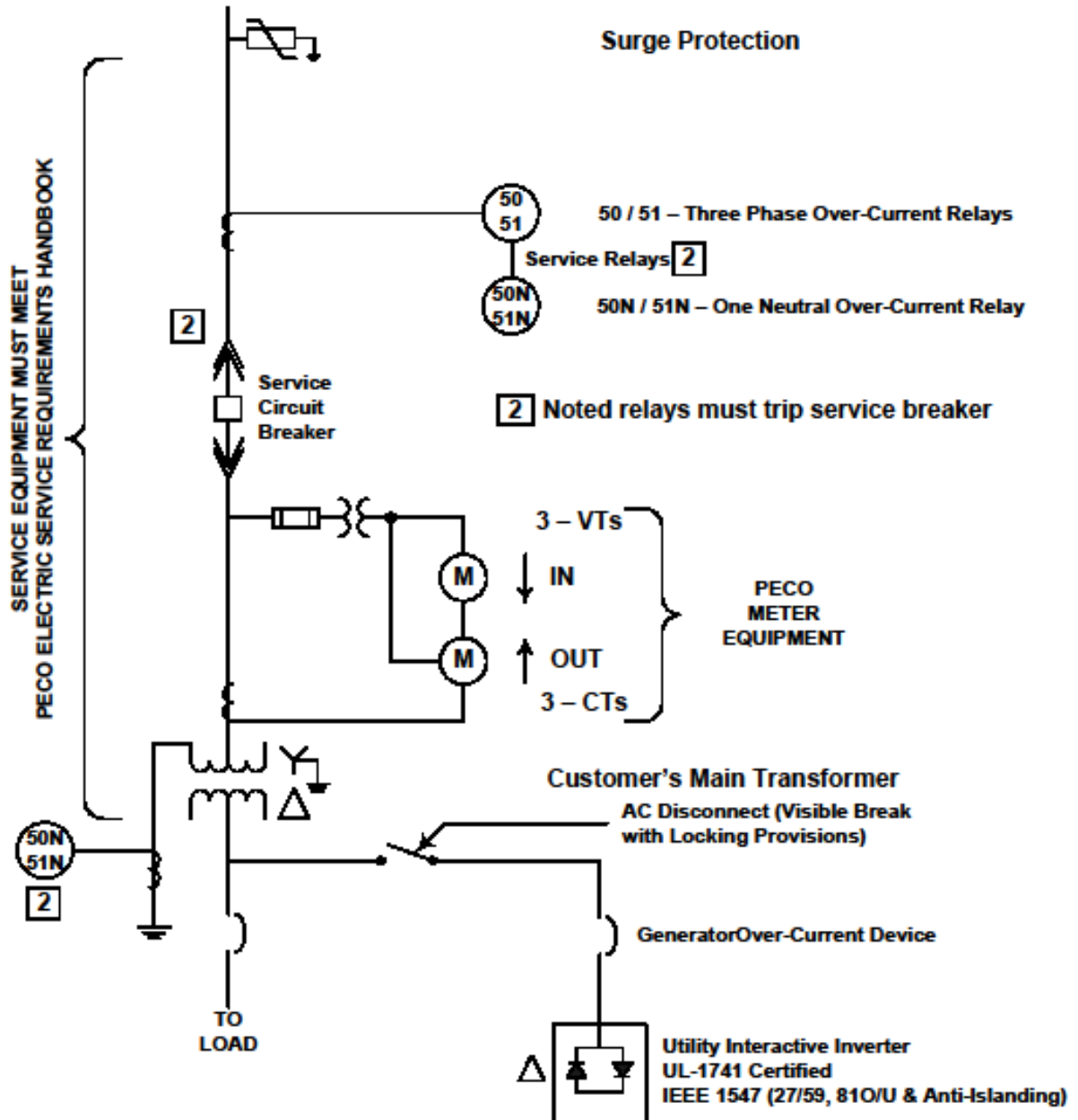


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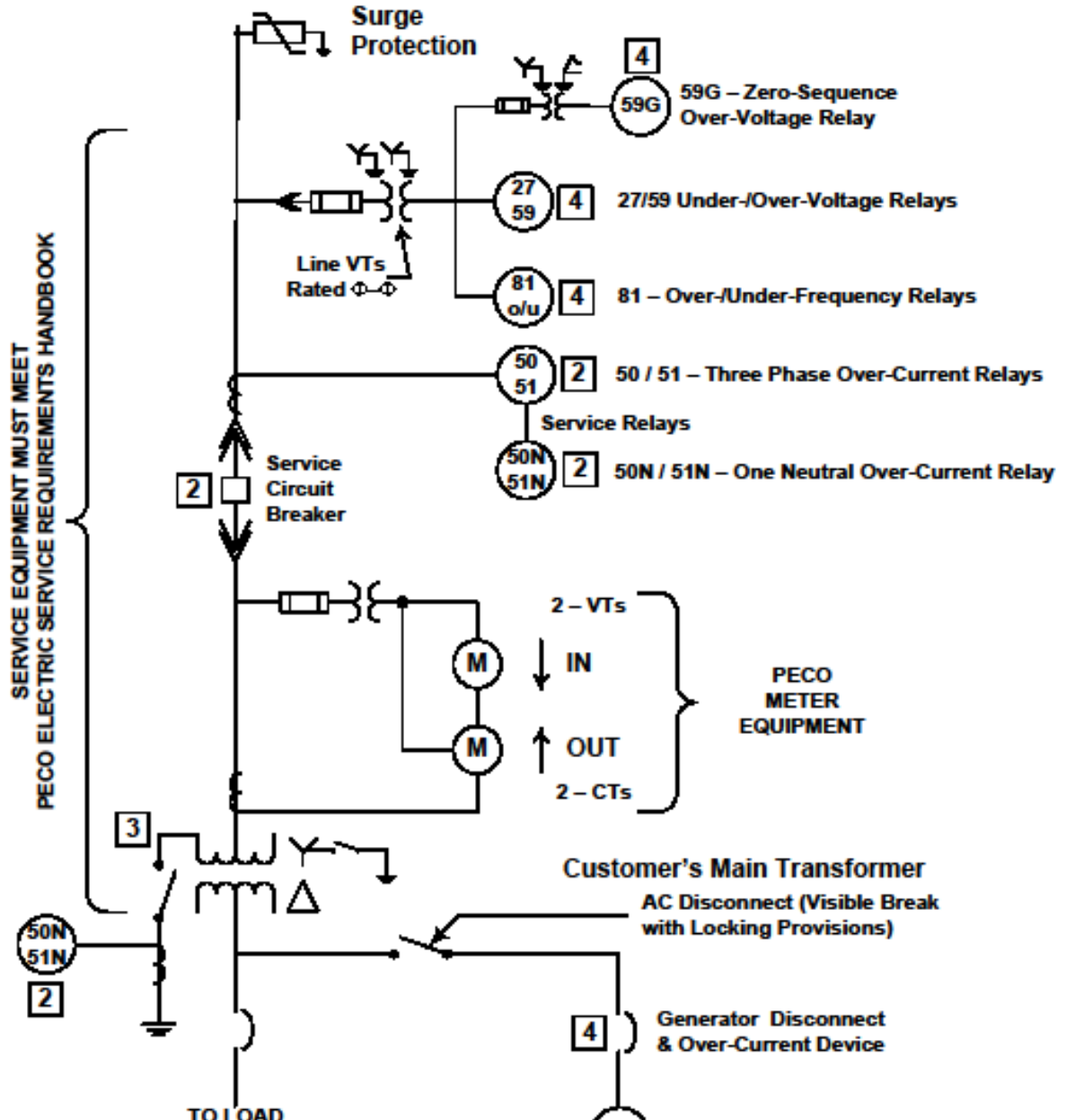
DIAGRAM F
BREAKER SERVICES OVER 600 VOLTS
(4,160, 13,200, 33,000)
THREE-PHASE FOUR-WIRE SYSTEM
(APPLIES TO UTILITY INTERACTIVE INVERTERS)

CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO METERING



**DIAGRAM G
 BREAKER SERVICES 13,200 VOLTS
 FROM RESISTOR-GROUNDED STATIONS
 THREE-PHASE THREE-WIRE SYSTEM
 (APPLIES TO SYNCHRONOUS & INDUCTION GENERATORS)**

CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO METERING

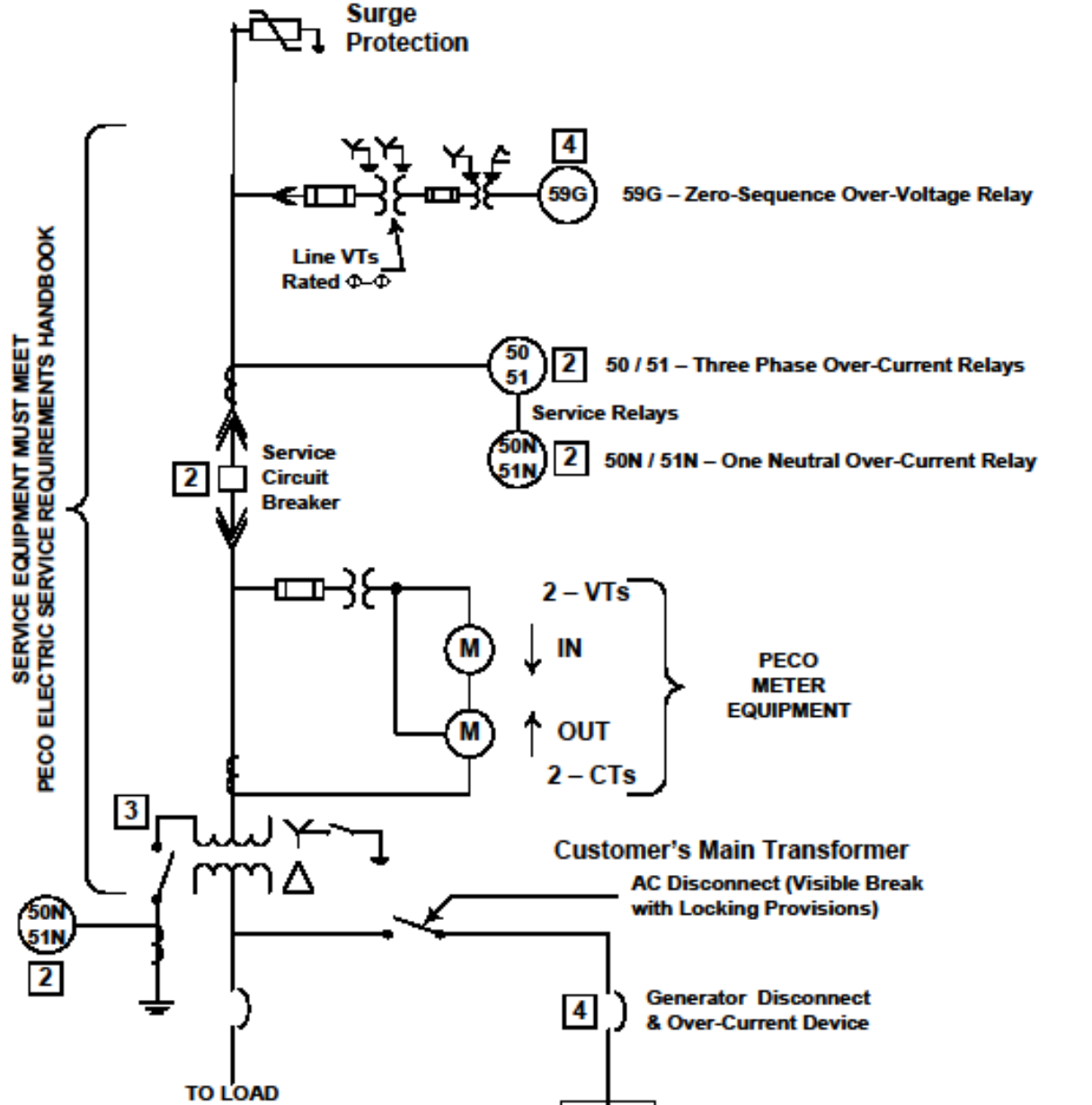


- 2** Noted relays must trip service breaker
- 3** Main transformer must have a grounded Wye primary winding with connection for a resistor or impedance and have provisions for future solid ground connection.
- 4** Noted relays must trip generator breaker

**GENERATOR OVER-CURRENT PROTECTION
 TO MEET NEC AND IEEE STANDARDS**

**DIAGRAM H
 BREAKER SERVICES 13,200 VOLTS
 FROM RESISTOR-GROUNDED STATIONS
 THREE-PHASE THREE-WIRE SYSTEM
 (APPLIES TO UTILITY INTERACTIVE INVERTERS)**

CUSTOMER OWNS, OPERATES AND
 MAINTAINS ALL EQUIPMENT EXCEPT
 PECO METERING



- 2** Noted relays must trip service breaker
- 3** Main transformer must have a grounded Wye primary winding with connection for a resistor or impedance and have provisions for future solid ground connection.
- 4** Noted relays must trip generator breaker

FIGURE X
AC SCHEMATIC – Y-CONNECTED INVERTER / GENERATOR INTERCONNECTION TO 3Φ 4 WIRE SOLIDLY GROUND SERVICE

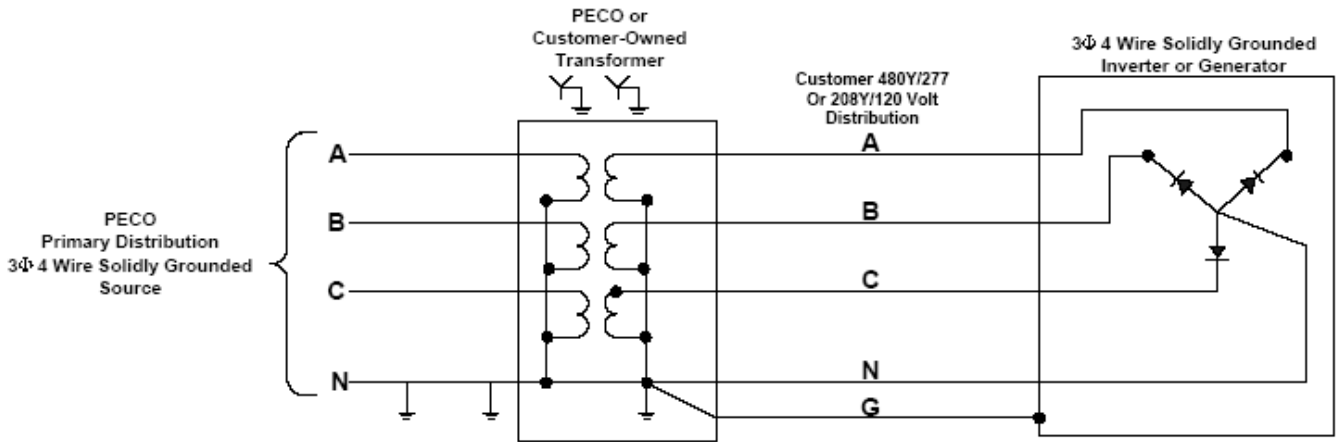


FIGURE Y
AC SCHEMATIC – DELTA-CONNECTED INVERTER / GENERATOR INTERCONNECTION TO 3Φ 4 WIRE
SOLIDLY GROUND SERVICE

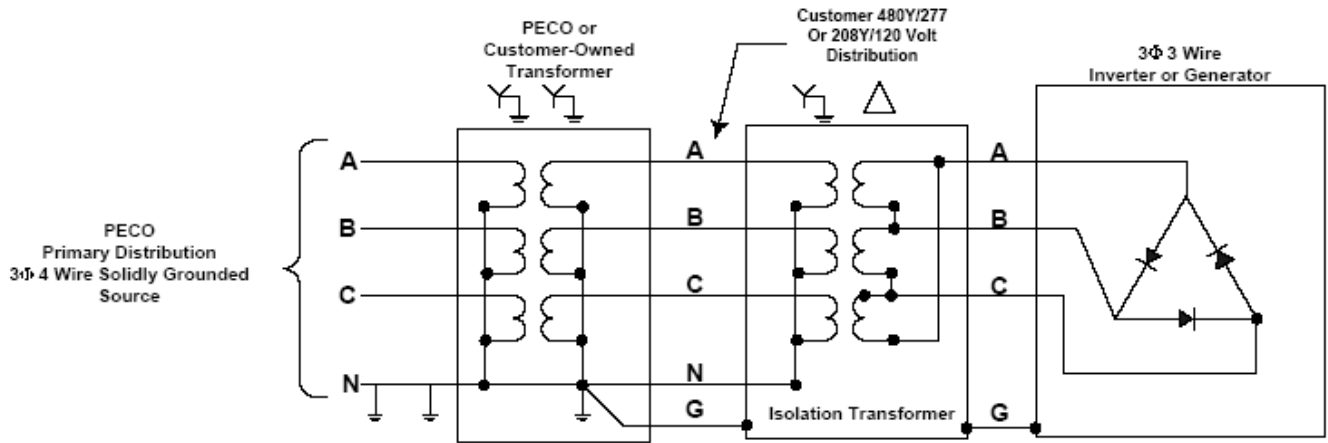
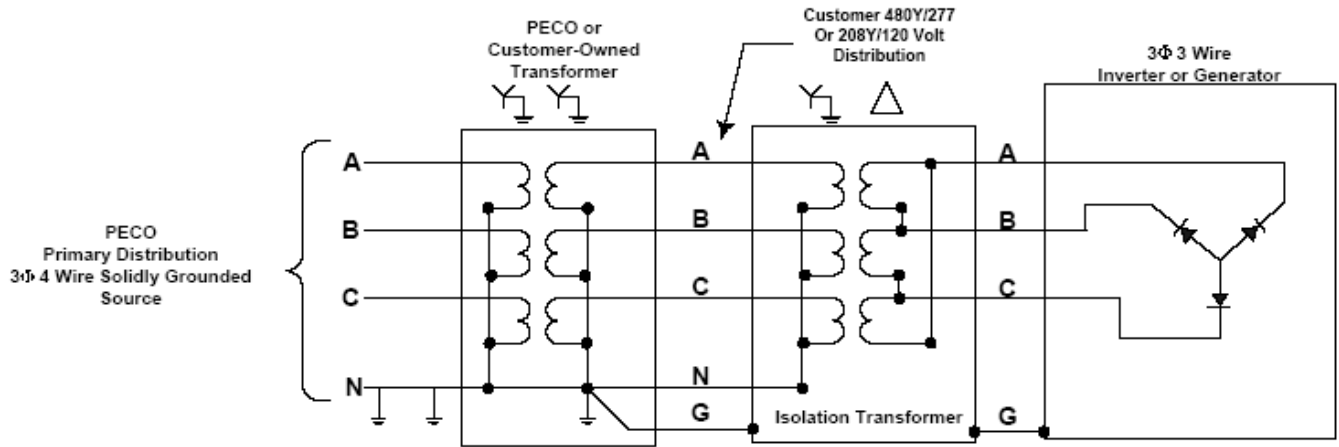


FIGURE Z
AC SCHEMATIC – IMPEDANCE OR UNGROUNDED Y CONNECTED INVERTER / GENERATOR
INTERCONNECTION TO 3Φ 4 WIRE SOLIDLY GROUNDED SERVICE



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