Alabama Power Company

Distributed Energy Resources

Technical Interconnection

Requirements Guidebook

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Systems less than or equal to (≤) 100kW

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This reduced table of contents shows only the sections of this guidebook typically applicable to systems less than or equal to (≤) 100kW in size for expediate review. If information concerning any portion of the design of the system in consideration is not found in these sections, please review the full guidebook for additional information.

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1 Purpose

The Alabama Power Company (herein after referred to as APC) Distributed Energy Resources Technical Interconnection Requirements Guidebook outlines the interconnection guidelines that should be met to install or modify a Distributed Energy Resource (herein after referred to as DER) intended to connect to and operate in parallel with the APC distribution system (herein after referred to as distribution system). These requirements apply to all sizes and types of DERs, including those that may not export to the distribution system. The requirements of this guidebook are intended to achieve the following:

a. Minimize the risk to the general public and APC personnel.
b. Minimize possible damage to the property of APC customers and the general public.
c. Minimize adverse operating conditions on the APC distribution system.
d. Ensure the power quality to other APC customers is not adversely affected.
e. Ensure the reliability of the APC distribution system is not adversely affected.

However, these guidelines are not comprehensive nor are all of these guidelines applicable to every situation. The personnel handling each interconnection situation must exercise his/her sound judgement under the particular facts at hand.

2 Scope

This guidebook is intended to provide requirements for interconnections to all distribution voltage classes including secondary and primary voltage up to and including 34.5kV. Interconnections above 34.5kV are considered transmission interconnections and are outside the scope of this guidebook. Transmission interconnections are controlled by APC's Open Access Transmission Tariff (OATT). For more information on transmission connected DERs, please refer to the OASIS system found at www.oasis.oati.com/SoCo .

This guidebook applies to customers connected to the APC Distribution system including secondary voltages and primary voltages up to and including 34.5kV. It provides the minimum intertie technical requirements for interconnection of customer owned DERs operated in parallel with the APC distribution system. These interconnections may be intended to serve as an alternate source of electrical power to all or part of the customer's load or may be intended to export all power generated onto APC's distribution system.

This guidebook only applies to DER intended to operate in parallel with the APC distribution system for longer than thirty (30) seconds. Systems not intended to operate in parallel for longer than thirty (30) seconds, such as Open Transition and momentary Closed Transition systems are addressed in the separate document entitled "*APC Standby Generator Interconnection Policy*".

This guidebook is supplemental in nature to the Southern Company Document entitled: "*Southern Company Distribution Interconnection Policy: Operation of Distributed Energy Resources (DER) in Parallel with the Distribution System Policy"* (hereinafter referred to as the SoCo IP). All requirements of the SoCo IP shall apply to all DERs unless expressly excepted or modified by this document. This guidebook provides clarifying information of requirements in the SoCo IP, additional information specific to APC, and requirements of APC in addition to the requirements of the SoCo IP. Requirements contained in the SoCo IP are not repeated in this document; therefore, both this document and the SoCo IP should be read in their entirety to gain a full understanding of the requirements and limitations of the DER.

This guidebook does not provide information regarding the protection of the DER or any requirements other than that of APC. The DER Owner is responsible for ensuring that DER design and installation meet the technical requirements of and comply with, as applicable, the National Electrical Code (NEC), the National Electrical Safety Code (NESC), Institute of Electrical and Electronic Engineers (IEEE), National Electrical Manufacturers Association (NEMA), American National Standards Institute (ANSI), National Fire Protection Association (NFPA), Underwriters Laboratories (UL), Federal Aviation Administration (FAA), Federal Communications Commission (FCC), other state/national codes, standards, local codes, and any jurisdictional requirements pertaining to electrical facility

design, construction, or safety. The DER owner is solely responsible for protecting the DER facility and equipment from the effects of power system disturbances that originate internal or external to the DER facility.

APC distribution feeders reclose after a trip operation to restore service to customers without checking for the absence of feeder voltage. Reclosing that occurs with the DER still connected to the distribution system may pose a severe risk to the DER. It is the sole responsibility of the DER owner to ensure the DER system is disconnected from the APC distribution system prior to reclosing by the APC distribution system.

While this document covers a wide variety of systems, many customers have unique system configurations and requirements, and no document can be an all-inclusive guide to integration of DER facilities. If any part of this document is unclear to the DER Owner, designer, or installer; APC Power Delivery Interconnections will clarify the intention of the requirements upon written request. APC's interconnection process requires the review and acceptance of the design by APC prior to installation. Said review is solely to ensure all of the requirements of APC are satisfied and APC design acceptance in no way may be interpreted to indicate the design meets any other applicable code or standard requirement as indicated above.

The DER owner is cautioned not to purchase equipment or start construction of the DER without the design being accepted by APC. The requirements of the SoCo IP and of this guidebook are to ensure the continued reliable and safe operation of the APC distribution system and the safety of APC personnel and the general public. Deviations from the requirements of the SoCo IP or this guidebook may only be made with the prior written consent of APC Power Delivery Interconnections. No exceptions will be made to accommodate an installation that fails to fully meet all requirements of the SoCo IP and this Guidebook that were made without prior written consent.

There are several appendices providing examples of the requirements within this document. There are a multitude of technically sound methods to meet various requirements of this document. The examples provided are not intended to imply the provided method of achieving the requirements are better than any other methods nor that any manufacturer mentioned within this document is preferred, recommended, or better than any other manufacturer. The examples provided are intended and for the sole purpose of providing a sense of the level of detail and layout of the documentation required.

3 Acronyms

AHJ	Authority Having Jurisdiction
APC	Alabama Power Company
ATM	Ahead of the meter
BTM	Behind the meter
CT	Current transformer
CTT	Closed Transition Transfer
DER	Distributed Energy Resource
EPS	Electric Power System
FEG	Full Export Generator
IBR	Inverter Based Resources
LEG	Limited Export Generator
LROV	Load Rejection Over Voltage
MID	Microgrid Interface Device
NEC	National Electrical code
NEG	Non-export Generator
OTT	Open Transition Transfer
PCC	Point of Common Coupling
PT	Potential transformer
POI	Point of Interconnection
RPA	Reference Point of Applicability

4 Definitions

AHJ: Authority having jurisdiction. The AHJ is an entity or individual that has the power to enforce or approve the requirements of a code, standard, or regulation as related to a project or site. The AHJ may be the appointed representative of the local city, municipality, county, state, or federal authority. The AHJ is typically the electrical inspector of the local municipality or city. If the installation is outside the jurisdiction of a municipal, city, state, or federal AJH; the homeowner becomes the defacto AHJ and has the responsibility to ensure the installation meets all applicable standards and codes.

ATM (Ahead of the meter): Ahead of the meter interconnections are those that connect directly to the APC owned distribution system for the purpose of exporting all generated power to the distribution system. Power produced by the generator cannot be consumed by the customer's load without passing through the utility revenue meter. There exists no customer load, except associated with the generator equipment and controls, which would use a part or all of the generated electricity. Disconnecting an ahead of the meter interconnection by means of a point of interconnection switch would not result in customer's load not associated with the generator experiencing a power outage nor adversely affect the customer's operation.

BTM (Behind the meter): Behind the meter interconnections are those that connect behind an existing customer's revenue meter for the purpose of providing all or a portion of the customer's electric power usage not associated with the generator. Power produced by the generator can be consumed by the customer's load without passing through the utility revenue meter. Disconnecting a behind the meter interconnection by means of a point of interconnection switch would result in other customer's load not associated with the generator experiencing a power outage and adversely affect the customer's operation.

Capable of exporting: For purposes of use in this policy, "capable of exporting" is defined as the total aggregate nameplate size unless exporting is actively limited by a control and/or protective scheme approved by the Company. Load is not an acceptable method of limiting capability to export.

Closed Transition Transfer (CTT): All modes of power source transfer in which the customer owned generator is connected before the electric utility power source is disconnected or vice versa; allowing both sources to momentarily operate in parallel to prevent power interruption to the customer's load. This system is typically referred to as "make-before-break". It requires the two sources to be synchronized prior to closing the paralleling device. The maximum time the power sources can operate in parallel is thirty (30) seconds. If the power sources operate in parallel for longer than thirty (30) seconds, it shall be considered a parallel operation and must meet all requirements of this document. Requirements for CTT can be found in the document entitled "APC Standby Generator Interconnection Policy."

Controller: See Microgrid Interface Device

Customer-owned Generation: Any source of electric energy that is either owned, rented or contracted by the customer that can supply power to the customer's load and interacts in any way with APC distribution system. Customer-owned generation may be operated as Full-Export Generation (FEG), Limited-Export Generation (LEG), or Non-Export Generation (NEG).

DER (or DER System): A source of electric power that is connected to Company's Distribution System either directly or indirectly. DER sources include, but are not limited to, energy storage systems, fuel cells, solar photovoltaic (PV), biomass, natural gas, wind, etc. DER energy conversion technology includes inverters, induction generators, and synchronous generators, including reciprocating or turbine-driven generators. DER system includes all parts of the DER including but not limited to the solar panel, wind turbine, inverter, relay, disconnect, energy management system, and controls.

Electric Utility Power Source: Source of electric energy supplied by APC for purpose of this document, this source is considered the normal power source.

Full-Export Generation (FEG): Any source of electric energy that is either owned, rented, or contracted by the customer that operates in parallel with the APC distribution system and may export to the APC distribution system the maximum available generating capacity.

Intentional Island: A portion of the electrical system that is intentionally disconnected from the APC distribution system for the purpose of powering the islanded portion from a DER system. An electrical island contains all of the following: (1) one or more DER, (2) electrical load, (3) ability to disconnect from and reconnect to APC system, and (4) is normally provided power by the APC system. The islanded portion is designed to operate disconnected from the APC system without adverse effect to the safety of APC employees or the general public or damage to the APC system, generator owner's equipment, or equipment of other APC customers.

Intertie: An interconnection between the APC electric utility power source and the DER owner's generation for the purpose of this document.

Limited-Export Generation (LEG): Any source of electric energy that is either owned, rented, or contracted by the customer that operates in parallel with the APC distribution system but the maximum export to the APC distribution system is limited to some amount less than the maximum available generating nameplate capacity.

Microgrid: See Intentional Island.

Microgrid Interface Device (MID): A MID is a device that controls the flow of real power between the distribution system and the distributed generation sources. It can disconnect the Customer's DER from the distribution system to form an intentional island using distributed energy resources connected to the system such as solar, battery, and/or synchronous generator to provide power to the backed-up load. It also can automatically synchronize and reconnect to the distribution system.

NEC: National Electrical Code, or NFPA 70, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.

Network Distribution System: An electrical distribution system that, excluding DER, has more than one path of power flow to the load.

Non-Export Generation (NEG): Any source of electric energy that is either owned, rented, or contracted by the customer that operates in a continuous paralleling scheme but is prevented from exporting to the APC distribution system. NEG is considered a type of Limited-Export Generation (LEG).

POI (Point of Interconnection): The point at which the customer's generator system connects to the existing electrical system of the customer or APC. This may or may not be the same location as the PCC.

PCC (Point of Common Coupling): The point at which the power produced by the customer's generator flows from the customer's system into the APC system. This may or may not be the same location as the POI.

Radial Distribution System: An electrical distribution system that, excluding DER, has only one path of power flow from the source to the load.

Readily Accessible: Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools, to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth. Access shall not be impeded by obstacles such as hedges or shrubs. A minimum working area of 36" in width, 60" in depth, and 72" in height shall be maintained directly in front of the communication cabinet and a clear path measuring a minimum of 30" in width and 72" in height for ingress and egress shall be maintained at all times.

(RPA) Reference Point of Applicability: The location where the interconnection and interoperability performance requirements of IEEE1547-2018 apply. Unless otherwise specified, this will be the location of the PCC.

Single Line Diagram (SLD): A SLD as defined by IEEE315 is a diagram which graphically shows, by means of single lines and standard symbols, the course of an electric circuit or system of circuits and component devices.

Synchronization: The act of verifying the voltage magnitude, phase angle, and frequency of the two alternating current sources are within allowable limits prior to paralleling the two sources.

Standby Generator: A reserve source of electric energy that provides electric power within a specified time (typically 60 seconds or less) to some or all of customer's load in the event of an interruption of the electric utility power source.

Unintentional Island: A portion of the electrical system that is disconnected from the APC distribution system and unintentionally provided power by a DER system. This is undesirable and may result in an unsafe operating condition or may result in damage to the APC system, generator owner's equipment, or equipment of other APC customers.

Utility-Interactive: Can only generate power while paralleled with a healthy utility power source.

Utility Grade Relay: A protective relay with required protection functions that meets the following:

- Meets IEEE C37.90
- Utilizes voltage and current on all phases for protection purposes
- Contains fail safe trip contact meaning that if voltage is lost to the relay, a trip signal will be sent to all devices controlled by the relay
- Provides human-machine interface (HMI) to monitor in real time 3 phase amps, 3 phase voltage, and total 3 phase real, reactive, and apparent power
- Trip targets for each trip function to indicate cause of trip
- Records pickup, dropout, and timeout of all utilized protective functions in sequence of events log
- Records waveform data from trip events that includes cause of trip. Data must include at minimum: date, time, and function that caused the trip.

- Event reports and logs must be retained for a period of 30 days
- Features the following protective functions:
  - Reverse power protection element (32)
  - Over/under voltage elements (27 & 59)
  - Over/under frequency elements (81)
  - Directional overcurrent (67)

5 Interconnection Application

5.1. Application process

See the separate document titled "Alabama Power DER Interconnection Process" for details on the application process and associated costs to interconnect DER with the APC distribution system.

5.2. Tiers

Interconnection applications are divided into three (3) Tiers based on total aggregate nameplate size of the DER energy conversion device(s).

5.2.1. Tier I: less than or equal to 25kW (≤ 25kW)
5.2.2. Tier II: Greater than 25kW (> 25kW) but less or equal to 100kW (≤ 100kW)
5.2.3. Tier III: Greater than 100kW (> 100kW)

5.3. Technical application requirements

This section details the information required to be provided as part of the application packet to enable the completion of a technical review to ensure the installation will not adversely affect the safety or reliability of the APC distribution system.

The following is the minimum technical information to be provided with the interconnection application. More details of each requirement are provided below.

1) Single line diagram (Section 5.3.1)
2) Site plan (Section 5.3.2)
3) Equipment specification (Section 5.3.3)
4) Labeling (Section 5.3.4)
5) Picture of existing facilities (Section 5.3.5)

5.3.1. Single line diagram

A single-line diagram (SLD) shall be provided depicting the graphical layout of the circuit design using standard electrical symbology. It shall include all major system equipment and how each piece of system equipment is electrically connected to each other, to the DER owner's existing electrical system, and to the APC system. The single line diagram shall include the below requirements that are applicable to the system. Some systems may not require all the information below.

a. Customer name
b. Installation address
c. Quantity of inverters, nameplate capacity of each inverter, total inverter kW AC nameplate capacity
d. Quantity of solar panels, nameplate capacity of each solar panel, total kW DC PV system capacity
e. Quantity of batteries, total kWh rating of battery system, maximum charge and discharge rate of battery system (if applicable)
f. Indicate which equipment is existing and which equipment is new
g. Manufacturer and model number of all major equipment to be installed (including, but not limited to, solar panels, inverters, AC disconnects, batteries, and controllers)

h. Customer owned transformer size(s), voltages, impedances, and winding configurations (if applicable)
i. AC Disconnect(s) must state all of the following:
    i. Either fused or not fused. If fused, include fuse size that will be utilized.
    ii. Is lockable in the open position.
    iii. Has visible load break (may be stated as visible blades).
    iv. The mounting location in reference to the utility revenue meter
        (1) If the AC disconnect is within 5' AND line of sight of the utility revenue meter, this must be stated.
        (2) If the AC disconnect is not within 5' AND line of sight of the utility revenue meter, additional labeling is required. See section 6.2 for more details.
    v. For more detailed information for the requirements of the AC disconnect, see section 6.1.
j. Point of interconnection (POI) indicating where the DER system will connect to the existing electrical equipment, the conductor size, and the method of connection (breaker lugs, insulation piercing tap, additional weather head, pad-mounted transformer secondary bushing, etc.). For more details on the available POI options, see section 6.3.
k. Microgrid controller (if applicable)
    i. For more detailed information of the requirements of a microgrid controller, see section 6.4.
    ii. If a system controller is utilized, an emergency stop is required to be installed for the controller that, when engaged, will cause the controller to cease to energize the backed-up load. This switch may have various names from different manufacturer such as e-stop, remote disable switch, rapid shut down switch, etc.
    iii. The emergency stop is required to be physically located adjacent to the generation AC disconnect.
    iv. The existence and physical mounting location of the emergency stop is required to be shown on the single line diagram.
l. While a computer generated single line diagram is preferred, for Tier I systems an easily legibly hand drawn single line diagram is acceptable. Computer generated is required for Tier II or Tier III systems.
m. System designs of greater than (>) 100kW must be stamped by a licensed professional engineer registered in the State of Alabama
n. CT, PT, and relaying information (if applicable, typically for systems over 100kW)
o. Examples of single line diagrams for various design configurations which show the minimum level of detail are provided in Appendix 1. These examples are not all inclusive. The system design may be different than those presented and may be in a different style or format. These are intended as examples only to aid the Customer's understanding of the required information. They do not address any protection necessary for the DER owner's equipment.

5.3.2. Site plan

A site plan shall be provided that shows an aerial view of the structure or location of the system installation and denotes, at minimum, the location of the utility revenue meter, main service panel, generation system AC disconnect, and controller emergency stop (if applicable).

While an aerial photograph is preferred, such as one that can be obtained from Google Earth, if an aerial photograph is unavailable, an easily legible hand drawn or computer-generated depiction is acceptable.

Examples of acceptable site plans are shown in Appendix 2. These examples are not all inclusive. The site plan may be different than those presented and may be in a different style or format. These are intended as examples only to aid you understanding of the required information.

5.3.3. Equipment specifications

Manufacturer specification (data) sheets for all major equipment are required to be provided. Major equipment includes, but is not limited to, solar panels, inverter(s), AC disconnect, batteries, and microgrid interface devices (controllers). This section defines minimum information that should be provided by the manufacturer specification sheet for the common major equipment.

a. Solar panel
    i. The manufacturer specification sheet is required to indicate the nameplate DC power rating.
b. Inverter
    i. See section 6.8 for detailed inverter requirements.
    ii. The manufacturer specification sheet is required to indicate the compliance certification, the continuous rated AC power output, AC output voltage, the number of phases [whether single phase or three phase], and the output frequency.
c. Microgrid Interface Device (MID)
    i. The manufacturer specification sheet is required to indicate the compliance certification, the continuous rated AC power output, AC output voltage, the number of phases [whether single phase or three phase], and the output frequency.
    ii. If the MID is not familiar to APC, an Authorization to Mark letter of certification may be required to be provided which can be obtained from the manufacturer.
d. AC disconnect
    i. The manufacturer specification sheet is required to indicate rated voltage, rated ampacity, and rated for outdoor installation.
    ii. Copies of information from the manufacturer website may be provided if a specification sheet cannot be obtained.
e. Battery
    i. The manufacturer specification sheet is required to indicate the continuous rated charge and discharge rate in kW or amps, output voltage, and total energy storage in kWh.

5.3.4. Labeling

Specific labeling is required by the NEC to be located throughout the DER installation. It is the responsibility of the owner/installer to ensure all proper labeling is installed and maintained to meet the requirement of the NEC and the local AHJ.

APC does not inspect labeling to ensure code compliance. APC may require and inspect specific labeling that affects the safety of our employees. APC required labeling is to be depicted in picture form on the application to ensure the installation meets the minimum APC labeling requirements. For detailed information of the APC minimum required labeling, see section 6.2.

Examples of labeling showing the minimum level of detail are provided in Appendix 4. These examples are not all inclusive. The system design may be different than those presented and may be in a different style or format. These are intended as examples only to aid in understanding the required information.

5.3.5. Photograph of existing equipment

A photograph of the existing utility revenue meter showing an area of 10’ on all sides of the meter, and a picture of the main service panel including an area of 10’ on all sides of the main service panel if it does not appear in the photograph of the utility revenue meter.

Examples of pictures showing the minimum level of detail are provided in Appendix 5. These examples are not all inclusive. The system design may be different than those presented and may be in a different style or format. These are intended as examples only to aid in understanding the required information.

6 Technical Design Requirements

This section provides the detailed technical requirements the system must meet for approval to operate in parallel with the APC distribution system.

6.1. AC Disconnect

The purpose of the AC disconnect is to provide a means for APC personnel to isolate the DER owner's DER system from the APC distribution system as needed for the safety of APC personnel while performing their work. This would typically be in the event of APC equipment failure such as the transformer, secondary, or service conductors providing electrical service to the Customer. It may also be used isolate the DER owner equipment from the utility distribution system in the event the DER were to cause adverse conditions on the APC distribution system or if the DER owner no longer wishes to contract with APC to operate the DER system in parallel with the APC distribution system. Therefore, it is recommended that the AC disconnect does not separate the customer's load from the APC system so that in the event of DER system failure the customer's load can be powered by the APC system; however, this is not a requirement. An AC disconnect that separates the customer's load from the APC system along with the DER system is acceptable.

The lack of an AC disconnect may delay the repair of APC equipment and extend electrical utility outage experienced by the Customer or may result in the total disconnection of electrical service to the Customer to isolate the DER owner's equipment from the APC's distribution system if required.

All DER systems shall have an AC disconnect that meets all requirements below.

> *Exception*: A device that is designed and produced by the manufacturer to plug into a standard 120V outlet which is protected by the facility's overcurrent protection will not require a separate AC disconnect as long as a main disconnect or circuit breaker is external, within 5' of the utility revenue meter, and readily accessible to APC personnel.

6.1.1. Appropriately rated for ampacity and voltage of the DER system and for installation outdoors.

6.1.2. Manually operable
- a. Disconnect switch must be operable by the throw of the hand at the device and not require operation from a remote device. Operation should not require the use of any tools to access the operator handle. Disconnect switch shall not be locked in the closed position or utilize any method to restrict the operation of the switch from the closed to the open position.

6.1.3. Visible break
- a. Disconnect switch must have a visible break so that when the switch is open the APC personnel can see the open point. Visible break should be visible by only opening the outer lid and not require removal of any internal covers. A standard breaker in a breaker panel does not meet this requirement since the operating blades cannot be visually verified to be in the open position.

6.1.4. Lockable
- a. Disconnect shall be lockable in the open position using a 3/8" padlock shank.
- b. A standard breaker in a breaker panel does not meet this requirement since it cannot be individually locked in the open position. Opening the breaker and locking the breaker panel closed would prevent the customer from accessing other breakers.

6.1.5. Readily accessible
- a. The disconnect shall be located such that it is readily accessible to APC personnel at all times 24 hours a day, 7 days a week, 365 days a year without exception. Readily accessible is defined, in APC's sole discretion, as capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools, to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth. Access shall not be impeded by obstacles such as hedges or shrubs. A minimum working area of 36" in width, 60" in depth, and 72" in height shall be maintained directly in front of the disconnect and a clear path measuring a minimum of 30" in width and 72" in height for ingress and egress shall be maintained at all times.

i. Exception: For systems larger than 1MW, a draw out circuit breaker may be used if desired and it may be located inside a building if ALL of the following conditions are met:
   (1) The utility transformer provides electrical service to only the Customer installing the DER and, in the sole opinion of APC, it is reasonably not expected to serve any other customer in the future
   (2) The building has one (1) phone number that is monitored 24/7/365 by maintenance personnel, or personnel that can reach maintenance personnel in a reasonable amount of time
      (a) This means the number cannot change. The number will be required in the section defining labeling requirements to be printed on a permeant placard affixed to the meter socket.
   (3) Said maintenance personnel will be willing and able to respond 24/7/365 to meet APC personnel onsite and have the knowledge and ability to rack out the circuit breaker and render it inoperable at the request of the APC
   (4) APC provides written approval of deviation from the readily accessible disconnect prior to installation.

ii. By opting to utilize this method, the Customer acknowledges that the inability of APC personnel to contact building maintenance personnel or the inability or delay of maintenance personnel to open and render breaker inoperable WILL result in delay to the repair of APC equipment and WILL extend any electrical utility outage experienced by the Customer if APC personnel cannot safely repair equipment without opening the breaker. The Customer also acknowledges that in the event the DER is causing adverse effects to the APC system and must be disconnected; the inability of APC personnel to contact building maintenance personnel or the inability or delay of maintenance personnel to open and render breaker inoperable in a timeframe acceptable to APC may result in disconnection of electrical service without advance notice to protect the reliability of the APC system and the safety of APC personnel and the general public. APC expressly disclaims any liability for such a situation.

6.1.6. Fused or not fused

a. Whether the disconnect is to be fused or not fused shall be indicated on the single line and if fused the size of the fuse shall be indicated.

6.1.7. Isolate entire DER system from distribution system

a. Must isolate entire DER system, including Microgrid Interface Device (MID, a.k.a. controller), from the distribution system when opened.
   i. When a MID is installed, this location of the disconnect will also cause the backed-up load panel to be isolated from the distribution system when opened resulting in no access to APC distribution system power in the case of a malfunctioning controller. If desired, this can be remedied with the use of a UL98 certified double throw switch acting as a bypass switch, in addition to the required AC disconnect, thus allowing the load to be energized from the distribution system when the control handle is in position 1, the microgrid controller when the control handle is in position 2, and disconnected from both sources when in the center (off) position. See Appendix 1, example 5.

6.1.8. Be located within 5’ and line of sight of the utility revenue meter **OR** have labeling as required by section 6.2.2 of the labeling requirements section.

6.1.9. All of the above information must be indicated on the single line diagram.

6.2. Labeling

The National Electrical Code provides information on all required labeling of the DER owner’s system required to meet code. The DER owner shall install and maintain all labels required by the current National Electrical Code (NEC) and Authority Having Jurisdiction (AHJ). The labeling required in this section is the minimum labeling required by the APC for the safety of APC employees.

All labeling and adhesive required by APC shall meet the requirements of NEC 110.21(B) which generally requires that they shall be of sufficient durability to withstand the environment involved for the expected life of the equipment referenced and warn of the hazards using effective words, colors, symbols, or any combination thereof.

Handwritten labels or labels printed from a label maker machine do not meet this requirement.

All labeling required by APC shall be included in the application packet submitted to APC for review. It should be provided in picture form and include proposed wording, coloring, and indication of placement. See examples provided in Appendix 4. This information may be on the single line diagram, site plan, or a standalone document.

See Appendix 4 for examples of all labels required by this section.

6.2.1. Required on all systems
   a. All disconnect devices required in 6.1 shall display a permanent label indicating that it is a generation AC disconnect device. The AC disconnect shall be labeled at minimum "GENERATION AC DISCONNECT".
   b. It is preferred that the source of generation the disconnect controls be identified (i.e. PV, Photovoltaic, Solar, Battery, wind, etc.) in which case the label would read "PV AC DISCONNECT", "PHOTOVOLTAIC AC DISCONNECT", "SOLAR AC DISCONNECT", "BATTERY AC DISCONNECT", "WIND AC DISCONNECT", etc.

6.2.2. Required only if the AC disconnect will be located more than five feet (5') from **OR** not within line of sight of the utility revenue meter
   a. A permanent placard shall be affixed to the meter socket with permanent adhesive providing the number of generation disconnects and the location of all generation AC disconnects.
   b. The placard shall be red UV resistant laminated plastic with computer engraved white letters and be legible from a minimum of 5'.
   c. The required placard may be affixed to the meter socket with adhesive only. The meter socket shall not be modified in any way at any time during installation including, but not limited to, the installation of screws or drilling of holes. If the placard is too large to be placed on the meter socket, it may be affixed in plain view within 3' of the meter socket.

6.2.3. Required only if more than one generation system disconnecting means exist
   a. The location of all disconnects shall be on the placard affixed to or near the meter socket and the label of each disconnect shall show the number of total disconnects and the location of all other disconnects as required by the NEC.

6.3. Point of Interconnection (POI) options

6.3.1. Options for systems less than or equal to (≤) 100kW and connected behind the meter at less than (<) 600 volts
   a. Breaker lugs of electrical panel; either main or sub
      i. DER is connected to the low side lugs of a circuit breaker in an electrical panel of the existing building electrical system.
      i. The circuit breaker provides overcurrent protection preventing a fault in the customer's electrical system to be carried by the APC system; therefore, no additional overcurrent protection is required.
   b. Line side tap
      ii. DER is connected to the existing electrical system by "tapping into" or "splicing onto" the existing wiring electrically before (or ahead of) any fuses or circuit breakers.
      iii. In this configuration, the existing overcurrent protection of the building wiring system will not isolate a fault in the DER system. APC's system is not designed nor intended to be relied upon to isolate a fault in the DER owner's system; therefore, additional overcurrent protection is required immediately adjacent to the location of the line side tap. Failure to provide this protection could result in a fire or other damage to the customer's facility in the event of a fault. The type and size of the overcurrent protection must be indicated on the single line diagram.

iv. The disconnect required in 6.1 may be fused to meet this requirement provided it is located immediately adjacent to the location of the line side tap.

v. Line side tap must be made in the customer's electrical panel. No modifications, including the installation of a line side tap, may be made in the utility revenue meter socket.

6.3.2. Additional options for systems greater than (>) 100kW and connected behind the meter at less than (<) 600 volts

a. Service riser

i. A new service riser may be installed on the wall of the building within 3' of the existing electrical service riser. This service riser must meet all the requirements of a new service riser provided in the APC documents entitled "*Residential Electric Service and Meter Installation Handbook"* or "Commercial *Electric Service and Meter Installation Handbook".*

ii. Special attention should be given to metering for this installation.

(1) This option is only available if the customer's electrical consumption is measured utilizing CTs located at the existing service entrance. This option cannot be utilized if the customer's electrical consumption is metered utilizing a self-contained meter socket (typical for 200A, 400A, and 600A).

iii. Customer would be responsible for installing the new service riser leaving sufficient conductor from the weather head to reach the connection point as determined by APC. APC would be responsible for making connections of the customer's conductors to the APC's service drop.

b. Secondary terminals of pad-mounted transformer

i. This option is only available if ALL the following conditions are met:

(1) The utility transformer only provides electric service to the customer installing the DER

(2) The utility transformer providing electric service is reasonably expected, in the sole opinion of APC, to never provide electric service to any additional customers, and Metering of the customer's electrical consumption is measured by CTs mounted on the bushings of the transformer (installations where the CTs are around the conductors may be modified to CTs mounted on the bushings upon request by the customer and agreement by APC)

(3) There are available terminal locations in the connector on each phase and the neutral of the transformer secondary. If current connectors do not have sufficient available terminal locations and larger connectors are approved for installation by the manufacturer the larger connectors may be installed by APC at the customer's expense.

(4) APC has approved this option for interconnection.

(a) APC reserves the right to disallow this option based on the site-specific limitations, at APC's sole discretion, other than described above. Approval of this option should be requested at the onset of design.

ii. The customer will be responsible for installing the conduit and wiring from the DER system under the existing pad and into the APC transformer. **NOTE: This shall not be performed with the pad-mounted transformer energized!** Therefore, an interruption of electrical service to the customer is required. This requires advance notice and coordination with APC. APC will be responsible for making all terminations inside the pad-mounted transformer.

6.3.3. Systems connected behind the meter and greater than (>) 600 volts

a. This option would be used in the case of primary metering where the customer takes service from APC at a voltage greater than 600V and owns the electrical distribution system beyond the primary meter.

b. The customer can connect the DER to the customer owned distribution system in any manner the customer sees fit.

c. All other requirements of this guidebook and referenced SoCo IP remain in effect.

6.3.4. Systems greater than (>) 100kW and connected ahead of the meter.

a. Systems less than (<) 100kW and connected ahead of the meter would not be anticipated. If so desired, contact APC for further information.

b. This option would be used in the case of a DER desiring to sell all power generated to APC. This option may be utilized at an existing customer's facility or at a site not associated with an existing customer.

c. A PCC electronic recloser may be required, per Section 6.7., on the high side of the transformer regardless if the PCC is located on the high side or low side of the transformer.
d. The customer may own, install, operate, and maintain the transformation or may request APC to do so.
   i. APC owned transformation
      (1) APC will install, own, operate, and maintain the transformer required to transform the voltage provided by the Customer to the primary voltage of the APC system including the primary cables connecting the transformer to the APC system and all associated terminations and protective equipment.
      (2) The customer must provide a standard low side voltage acceptable to APC. Those are 120/240 volt single phase, 120/208 volt three phase, or 277/480 volt three phase.
      (3) If overhead, the Customer must provide and install a secondary metering pole meeting the requirements of the "*Residential Electric Service and Meter Installation Handbook"* or "Commercial *Electric Service and Meter Installation Handbook".* APC will install service conductors from the overhead transformer to the metering pole and make terminations at the weatherhead.
      (4) If underground, the Customer must provide and install, to APC specifications, the concrete pad for the pad-mounted transformer, 5" conduit from the pad-mount to the APC pole along a route agreed upon by APC, and bring all secondary conductors to the pad-mounted transformer. APC will make all terminations inside the pad-mounted transformer.
      (5) Metering will be per the requirements of "*Residential Electric Service and Meter Installation Handbook"* or "Commercial *Electric Service and Meter Installation Handbook".*
      (6) Cost of all system upgrades, including the transformer, metering, required protective equipment, etc. and all associated equipment, will be the responsibility of the customer and will be provided as system upgrade costs at the time of technical review.
   ii. Customer owned transformation
      (1) Customer will install, own, operate, and maintain the transformer required to transform the voltage provided by the Customer to the primary voltage of the APC system including the primary cables connecting the transformer to the APC system and all associated terminations and protective equipment.
      (2) It is strongly preferred that the customer utilize a transformer that is grounded wye high side and grounded wye low side configuration with no tertiary windings. If other configurations are desired, prior approval is required from APC and may require additional protective measures.
      (3) The nominal impedance of the transformer must meet the requirements of IEEE C57.12.34-2022 with tolerances that meet the requirements of IEEE C57.12.00-2021.
      (4) The customer must coordinate with APC to ensure coordination of the customer's protective equipment with APC's protective equipment.
      (5) Metering will be primary metering on the high side of the transformer.
      (6) Cost of all system upgrades, including the metering, required protective equipment, etc. will be the responsibility of the Customer and will be provided as system upgrade costs at the time of technical review.

6.4. Microgrid Interface Device (MID) for systems less than or equal to (≤) 100kW

A MID is commonly called a Microgrid Controller or just a controller.

A MID is a device that controls the flow of power between the distribution system and the distributed generation sources. It can disconnect the Customer's DER from the APC distribution system to form an intentional island using distributed energy resources connected to the system such as solar, battery, and/or synchronous generator to provide power to the backed-up load. It also can automatically synchronize and reconnect to the distribution system.

6.4.1. Certification

a. The MID shall be UL1741SA or UL1741SB certified by a Nationally Recognized Testing Laboratory (NRTL) accredited by the United States Occupational Safety and Health Administration (OSHA). A current list of

OSHA accredited NRTLs may be found at this link: [OSHA's Nationally Recognized Testing Laboratory (NRTL) Program - Current List of NRTLs | Occupational Safety and Health Administration.]

6.4.2. Disconnect

a. An AC disconnect shall be provided that will isolate the entire DER system including the MID from the APC system. See 6.1.6 for more information.

6.4.3. Emergency Stop

a. A MID is designed and installed for the purpose of continuing to provide electrical power to the backed-up load panel in the event of a distribution system outage. In the event of an emergency where power must be turned off to all electrical load for the safety of first responders (such as a structure fire), following the normal process of opening the AC disconnect or APC removing the meter will not turn off power to all electrical loads because the MID will see this as a distribution system outage and go into microgrid mode to continue providing power to the backed up load panel. Because of this functionality, all certified controllers have the ability to have an emergency stop installed which, when activated, will cause the controller to cease to energize the backed-up load panel. Manufacturers use various terminology for this function, such as remote disable switch, E-stop switch, emergency stop switch, or rapid shut down switch. However, they all have the same functionality.
b. To ensure the safety of first responders, APC requires that this emergency stop be installed on all controllers.
c. The emergency stop must be shown on the single line diagram. See Appendix 1, Example 4, for an example of an acceptable method to show the emergency stop on the single line diagram.
d. This emergency stop must be physically located adjacent to the AC disconnect switch. Picture of proper placement shown in Appendix 5, example 3.
e. This emergency stop must provide instructions on how to active it. Switches employ various methods to activate such as push to activate, pull to activate, or turn to activate. Picture of proper labeling shown in Appendix 4, example 5.

6.5. Interconnection transformer winding configuration

A customer owned interconnection transformer with grounded-wye windings on the APC side and grounded-wye windings on the DER side with no delta tertiary windings is preferred for three-phase DER interconnection. These winding configurations minimize interconnection protection requirements. Other transformer winding configurations may be used only with written approval by APC prior to installation. Usage of any transformer winding configuration other than the preferred configuration will necessitate a detailed system impact study, along with associated fees, and may require additional protective measures be installed by the Customer.

A three (3) phase DER system shall not be connected to a service utilizing an APC owned Open Wye – Open Delta transformer bank. This is a transformer bank that provides three (3) phase electrical service from two (2) transformers. A singe Phase DER system may only be connected to Open Wye – Open Delta banks if it is less than (<) 20% of the capacity of the lighting transformer and creates less than (<) 20% current unbalance. If the customer desires to connect a three (3) phase DER to service provided by an APC owned Open Wye – Open Delta transformer bank or connect a single phase DER that is greater than (>) 20% of the lighting transformer capacity or creates greater than (>) a 20% current imbalance it will be necessary for APC to change the transformer bank to a closed Wye – Delta transformer configuration which will include installing a third primary phase from the nearest source if it is not already in place. The cost of this necessary system upgrade will be included in the system upgrade cost provided during the technical review of the application.

6.6. Monitoring, Information, and Control Requirements

To meet the requirements of the SoCo IP, Section A13.0, the following communication and control requirements must be met for all DER systems with a nameplate capacity of greater than or equal to (≥) 250kW. The Company reserves the right to require the following communication and control requirement for systems less than (<) 250kW but greater than or equal to (≥) 100kW. The communications interface must be a local, physical, interface and may not be remote or cloud based.

APC will provide a communication cabinet measuring no larger than 36" tall, 24" wide, and 18" deep and weighing no more than 50lbs. The communication cabinet and all equipment within shall be the property of the Company and will remain locked with a Company owned padlock after commissioning. No customer owned equipment may be placed inside or customer owned conductors pass through the communications cabinet except fiber communication medium terminated within as specified below. The cabinet shall be located such that it is readily accessible to APC personnel at all times. See definition section for full description of readily accessible meaning.

If an overhead PCC recloser is required or the DER is metered overhead at greater than 600 volts, the Company will mount the communications cabinet on the Company owned pole for the PCC recloser or primary meter. Otherwise, the DER Owner will be responsible for securely mounting the communications cabinet no more than 36", but no less than 12" laterally from, the meter socket and positioned so that no obstruction exists between the communications cabinet and the meter socket that would interfere with conduit installation by the Company between the meter socket and communication cabinet. The Company will provide power to the communications equipment housed within the communications cabinet. The method of providing power will vary based on site specific equipment and Company policy. For other unique installations, the cabinet will be placed at a location approved by the Company. Communications cabinet mounting requirements will be the same as those of the revenue meter as provided in "*Residential Electric Service and Meter Installation Handbook"* or "Commercial *Electric Service and Meter Installation Handbook".*

Regardless of cabinet location, the DER owner shall provide, install, own, and maintain a communication medium acceptable to the Company from the DER system communications interface to the communication cabinet. The termination at the communications cabinet for Company use shall be single modal fiber jumper with a ST connector, unless specified otherwise. Fiber termination and fanning shall be external to the communications cabinet. Attachment of fiber or fiber termination box to Company poles are subject to Company specific requirements. The DER system shall monitor the communication integrity and cause the DER system to initiate the loss of communication protocol if the communication integrity is lost for more than 30 seconds.

The DER system shall be programmed with behavior satisfactory to the Company in the event of communication failure (Lost Communication Protocol). Depending on the Company's system at the site-specific location and the DER system parameters, this may include a requirement to curtail real power production to a level established by the Company. Loss of communication due to DER owner equipment or communication medium failure that is not corrected in a timely manner as established by the Company may result in disconnection of the DER system by the Company until repairs are made.

APC will perform a communications signal test to ensure sufficient signal strength for the reliable operation of the APC communication equipment at the location of the communication cabinet prior to providing the cabinet for installation. If sufficient signal strength is not obtainable at the communication cabinet location, an elevated antenna may be required to provide sufficient signal strength. If the communications box will not be mounted on an APC owned pole, the DER owner will be required to install such elevated antenna provided by APC at the specified height by APC. If an elevated antenna is required, the customer will be required to install conduit as specified by APC from the elevated antenna to the communications cabinet.

At the time of APC communication equipment installation, the customer shall coordinate with APC and make available a communications engineer to terminate the fiber cable for connection to APC equipment as needed and assist APC personnel in verifying the proper communication between the APC equipment and the customer's DER equipment.

The local communications interface must support the Company's ability to remotely enable or disable permit service of the DER and change the various modes of operation and settings of the DER. To support this objective, DER systems with multiple DER units and supplemental DER devices totaling 250kW or greater in size are required to have a power plant controller (PPC) that controls, manages, and operates various DER devices within the DER system to meet interconnection performance and capability requirements at the PCC. The DER system must be able to communicate

with the company to set, control, and manage functions in the DER system remotely by use of the communications cabinet.

See communication and control witness testing requirements in Section 9.4.

6.7. Point of Common Coupling Isolation equipment requirement

To increase the reliability of the distribution system, APC has employed smart grid functionality that can reconfigure the system in the event of a power outage (such as a tree falling on the line or a car hitting a pole) to minimize the number of customers affected by the outage. Utilizing smart grid functionality, devices on the distribution system may be opened or closed resulting in multiple configuration options for the distribution system. This reconfiguration is infrequent and short in duration. It is not cost effective or practical to review all possible system configurations during the technical review of DER systems and the resulting requirements to safely operate the customer's DER during all possible configurations would be cost prohibitive. For these reasons, the technical review to determine the adverse effects, if any, of the proposed customer DER will have on the APC system only considers the APC system in its normal state of operation. Therefore, a methodology must be adopted to prevent the customer's DER from operating and exporting power to the APC system during times of abnormal circuit configuration. Therefore, certain isolation equipment may be required at the PCC to isolate the customer's DER from the APC system during these times.

The most effective method to accomplish this need is to install an electronic recloser at the PCC. This electronic recloser would be owned by APC. By utilizing APC's equipment, the recloser could be integrated into APC's smart grid functionality to seamlessly operate as needed. For installations that are ahead of the meter, this is the best method.

However, for installations that are behind the meter, operating this recloser would also result in the disconnection of electrical service to the customer. Since most DER installations are not large enough to provide all necessary power and do not always operate, this would leave the customer without power during these times, which would be undesirable. An alternative option is to utilize the communication equipment required by Section 6.6 to send a command causing the generation equipment to cease to generate. This would accomplish the need of preventing the DER from exporting to the APC system without interrupting electrical service to the customer. To protect the reliability of the APC system and safety of the APC personnel, the electronic recloser may still be required at the PCC as a backup. Should the DER continue to operate after receiving the command to cease to energize, the recloser at the PCC would open causing a total loss of power to the customer.

Below provides the isolation equipment required at the PCC based on the size of the DER and its location ahead of or behind the meter.

6.7.1. Tier I and Tier II ahead of the meter interconnections

a. All interconnections less than (<) 100kW are typically behind the meter. Any DER less than (<) 100kW wishing to connect ahead of the meter should contact APC for further discussion prior to beginning design.

6.7.2. Tier I and Tier II behind the meter interconnection

a. There will be no requirement for PCC isolation equipment for these installations.

6.7.3. Tier III DER system greater than or equal to (≥) 1 MW

a. Pursuant to section A7.1 of the SoCo IP, all interconnections capable of exporting greater than or equal to (≥) 1MW will be required to have a recloser installed at the PCC to the APC system. The recloser will be owned by APC. The cost of the required recloser will be included in the system upgrade cost.

6.7.4. Tier III DER system capable of exporting greater than (>) 100kW but less than (<) 1MW

a. Interconnections capable of exporting greater than (>) 100kW, connected ahead of the meter, and connected at voltages less than (<) 600V would be unusual and should contact APC for further discussion prior to beginning design.

b. All interconnections capable of exporting greater than (>) 100kW and less than (<) 1MW, connected ahead of the meter, and connected at voltages greater than (>) 600V will be required to have a recloser installed at the PCC to the APC system.
c. All interconnections capable of exporting greater than or equal to (≥) 250kW but less than (<) 1MW and connected behind the meter:
    i. *Will* be required to have a fully functional communications method for APC to cause the DER system to cease to energize utilizing the required monitoring, information, and controls communications cabinet in Section 6.6.
    ii. *May* be required to have a recloser installed at the PCC to the APC system. If required, the recloser will be owned by APC. The cost of the required recloser will be included in the system upgrade cost. A final determination will be made during the technical review of the application.
d. All interconnections capable of exporting greater than (>) 100kW but less than (<) 250kW and connected behind the meter:
    i. *May* be required to have a fully functional communications method for APC to cause the DER system to cease to energize utilizing the required monitoring, information, and controls communications cabinet in Section 6.6. A final determination will be made during the technical review of the application.
    ii. *May* be required to have a recloser installed at the PCC to the APC system. If required, the recloser will be owned by APC. The cost of the required recloser will be included in the system upgrade cost. A final determination will be made during the technical review of the application.
e. The ability to export may be limited below the required thresholds above by use of a LEG system. See Section 6.9 for more details on the requirements for these systems.

6.8. General system requirements and default settings

6.8.1. Tier I and Tier II systems (systems with a nameplate rating of 100kW or less)
a. The inverters and MIDs shall be at minimum UL1741SA certified by a Nationally Recognized Testing Laboratory (NRTL) accredited by the Unites States Occupational Safety and Health Administration (OSHA). A current list of OSHA accredited NRTLs may be found at this link: OSHA's Nationally Recognized Testing Laboratory (NRTL) Program - Current List of NRTLs | Occupational Safety and Health Administration
b. If inverters certified to UL1741SB are utilized, the inverter shall meet all of the requirements of section 6.8.2.a below.

6.8.2. Tier III system (systems with a nameplate rating of greater than 100kW)
a. Shall meet all requirements of IEEE 1547-2018. Specifically including but not limited to:
    i. The inverters shall be UL1741SB certified by a Nationally Recognized Testing Laboratory (NRTL) accredited by the United States Occupational Safety and Health Administration (OSHA). A current list of OSHA accredited NRTLs may be found at this link: OSHA's Nationally Recognized Testing Laboratory (NRTL) Program - Current List of NRTLs | Occupational Safety and Health Administration.
    ii. An "Authorization to Mark" letter will be required for all Tier III inverters to ensure UL1741SB certification.
    iii. Inverter based DER system shall have reactive power capability and voltage regulation performance requirements meeting Category B of IEEE 1547-2018 at the RPA.
    iv. Inverter based DER system shall have abnormal voltage and frequency ride-through capability performance of Category III of IEEE 1547-2018 at the RPA.
    v. Inverter based DER system shall be capable of meeting the reactive power capability and voltage/power control requirements of IEEE1547-2018 Section 5 and the Response to the Area EPS abnormal conditions of IEEE1547-2018 Section 6 at the RPA.
    vi. Inverter based DER system shall meet the requirements of IEEE1547-2018 Section 10.2 by providing one (1) local, physical, DER communication interface for the monitoring, control, and information exchange of the entire system. It shall not be remote or cloud based. Specifications of the communications interface requirements can be found in Section 6.6.
b. Required settings will be communicated from the Company to the DER owner and applied settings will be communicated from the DER owner to the Company by use of the EPRI Common File Format (EPRI CFF).

i. Each equipment manufacturer utilizes different nomenclatures for the numerous settings of the UL1741SB certified inverters that define its operating characteristics. Review of settings using varying nomenclature unfamiliar to the Company representative presents a significant challenge. To aid with this concern, many utilities have worked together with the Electric Power Research Institute (EPRI) to develop standard nomenclature and format for each setting that is of interest to the utilities.

ii. The EPRI CFF tool along with instructions and definitions of the common nomenclature can be found by following the below link. You must sign a license agreement and provide some information to be granted access, but there is no cost to utilize this tool.
DER Settings File Creator (SFC) v0.0.1 (epri.com) [epri.com]

c. Unless specified otherwise by APC after technical review, the DER system shall operate in constant power factor reactive control mode with unity power factor.

d. Pursuant to Section A6.3 of the SoCo IP, DER must be capable of operating between 90% power factor leading (or reactive power absorbing) and 90% power factor lagging (or reactive power producing).

e. At any time in the future, if needed for the continued reliable operation of the distribution system, APC may require a change of operating mode to other reactive power functions, including but not limited to a constant power factor other than unity or volt-var control mode. The DER owner is responsible for properly sizing the inverter's apparent power rating to provide these reactive power functions while maintaining the desired real power output. If not properly sized, the change to reactive power modes of non-unity power factor, volt-var, or other modes may require the inverter to reduce real power output to enable the ability to inject or absorb reactive power. APC will not be liable nor compensate the DER for this reduction in real power production.

6.8.3. Inverters with model number exactly listed on the California Energy Commission Solar Equipment List (Solar Equipment List - CA Energy Commission) will be accepted as meeting the requirement of being UL1741SA certified for Tier I and Tier II. Any inverters not on this list may still be approved but will be required to submit a "Authorization to Mark" letter from the manufacturer and may require additional review prior to approval. This will delay the approval process of the project. Example "Authorization to Mark" letter provided in Appendix 7. Any inverters not on the CA equipment list nor submitted with an "Authorization to Mark" letter will not be accepted. An "Authorization to Mark" letter must be provided for all Tier III inverters confirming certification to UL1741SB.

See section 9.1 for fully exporting generator (FEG) witness test requirements.

6.9. Limited Export Generator (LEG)

Upon completion of the system impact study, a maximum allowable export limit, which provides the maximum amount of real power that may be exported to the APC distribution system without adversely affecting the safety and reliability of the system, will be determined for the location of the interconnection application to the APC distribution system. Any export above this limit would require additional mitigation or protection measures to ensure the continued safe and reliable operation of the APC distribution system. If the proposed DER nameplate size is larger than the given maximum allowable export limit, the DER owner will be required to pay the cost of the required mitigation and/or protective measures, which is often quite expensive. To avoid the requirement of paying for these mitigation measures, the DER owner may choose to install a control system that limits the export of power to at or below the maximum allowable export limit as provided by the system impact study. This is called a Limited Export Generator (LEG).

APC requires certain additional equipment to be installed as a backup to the controls that limit the export to prevent the unintentional export above the maximum provided export limit in the event of failure or malfunction of the control system.

This section provides the technical requirements of this LEG. These requirements are in addition to all of the requirements of a FEG.

6.9.1. A three-line electrical diagram and DC elementary control circuit diagram shall be submitted for all LEG systems for the portions of the system associated with the export protective control system.

6.9.2. The control system must include provisions for limiting generation in a manner that, during normal operation, will not cause the backup export limit protection to trip.

6.9.3. Backup export limit protection shall include a utility grade relay
   a. See definition of utility grade relay for specific relay requirements
   b. Relay protective functions must not depend on electrical quantities obtained via digital protocol from other devices.
      i. This only applies to the backup export protection system and does not exclude the limited export control system from using digitally obtained values.

6.9.4. Current Transformers meeting the following requirements:
   a. Relay accuracy of C200 or better
   b. Meet requirements of ANSI/IEEE Std C57.13
   c. CT circuits shall be continuous and dedicated for the backup export limit protection relay. Any splices or transitions of CT circuit shall be made using full ring lugs on a mounted termination block.
   d. Test switches and blocks which provide “make before break” shorting may be included in the CT circuit.
   e. The protective relay current inputs shall accept signals directly from the current transformers. The use of signal converters or amplifiers in the CT circuits is not permitted (i.e. Rogoski coil CT signals converted for a 5A current input on the relay)

6.9.5. Voltage transformers (if required) must meet the following requirements:
   a. Thermal burden rating of 75VA or better
   b. Meet requirements of ANSI/IEEE Std C57.13

6.9.6. System shall be designed such that if the power source for the protective relay is deenergized, the DER intertie breaker will trip, the generation will be rendered inoperable, or the generation will revert to a minimal generation amount not more than 1kW per inverter and not to exceed a maximum of 25kW for the entire system.

6.9.7. System shall be designed such that if the power source to shunt trip the intertie breaker is deenergized, the generation will be rendered inoperable or revert to a minimal generation amount of not more than 1kW per inverter and not to exceed a maximum of 25kW for the entire system.

6.9.8. The protection system shall be designed to trip the intertie breaker for any export greater than the export limit provided by APC based on the system impact study. No margin is allowed in excess of the provided limit. Time delay for reverse power trip shall not exceed 60 seconds.

6.9.9. If inverter voltage and frequency protection is disabled or set less sensitive than specified by IEEE 1547-2018 (shown below) the backup export limit protection relay must provide this function.

Table A5 – DER Shall Trip Settings for Abnormal Voltages & Frequencies

Voltage Protection Function	Pickup (p. u. of nominal voltage)	Clearing time (s)
59-2	1.20	0.16
59-1	1.10	1.0
27-1	0.88	2.0
27-2	0.50	0.16

Frequency Protection Function	Pickup (Hz)	Clearing time (s)
81O-2	62.0	0.16
81O-1	61.2	300
81U-1	58.5	300
81U-2	56.5	0.16

See section 9.2 for LEG witness test requirements.

6.9.10. Remote trip requirements if used for LEG systems

If there are multiple individual DER systems behind a single meter, it may be desired to provide the LEG reverse power relay protection at a common point on the customer owned electrical system to achieve maximum aggregate benefit of all systems. This may be accomplished by the use of one reverse power relay to send trip signals remotely to all DER system breakers.

This is only permissible when all DER systems are behind one (1) APC revenue meter. DER systems behind more than one (1) APC revenue meter shall not be aggregated behind reverse power relays. Each APC revenue meter must have at least one (1) separate reverse power relay to limit export from that metering location and shall not interact with intertie breakers behind a different APC revenue meter.

These systems shall meet the following requirements:

a. The transmitter and receiver of the remote trip signal shall be a device with an appropriate UL listing category that meets ANSI/IEEE C37.90.
b. The remote trip system shall employ the use of a heartbeat signal to ensure continuous functionality. Loss of the heartbeat for any time exceeding 30 seconds shall cause a trip of all DER intertie breakers and prevent their reclosing, either automatically or manually, until the heartbeat signal is restored.
c. Failure of any device in the protection system shall result in a trip of all intertie breakers or disabling of all generation sources. This includes the protective relay, remote trip send and/or receive unit, communication path, and any other equipment necessary for the trip circuit to function. The time delay from equipment failure to intertie breaker trip or disabling of generation shall not exceed 30 seconds.
d. The system shall not be operated at any time without all of the above requirements being met including during initial energization, commissioning, testing, and troubleshooting.

See section 9.2.3 for remote trip witness test requirements.

6.10. Microgrid

A microgrid, which is designed to intentionally island, can have unique challenges associated with its operation including successful separation from the APC system - both commanded and uncommanded, resynchronization with the distribution system, and grounding.

This section provides the interconnection technical requirements of a microgrid. These requirements are in addition to all of the requirements of a FEG and LEG (if applicable).

A sequence of operation, including reference to specific device identification numbers on the single line, shall be provided for each designed operating scenario of the microgrid (i.e. loss of APC system, commanded operation, etc.). It should identify all steps the microgrid controller takes before initiating the next action. It shall include loss of APC system as one of the designed operating scenarios. See Appendix 7 for an example.

A grid isolation device is defined as a device, or combination of devices creating a system, containing a method to separate the portion of the electrical system intended to island from the APC distribution system. The use of a grid isolation device is inherently necessary to create the island. The grid isolation device may be one of three options: (1) a UL1741 certified device, (2) a UL1008 certified device, or (3) a non-UL certified device.

For the purpose of determining witness testing requirements, APC defines a UL1741 and UL1008 certified grid isolation device as one in which the system has been built by the manufacturer and been certified to meet the requirements of UL1741SA or higher or UL1008 as a package. More specifically, all critical components of the system including the CTs, PTs, relays, controls, and contactors are preinstalled and wired by the manufacturer and not available for manipulation by the installer. The use of pre-terminated wiring in a connector that is made such that it can only be plugged in correctly, thus eliminating the possibility of on-site wiring errors, is allowed to connect separate manufacturer provided parts of the whole system and the use of such does not in and of itself disqualify

the system as a whole from being UL certified. The only terminations allowed by the installer are to connect the utility source, DER source(s), and load to the manufacturer provided package. Any additional termination requirements would disqualify the system as deemed UL certified as a system by APC. Examples of qualifying devices would be Solark 8k and 12k, Solar Edge BUI, Tesla Gateway, etc.

APC requires that the microgrid device isolation control utilizes some method to actively confirm the grid isolation device is open before microgrid begins operation to power load. The method chosen must identify a failure of the grid isolation device to open, regardless of APC system status, and take action to prevent the microgrid from operating in the event of a failure.

6.10.1. Use of non-UL certified grid isolation devices on systems less than or equal to (≤) 25kW is not allowed.

6.10.2. Use of a UL1741 or UL1008 certified grid isolation device on systems great than (>) 25kW but less than or equal to (≤) 100kW will not require any additional design requirements or witness testing by APC.

6.10.3. Use of a grid isolation device that is not UL1741 nor UL1008 certified on systems greater than (>) 25kW but less than or equal to (≤) 100kW will require the same microgrid design requirements and witness testing as systems greater than (>) 100kW including the associated fees. This witness testing will be specific to the microgrid portion of the system, the DER FEG system will not require any additional testing.

6.10.4. Use of UL1741 or UL1008 certified grid isolation devices on systems greater than (>) 100kW.
There are no additional design requirements when using a UL1741 or UL1008 certified grid isolation device.

See section 9.3.1 for UL certified grid isolation device witness test requirements.

6.10.5. Use of a grid isolation system that is not UL1741 nor UL1008 certified on systems ≥ 100kW

a. If any interconnection protection requirements required in Section A7.0 of the SoCo IP are disabled in the IBR during interconnected operations of the microgrid with the APC system, they shall be provided by a grid isolation device control relay and associated equipment meeting the same requirements as the reverse power relay given in sections 6.9.3, 6.9.4, and 6.9.5.
b. System shall be designed such that if any part of the microgrid grid isolation device system fails (including but not limited to loss of control or power required to trip isolation device, loses of control or power to the control system, or failure of the grid isolation device to open for any reason), the DER system will maintain the same IEEE1547-2018 functionality as required during interconnected operations or shall be rendered inoperable.
c. Grounding
    i. Any grounding transformer utilized should be clearly indicated on the single line diagram including the winding configuration.
    ii. Use of grounding transformer may require additional protections at the grid isolation device to prevent adverse effects to the APC distribution system.
    iii. If the detailed impact study indicates the APC distribution system cannot support the grounding bank during interconnected operation, the design will be required to provide provisions for the grounding transformer to not supply zero sequence current to the APC distribution system during interconnected operation.

See section 9.3.2 for non-UL certified grid isolation device witness test requirements.

6.11. Network Underground

A network underground system is one in which the secondary conductors of all transformers are connected to form a “network” so that the failure of any one piece of equipment does not cause an interruption of power to the customers served from the network underground system. APC operates three (3) network underground systems in the downtown areas of the cities of Birmingham, Montogomery, and Mobile. Due to the type of protective equipment used in network underground systems, no export of power is allowed on the network underground

system. An interconnection on the network underground system must have a minimum import of power from the APC network system at all times to prevent erroneous operations of the protective equipment.

For details on these requirements, contact APC before designing a system or ordering any equipment that will be connected to the APC network underground systems.

7 Construction, Initial Synchronization, and Commissioning

7.1. DER systems less than or equal to (≤) 100kW

The DER system may not be synchronized or operated in parallel with the APC system at any time, including for short-duration time of temporary testing, until the design is accepted and permission to proceed with construction has been provided by APC. Doing so prior to receiving permission to proceed with construction may result in damages to APC equipment and/or other customer equipment for which the DER owner would be liable.

After the design has been accepted and permission to construction has been provided by APC, the DER owner may synchronize and operate the DER system connected in parallel with the APC system for short-duration time periods for the purpose of testing the system. The system should only be operational while on-site testing is actively being conducted. The system should be immediately disabled upon completion of testing.

The system shall not remain operational in continuous parallel with the APC system without written permission to operate from APC.

7.2. DER systems greater than (>) 100kW

Refer to section 8.6 of the SoCo IP for more detailed information related to the initial synchronization and commissioning procedure.

The DER system shall not complete initial synchronization nor operate in parallel with the APC system until approved in writing by APC after review of the required information specified in sections 7.2.1-7.2.3 as applicable to the DER installation.

7.2.1. FEG system information provided to APC

A minimum of 30 days prior to the desired initial synchronization date, APC shall be provided the required information in section 8.6.2 of the SoCo IP as detailed below:

a. Make, model, and serial number for all generators
   i. For IBR systems,
      (1) The firmware version of each inverter
      (2) The default settings for each inverter
      (3) The applied settings for each inverter
      (4) Settings shall be provided using the EPRI CFF. See Section 6.8.2.b for more information.
b. Maximum fault current contribution of DER system.
c. As-built single line drawing showing at minimum all required information for single line diagram of FEG.

APC will collect power quality data for a minimum of seven (7) consecutive days with the generation offline utilizing the APC provided power quality monitoring equipment located at the point of interconnection with the APC distribution system. This will establish the baseline APC system power quality information required for use after the witness test to determine the power quality impact to the APC system by the DER system.

7.2.2. LEG system information provided to APC

If the system is a LEG system, at the same time the information is provided as required in section 7.2.1, APC shall be provided the below additional information pertaining to the LEG portion of the system:

a. As-built single line drawing showing, at minimum, all required information for single line diagram of FEG plus the following:
   i. Location of breaker that will be tripped by the backup export limit protection.
   ii. Location of all CTs, PTs, and voltage sources for backup export limit protective relay.
   iii. Details of the fail safe operation of the system
b. Three-line diagram showing the current and voltage circuits for all protection relays.
c. Make, model, and part number for backup export limit protective relay.
d. Copy of relay settings for validation.
e. Intertie breaker DC elementary showing trip and close circuits.

7.2.3. Microgrid system information provided to APC

If the system is a microgrid system, at the same time the information is provided as required in section 7.2.1 and 7.2.2 (if applicable), APC shall be provided the below additional information pertaining to the microgrid portion of the system:

a. As-built single line drawing showing, at minimum, all required information for single line diagram of FEG and LEG (if applicable) plus the following:
   i. Location of the grid isolation device that will be tripped by the grid isolation device relay
   ii. Sequence of operation for the microgrid

7.2.4. Commissioning and testing

APC may require testing of the export limit protection or microgrid grid isolation device and control schemes per section 8.6.5 of the SoCo IP prior to initial synchronization of the DER system. If required, the Customer will work with the Company to schedule a mutually agreeable time for the Company to perform witness testing. Testing will be conducted per the procedure set forth in Section 9.

After APC has approved the provided information required in sections 7.2.1-7.2.3, the Customer shall provide, in writing, the desired date of initial synchronization and time period requested to perform commissioning and testing of the system. The initial commissioning and testing time period shall not exceed 5 consecutive business days (Monday – Friday) but may include non-business days adjacent to the business days (Saturday – Sunday), for a total maximum time period of 9 consecutive days (Saturday – the following Sunday). The request for operating in parallel with the APC system shall be provided a minimum of 10 business days in advance. It may be requested concurrent with providing the required information above.

If commissioning and testing cannot be completed in the allotted time period, additional time periods may be requested. An extension of the existing time period must be requested a minimum of 2 business days prior to the ending of the approved time period. If the initial approved time period expires prior to approval by APC for an extension, the system shall be disabled until approval is received.

APC does not guarantee that additional time will be granted on consecutive weeks following the initial testing time period. In this case, APC will communicate when the next available time period will be.

The DER system shall only be operated during times of active commissioning and testing. The DER system shall be turned off at all other times during the approved time period.

It is imperative for the safety of APC employees that the Customer shall only operate the DER system in parallel with the APC system during the approved time period. Because the DER system has not been witness tested to ensure proper operation, APC may modify internal work procedures during the approved DER testing time

period. Any operation outside the time period approved by APC may jeopardize APC employee safety and system reliability.

a. LEG system

The LEG owner shall not at any time operate the LEG system in a manner that allows the system to export any amount of power exceeding the export limit provided by APC without written consent of APC. To ensure the safe and reliable operation of the APC distribution system, should APC become aware that the LEG system is exporting any amount greater than the provided export limit, APC shall have the right to open, and lock open with an APC padlock, the LEG system disconnect. APC will make reasonable efforts to contact the LEG owner prior to opening the disconnect but may proceed to open and lock open the disconnect even if contact is not established with the LEG owner.

APC understands the potential need to test the system during commissioning in a manner that may export an amount of power to the APC system exceeding the maximum export limit provided. If an exception to the export limit is desired for testing, the LEG owner or installer shall make this request in writing to APC a minimum of 5 business days prior to the desired testing date and provide the following information: 1) the maximum desired export amount 2) requested timeframe of testing to include dates and time range 3) name and cell phone number of the person in charge of testing that will be onsite and reachable at all times during test. APC will evaluate the affects the requested output will have on the system and respond in writing either granting or denying permission for said output exception. If granted, the permission will define specific dates and times based on projected system loading conditions. The LEG system shall only be operated above the provided maximum export limit during the date and time exceptions as defined by APC. After making the request, the LEG owner shall not proceed with testing until expressed written permission has been provided by APC.

8 Post Construction design confirmation (for systems less than or equal to (≤) 100kW)

8.1.1. Photographs

a. Upon completion of the installation, DER owner shall provide to APC the following photographs to confirm DER system was installed per the accepted design.
   i. APC revenue meter including zoomed out to show an area 10’ on all sides
   ii. If the AC disconnect is not within the above picture, a picture of the AC disconnect zoomed out to show an area of 10’ on all sides.
   iii. A picture of the AC disconnect close enough for the label to be clearly legible
   iv. If the AC disconnect is not within 5’ and line of sight of the revenue meter:
      (1) A picture of the revenue meter socket with the required label clearly legible
      (2) A picture of each disconnect with the required label clearly legible
   v. If an E-stop is required
      (1) A picture of the E-stop with the required label clearly legible

8.1.2. On-site check out

a. APC reserves the right to perform an on-site check out to confirm the DER was installed according to the accepted design and confirm proper operation of the AC disconnect and E-stop button at Company discretion.
b. If an on-site check out is performed, APC will arrange to meet the DER owner on-site to complete the following steps.
   i. The check out will be performed on a sunny day between 10am – 3pm. If the DER owner cannot be present during this time, the DER owner will need to make arrangements for a representative to be present that is familiar with the operation of the load breakers, PV breaker, PV disconnect, and controller (if applicable).
   ii. APC will verify the disconnect is within 5’ and line of sight of the revenue meter, that required labeling is installed, and has proper access.

iii. APC will request the DER owner to turn off all load breakers, but leave the PV system connected, and turn on the PV AC disconnect.
iv. This will cause the full PV generated power to be exported to the APC system. APC will verify generation by taking amp readings at the APC revenue meter socket.
v. APC will request the DER owner open the DER AC disconnect.
vi. APC will verify the DER system is separated from the APC distribution system by confirming the amp reading at the meter goes to zero.
vii. If the system has a MID, APC will request the DER owner to turn on load powered by the backed-up load panel that is visually observable to be running (light bulb, dryer, etc.). APC will then request the DER owner activate the E-stop and verify the MID ceases to energize the backed-up load panel by visually confirming the load from the backed-up load panel stops running.

9 Witness testing requirement (for systems greater than (>) 100kW)

Witness testing verifies the proper construction of the DER system and demonstrates that the control and protection schemes operate as required under a variety of APC system conditions. Since the DER system is best known by the DER owner, it is the DER owner's responsibility to develop the witness test plan and submit it for approval to APC.

The witness test plan shall, at a minimum, demonstrate that:

a. The DER system grid interactive functions operate appropriately.
b. The DER system will respond appropriately in the event of a failure of any single device or loss of the APC system voltage.
c. Following a system outage, the DER system does not generate into the APC system for a minimum of five (5) minutes after voltage and frequency have returned to normal and follows required ramp requirements back to full generation.
d. All interrupting devices operate appropriately for all required trip initiating conditions.
e. The protective system will be able to detect and isolate, within two (2) seconds, the DER system for a loss of any one (1) phase or all three (3) phases on the APC system.
f. All required protective relaying operate correctly to all required system conditions by use of a secondary injection test kit (LEG system only)

The witness test plan should set forth a step-by-step guide for testing each required design function. The step should indicate who is responsible for completing that step. Each test should define what is considered a successful and unsuccessful testing outcome. The test plan step should reference each piece of equipment by a unique identifier indicated on the single line diagram. See appendix 6 for an example test plan.

The following sections provide information on the tests that are required to be completed and the expected result for successful completion. The witness test plan submitted by the Customer shall address all of the below tests, can be in any order desired by the installer, and specifically relate each test to the individual system by device number indicated on the single line.

All inverters of the DER system must be operable for all portions of the witness test. Where a percentage of nameplate capacity output is required by the tests below, that percentage must be output from each inverter individually. No inverter may be turned off or disabled. The over or under output of one inverter cannot be made up by other inverters. This is to ensure the proper functioning of all inverters in the DER system.

A portion of the witness testing must be conducted while the DER system is generating a minimum of 85% of the maximum nameplate AC capacity of the system. This requires appropriate weather for some DER energy sources (i.e. photovoltaic). It is the customer's responsibility to monitor the weather forecast and contact APC to reschedule the witness test a minimum of two (2) business days prior to the scheduled date if the weather forecast is not conducive to successful testing conditions. Cancellations without a two (2) business day notice may result in a rescheduling fee.

APC recognizes the customer may incur non-refundable expenses the day of witness testing and will make every reasonable effort to not cancel properly scheduled testing without the same two (2) day notice required by the customer; however, in the event of urgent unforeseen circumstances, APC reserves the right to cancel at any time, including the day of scheduled testing. APC will provide an explanation of the last-minute cancellation but will not reimburse the customer for expenses due to APC cancelling a witness test.

When the customer is prepared to schedule a witness test, the following process shall be followed:

a. The DER owner shall provide updated, as-built, information for any changes after information was provided in Section 7 or provide positive confirmation that none of the information provided for Section 7 has changed.
b. The DER owner shall provide the appropriate witness test plan as required below in this section.
c. The DER owner shall pay the $2,500 witness test fee.
d. APC will review the provided witness test plan and updated as-built information (if applicable) and respond within ten (10) business days either approving the updated information and witness test plan or providing any clarifications or modifications required. APC will work with the customer to resolve any concerns.
e. After APC has approved the as-built design and witness test plan, the customer can provide the proposed date, time, and meeting location of the witness test with a minimum fourteen (14) business days advance notice between the request and proposed testing date.
f. APC will respond within 7 business days either agreeing to the proposed date and time of the witness testing or providing alternate dates and time that would be acceptable to APC. APC will work with the customer to establish a mutually agreeable date and time for the testing.

The witness test may be scheduled outside of business hours if desired by the customer for an additional fee. The witness test may not be scheduled on a nationally recognized holiday.

All witness testing will be scheduled on a “first ready”, basis and contingent on employee availability. “First ready” means the first request received that meets all of the requirements including an approved as-built design and test plan at the time of the witness test date request. For example, if system A requests to witness test before system B but does not meet all of the requirements, but system B does meet all of the requirements, system B will be scheduled to witness test before system A.

APC cannot guarantee the ability to provide all witness testing in the requested time and date. The customer is encouraged to complete DER projects with ample margin in the schedule for witness testing delays and/or modifications required during as-built review or in the event of not successfully passing witness testing on the first attempt to avoid the possibility that APC witness testing limitations prevent the completing of the DER project within the timeframe needed to meet any internal deadlines or qualify for any financial incentives. APC will not be held responsible for missed deadlines due to APC’s inability to complete the witness testing on the requested timeline.

APC will not provide temporary or contingency permission to operate until the DER system fully meets all requirements, including the Power Quality evaluation in Section 9.5 which will take a minimum of ten (10) business days after the on-site portion of the witness test.

Once a DER has successfully completed the witness test, APC must be notified in advance of any desired equipment or settings change to the inverter or control relay. APC must provide acceptance of any desired change in advance. APC reserves the right to determine if additional witness testing is required as a result of the change.

9.1 Fully Exporting Generator (FEG)

IMPORTANT NOTE: THE WITNESS TEST WILL REQUIRE AN INTERUPTION OF ALL CUSTOMER LOAD FOR PORTIONS OF THE TEST PERIOD AS INDICATED BY TEST SPECIFIC REQUIREMENTS BELOW. The witness test will subject any inadvertently remaining load to a single-phase condition, which could damage the customer’s equipment.

Customer load may be transferred to a standby generator as long as it is electrically isolated from the remaining load and DER system.

9.1.1. At the beginning of the witness test, APC will:

a. Verify disconnect is present and meets requirements of Section 6.1.
b. Verify labeling is present and meets the requirements of Section 6.2.
c. Take pictures of all inverter name plates.
d. Confirm system is built as shown in drawings submitted by installer.
e. Confirm transformer nameplate matches drawings submitted by installer (if applicable).
f. Confirm that the inverter firmware version and settings installed match those provided.
    i. Specifically, the installer must be familiar with manipulating the inverter HMI and be able to display on the HMI or be capable of utilizing a computer plugged directly into the inverter to display that the settings match those provided in the download for a random sampling of inverters as selected by APC.

9.1.2. Disconnect Test

The purpose of this test is to confirm that the DER AC disconnect switch successfully isolates the DER from the APC system. The following tests will be required to be performed by the DER owners test engineer and witnessed by the APC representative:

a. The installer will be required to open the DER AC disconnect and demonstrate the DER ceases to generate power within two (2) seconds.
b. A time period of at least seven (7) minutes will lapse to ensure the DER does not begin to generate with the disconnect open.
c. The installer will be required to close the AC disconnect and demonstrate the DER system waits the required 5 minutes before reconnecting to APC system after simulating power restoration and upon reconnecting follows the required ramp up time to reach full production.

9.1.3. Open phase test

If a microgrid is present, the system may go into microgrid mode by isolating from the APC system within two (2) seconds instead of the inverters tripping if desired.

If a microgrid is present that has not been previously witness tested, the grid isolation device system shall be tested in accordance with section 9.3.2 prior to performing the open phase test.

The DER system must be curtailed to the minimum export allowable as provided by the manufacturer for the duration of this test or 5%, whichever is greater. This cannot exceed 20% of the AC nameplate capacity. All customer load must be disconnected for this test.

The preferred method will be for APC to open each phase on the APC system to test the entire system response by simulating a single phase outage on the APC system. However, if this will affect other customers of APC or is not practical without temporary equipment installation due to the APC system design, the DER owner may be provided the option to make arrangements to open each of the phases at a location acceptable to APC that will disconnect the entire DER system from the distribution system. Depending on DER system design, that option may not be allowed. If the DER owner chooses not to exercise the option to make arrangements to open each phase or if this option is not allowed by APC, APC will make necessary temporary arrangements on the APC system to accomplish this test at the DER owner's expense.

For each condition below, the installer will be required to demonstrate the system recognizes and disconnects from the APC distribution system within two (2) seconds, remains disconnected for the duration of the condition, and waits five (5) minutes before reconnecting after the APC system returns to normal.

a. Phase "A" only open
b. Phase "B" only open
c. Phase "C" only open
d. Exception
    i. In the event that the customer is served from an APC owned closed delta transformer bank, the installer must demonstrate that the DER can recognize and isolate from the APC distribution system

within two (2) seconds and remain isolated for the duration of the condition for any two (2) phases being opened simultaneously.

9.1.4. Transient Overvoltage Test

The DER shall not cause a cumulative overvoltage on the APC system exceeding the limits provide in IEEE1547-2018 Section 7.4.2 Figure 3, shown below. Each inverter must be operating at a minimum of 85% AC nameplate capacity for this test. All customer load must be disconnected for this test.

To take the required measurements, APC test equipment will be connected at the appropriate location by the APC representative with assistance from the customer.

The installer will be required to open the AC disconnect, wait until directed by the APC representative, then close the AC disconnect.

This test will be repeated three (3) times.

Recorded data will be analyzed offsite, after completion of the witness test, to verify compliance. The DER must pass all three tests. Failure of any one test is failure of the entire test.

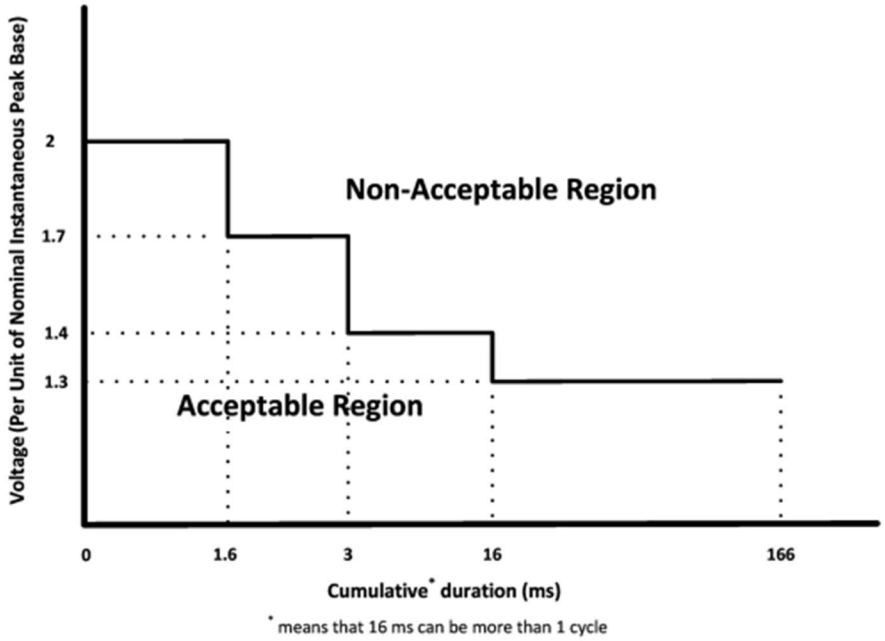


Figure 3 —Transient overvoltage limits

9.2 Limited Export Generator (LEG)

The test plan for a LEG shall include all witness testing requirements of the FEG in section 9.1 and the below additional requirements.

The test plan shall include the use of a three-phase secondary injection test set provided by the installer and operated by the installer's qualified test engineer. The installer's test engineer will be responsible for all connections and operations of the secondary injection test set to demonstrate the required tests indicated below.

Prior to scheduling the witness test, the test engineer should become familiar with connecting and operating the secondary test set and should perform all of the below tests to ensure proper functioning of the system. Should the witness test be unsuccessful, additional fees will be charged for each re-test.

9.2.1. At the beginning of the witness test, APC will:

a. Visually confirm CTs, PTs, and associated circuits are in accordance with requirements.
   i. The installer will be asked to show these devices to the APC representative, including their nameplates. If this requires the removal of panel covers this may be done energized or de-energized at the installer's discretion. APC representative will only visually inspect the equipment, including the nameplates, without contacting any equipment or panels or energized cabinets. If this cannot be accomplished, the panels will be required to be de-energized for the safety of the APC representative.

b. Confirm that the protective relay firmware version and settings installed match those provided.
   i. Specifically, the installer must be familiar with manipulating the relay HMI and be able to display on the HMI that the settings match those provided in the download for all protective relays.

c. Request the installer assist in connecting APC recording equipment to the appropriate voltage and current sources to allow the APC representative to validate that the steady state amps, volts, and power readings shown on the HMI display of the backup export limit relay match APC recorder under normal conditions.

9.2.2. The following tests will be required to be performed by the test engineer and witnessed by APC:

a. Normal operation test:
   i. The secondary injection test set should be used to inject forward direction standard operating amps and volts to simulate the normal operation of the system.
   ii. Correct operation of the secondary injection set will be validated using the relay HMI display.

b. Export Violation test:
   i. The secondary injection test set should be used to inject reverse power beginning at 85% of the reverse power setting and increasing at a rate of 10% per step with each step lasting a time period of twice the set delay time until the relay trips.
   ii. The relay HMI interface will be used to verify reverse power injection setting changes and verify the relay trips at the required reverse pickup setting and time delay.
   iii. The reverse trip pickup should not exceed the provided export limit for any period longer than the provided export time limit.

c. Fail safe operation test:
   i. The installer will be asked to demonstrate the fail-safe operation of the DER system when power is removed from the protective relay.
   ii. The installer will be asked to demonstrate the fail-safe operation of the DER system when power is removed from the whetting voltage to the breaker.

d. Event reporting test:
   i. At the conclusion of testing, installer will be asked to provide event reports from the protective relay for all operations from the above tests.

e. Other tests:
   i. Any other protective function identified as required by APC during the design review must be tested and demonstrated to operate properly utilizing the secondary injection test set (i.e. undervoltage trip, etc.).
   ii. This requirement, if any, will be made clear during the APC response after the design review.

9.2.3. The following tests will be required to be performed only if the system utilizes a remote trip system to trip the intertie breakers by the reverse power relay. Tests will be required to be performed by the test engineer and witnessed by APC:

a. Heartbeat test:
   i. The test engineer shall disable the heartbeat signal and demonstrate all intertie breakers trip within maximum of 30 seconds.
   ii. The test engineer shall then attempt to close each intertie breaker to demonstrate the breaker will not close while the heartbeat signal is absent.

b. Equipment failure test:
   i. The test engineer shall remove power from the following equipment individually and demonstrate that all intertie breakers trip within a maximum of 30 seconds when any one (1) piece of equipment is disabled.

ii. The test engineer shall then attempt to close each intertie breaker to demonstrate the breaker will not close while each individual failure is present.
    1. Remote trip transmitter
    2. Each remote trip receiver
    3. Each section of communication path (may be only 1 path or may be multiple paths depending on system design
    4. Each other necessary piece of equipment

9.3 Microgrid

The test plan for a microgrid shall include all witness testing requirements of the FEG in section 9.1, LEG in section 9.2 if applicable, and the below additional requirements.

9.3.1 UL1741 or UL1008 certified grid isolation device for systems greater than or equal to (≥) 100kW

a. Commanded microgrid mode
    i. While the APC system is in a normal state, the microgrid shall be commanded to enter microgrid mode and demonstrate isolation functionality without adverse effect to the APC system.
    ii. The microgrid shall be commanded to exit microgrid mode and demonstrate the ability to successfully synchronize and parallel the APC system without adverse effect to the APC system.
b. Automatic microgrid mode (if equipped)

    This functionality may be tested in conjunction with the FEG witness test in section 9.1.3 but must utilize the APC upstream device protective device to initiate system abnormality.

    The APC representative will utilize the first available upstream protective device on the APC system to create the following conditions that could occur on the APC system. For each condition, the installer will be required to demonstrate the system recognizes and isolates from the APC distribution system within two (2) seconds and remains isolated for the duration of the condition and at least five (5) minutes after the APC system returns to normal. The installer must demonstrate the microgrid can successfully recognize when the APC system has returned to normal, either shut down DERs or synchronize, close the isolation device, and operate in parallel with the APC system without adverse effect to the APC system.
    i. Phase “A” only open
    ii. Phase “B” only open
    iii. Phase “C” only open
    iv. Exception
        (1) In the event that the customer is served from an APC owned closed delta transformer bank, the installer must demonstrate that the microgrid can recognize and isolate from the APC distribution system within two (2) seconds and remain isolated for the duration of the condition for any two (2) phases being opened simultaneously.

9.3.2. Grid isolation system not UL1741 nor UL1008 certified

The test plan for a grid isolation system not UL1741 nor UL1008 certified shall include all witness testing requirements of the UL1741 certified grid isolation device in section 9.3.1 and also the below additional requirements.

a. Microgrid grid isolation device system failure
    i. The installer shall demonstrate that if any portion of the microgrid grid isolation device system fails (including at minimum but not limited to loss of control power to the control relay, loss of power required to trip isolation device control system, or failure of the grid isolation device to open for any reason, and any other critical component requested by APC), the DER system will maintain the same IEEE1547-2018 functionality as required during interconnected operations or shall be rendered inoperable.
    ii. If the microgrid is designed for seamless transition (no intentional time at zero voltage between microgrid serving load and return to APC system), APC will require additional design information and may require additional testing.

9.4. Monitoring, Information, and Control Requirements

The test plan for monitoring, information, and control requirements shall demonstrate that the system meets all requirements established in Section 6 of this document as applicable to the individual system size and design.

9.4.1. Information exchange and monitoring

APC will verify the ability to exchange information with and monitor the parameters specified for the DER system.

9.4.2. Permit Service

The installer will demonstrate that the system ceases to energize within two (2) seconds of removal of permit service by APC and does not begin to energize again until the permit service is enabled by APC.

If the DER system is part of a microgrid, the system may enter microgrid operation and fully isolate from the APC system by opening the grid isolation device within two (2) seconds and remain isolated for as long as the permit service is removed by APC instead of causing the inverters to cease to energize. The microgrid shall meet the requirements of Section 9.3.

9.4.3. Active Power Limit

The installer will demonstrate that the DER system reacts appropriately by changing the maximum AC power output when the active power limit is enabled, and an active power limit is set by APC.

9.5. Power Quality evaluation

At the conclusion of the above testing, APC will make a determination if the system meets all of the requirements necessary to safely and reliably operate connected in parallel with the APC system. If the system does not meet these requirements, the system will be required to remain disconnected until appropriate measures are taken to the satisfaction of APC. Depending on the deficiency found, this may require an additional witness test. Each additional witness test required may incur additional charges from APC. Once the system meets all requirements to the satisfaction of APC, APC will provide written (via email) permission to operate in parallel with the APC system on a temporary basis for the continuation of testing as described below.

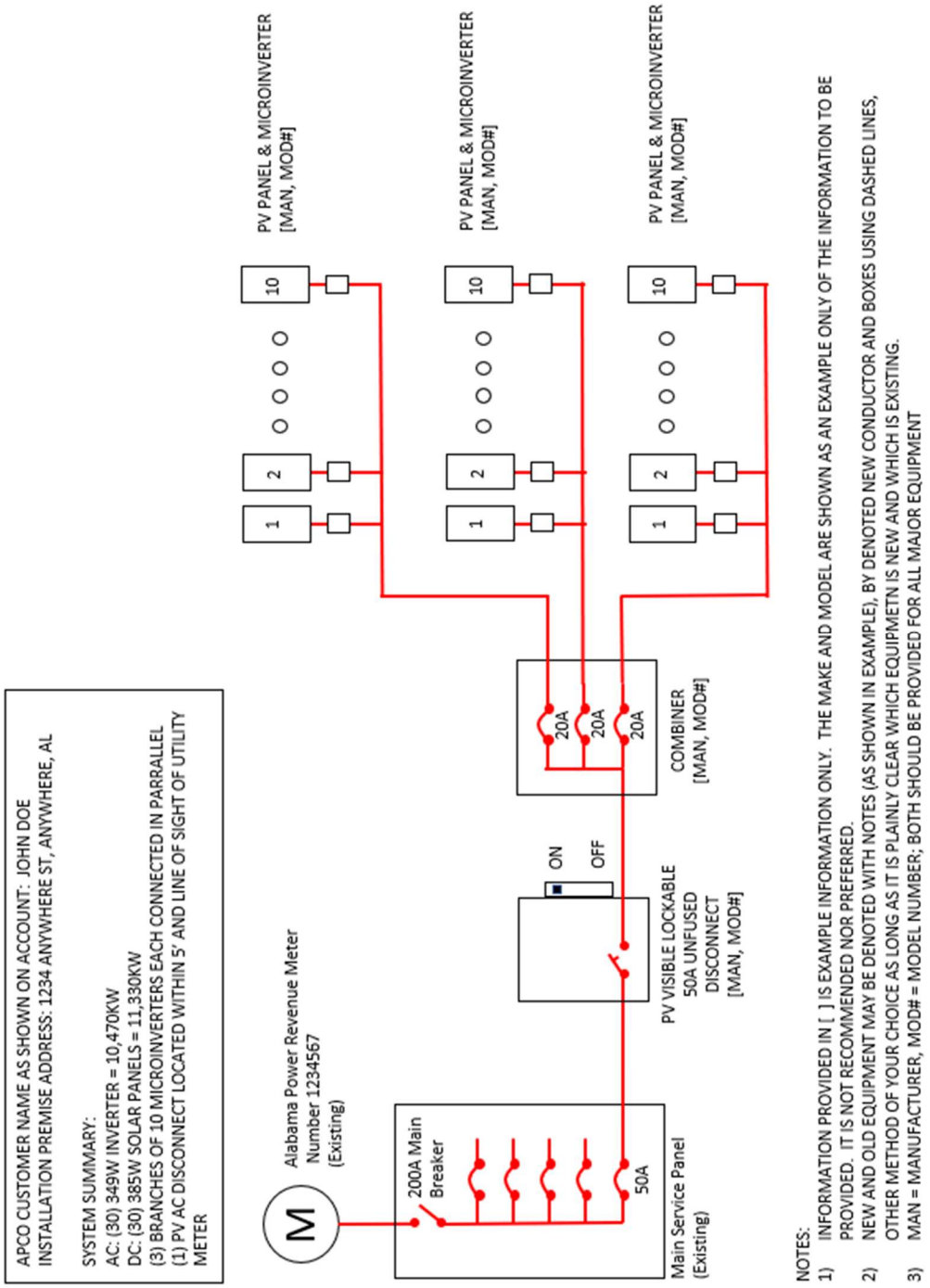
After the successful completion of the on-site witness testing described above, APC will continue to collect power quality data for an additional 7 days with the generation online utilizing the APC provided power quality monitoring equipment located at the point of interconnection with the APC distribution system. Data will be compared to base line data obtained in section 9.2.1 to determine the power quality impact of the DER system.

If at any time during the Post Site Visit testing the APC Testing Team determines that the Power Quality impact of the generation is outside of the allowed threshold or if upon office evaluation of testing data collected during the onsite witness test it is determined that the system is not meeting the requirements, APC may request the system be immediately disconnected until appropriate measures are taken to the satisfaction of APC.

Upon successful completion of all parts of the required witness testing, the witness testing team will complete a witness testing report and provide the report to APC marketing department to be included in the final executed documents.

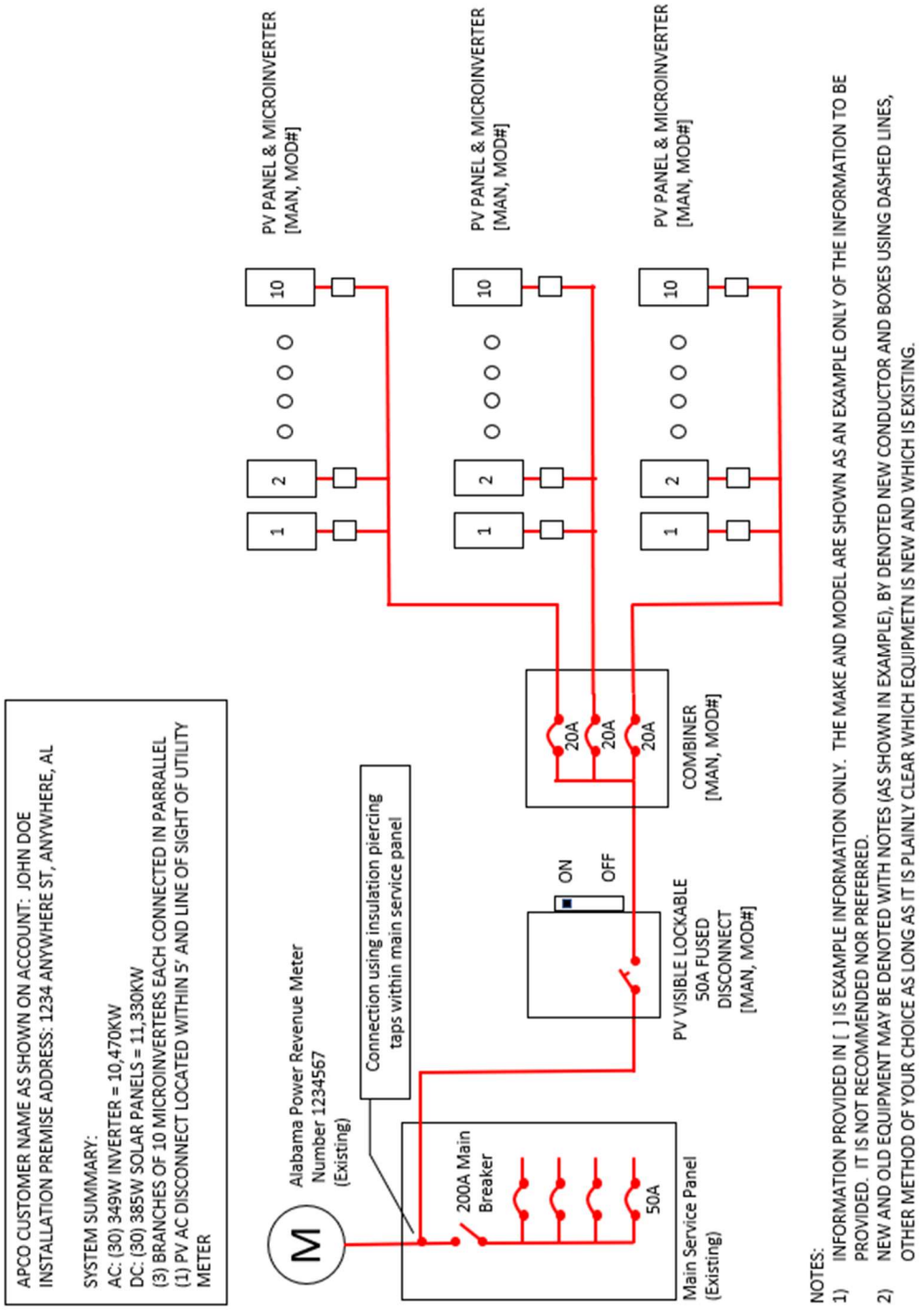
Appendix 1. Single line diagram examples

Example 1. PV only with microinverters connected to breaker in existing breaker in main service panel.



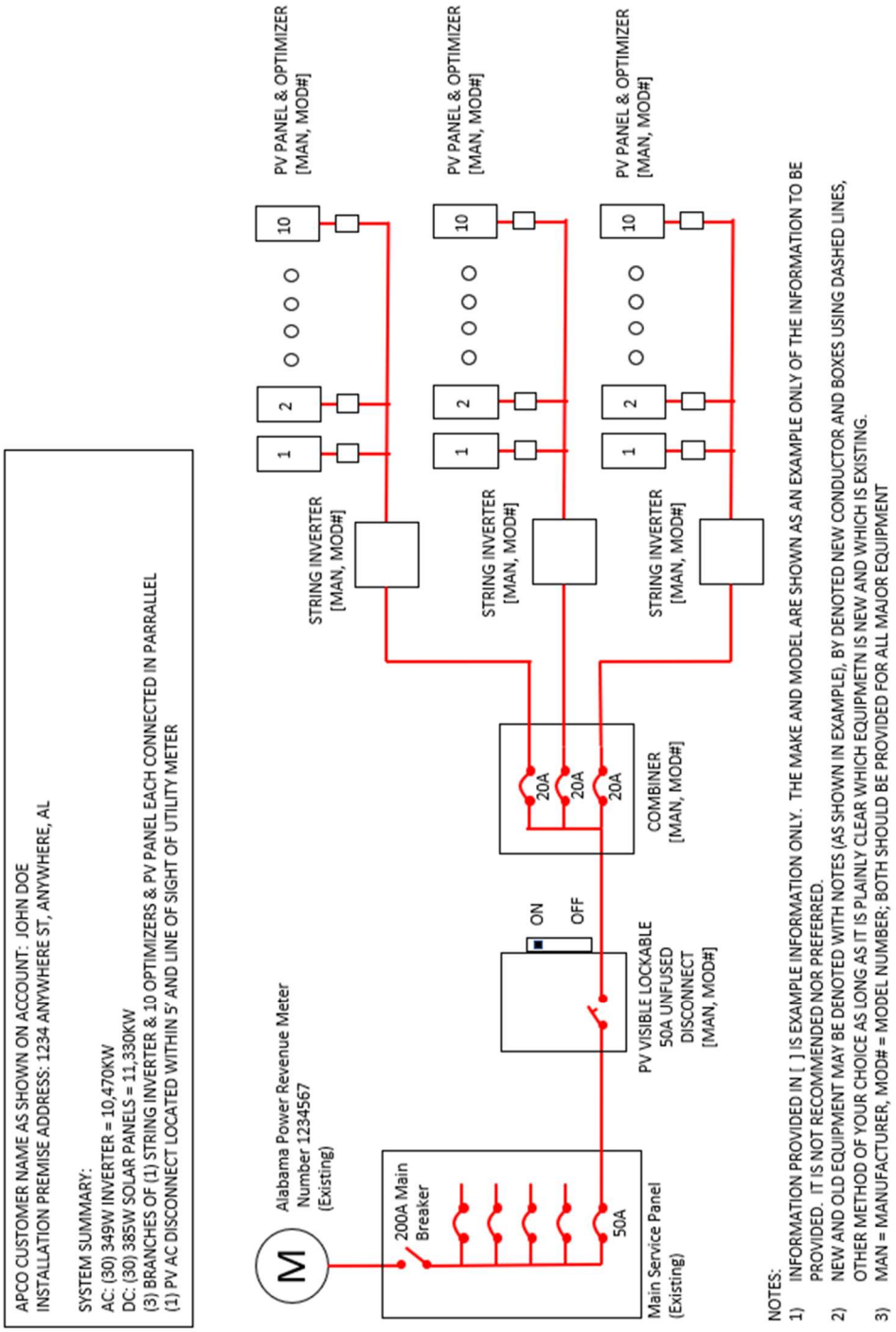
Appendix 1. Single line diagram examples

Example 2: PV only with insulation piercing tap within customer main service panel.
Connection not allowed within APC utility meter socket.



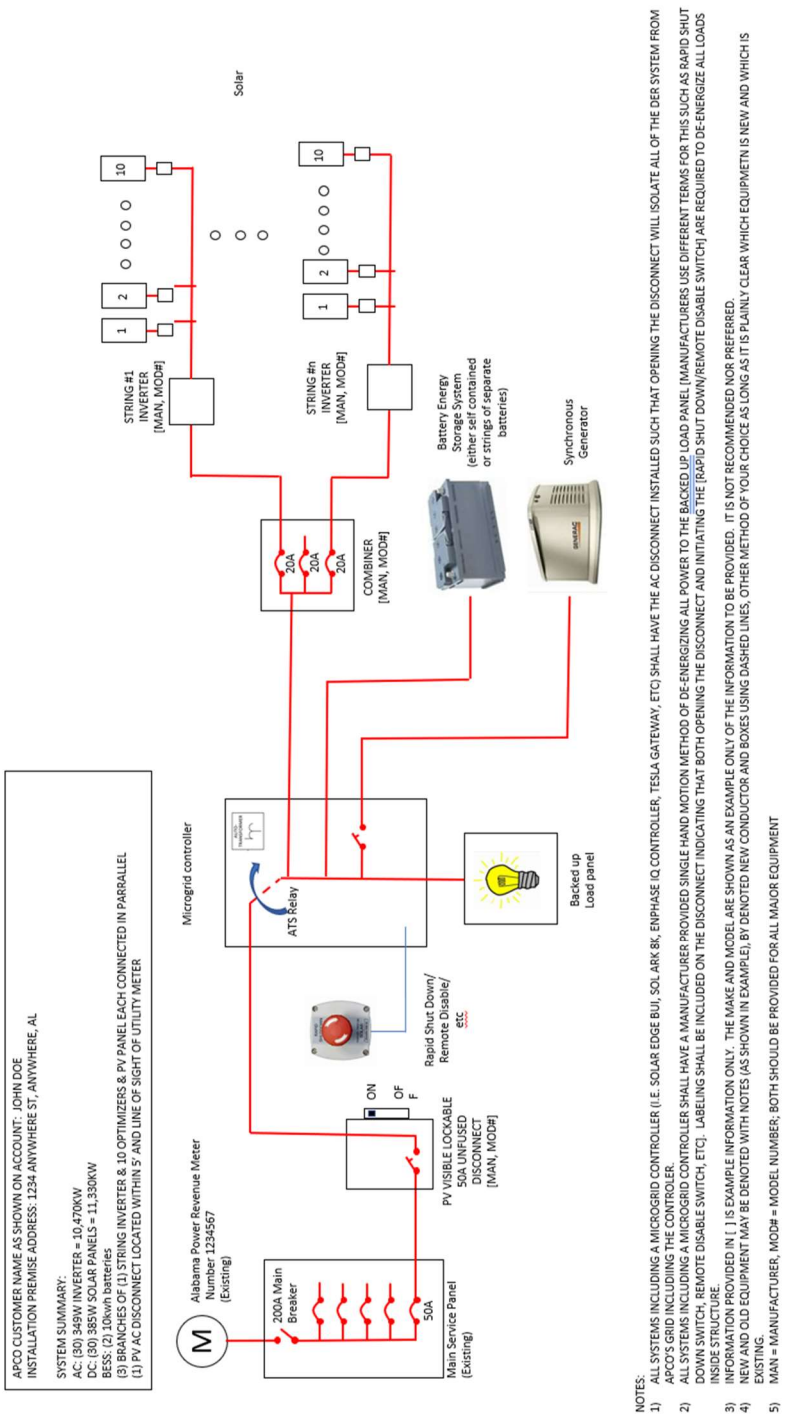
Appendix 1. Single line diagram examples

Example 3: PV only with string inverters connected to breaker in existing breaker in main service panel



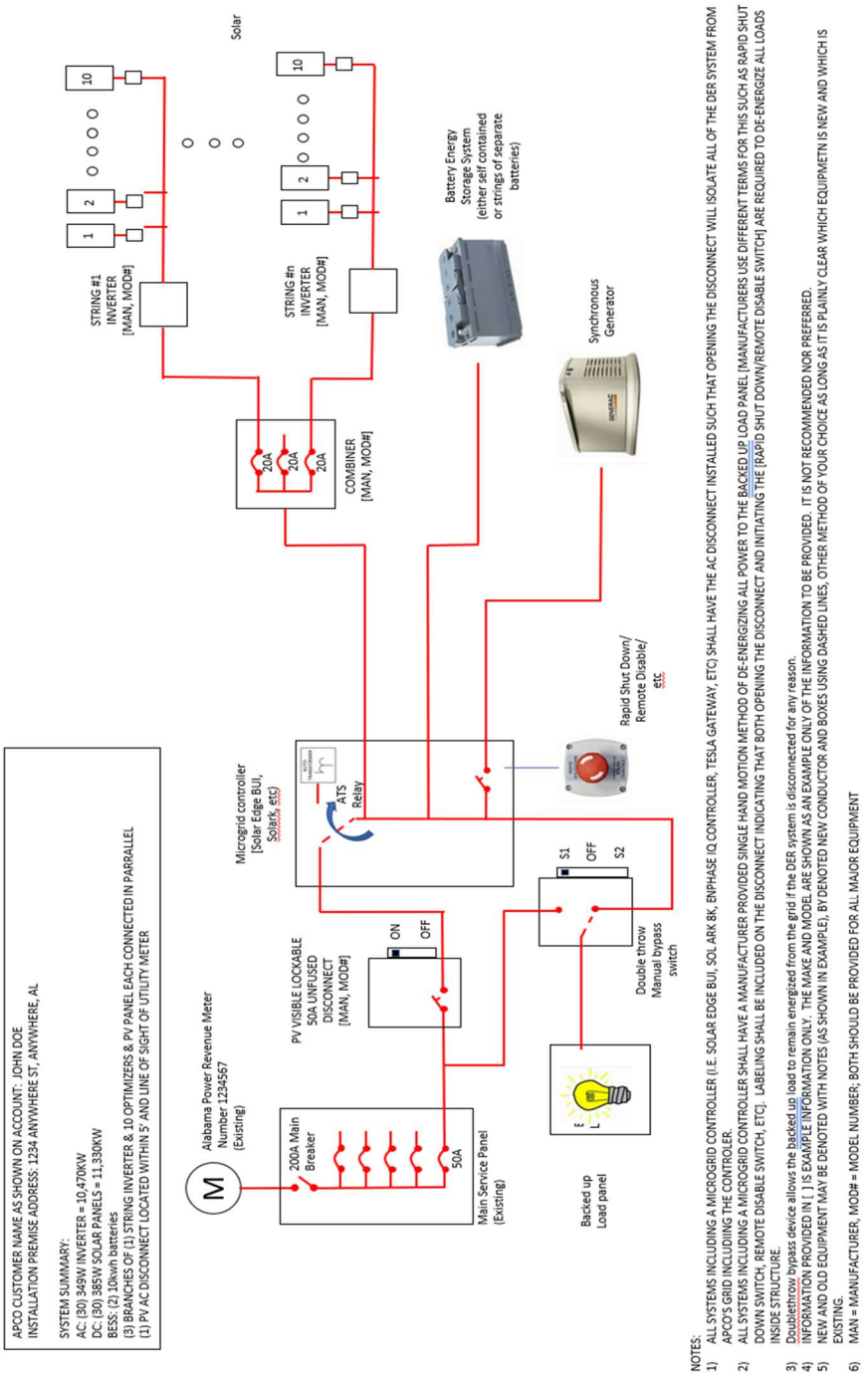
Appendix 1. Single line diagram examples

Example 4: Microgrid Interface Device (MID) with PV + Battery + synchronous generator; with string inverters connected to breaker in existing breaker in main service panel

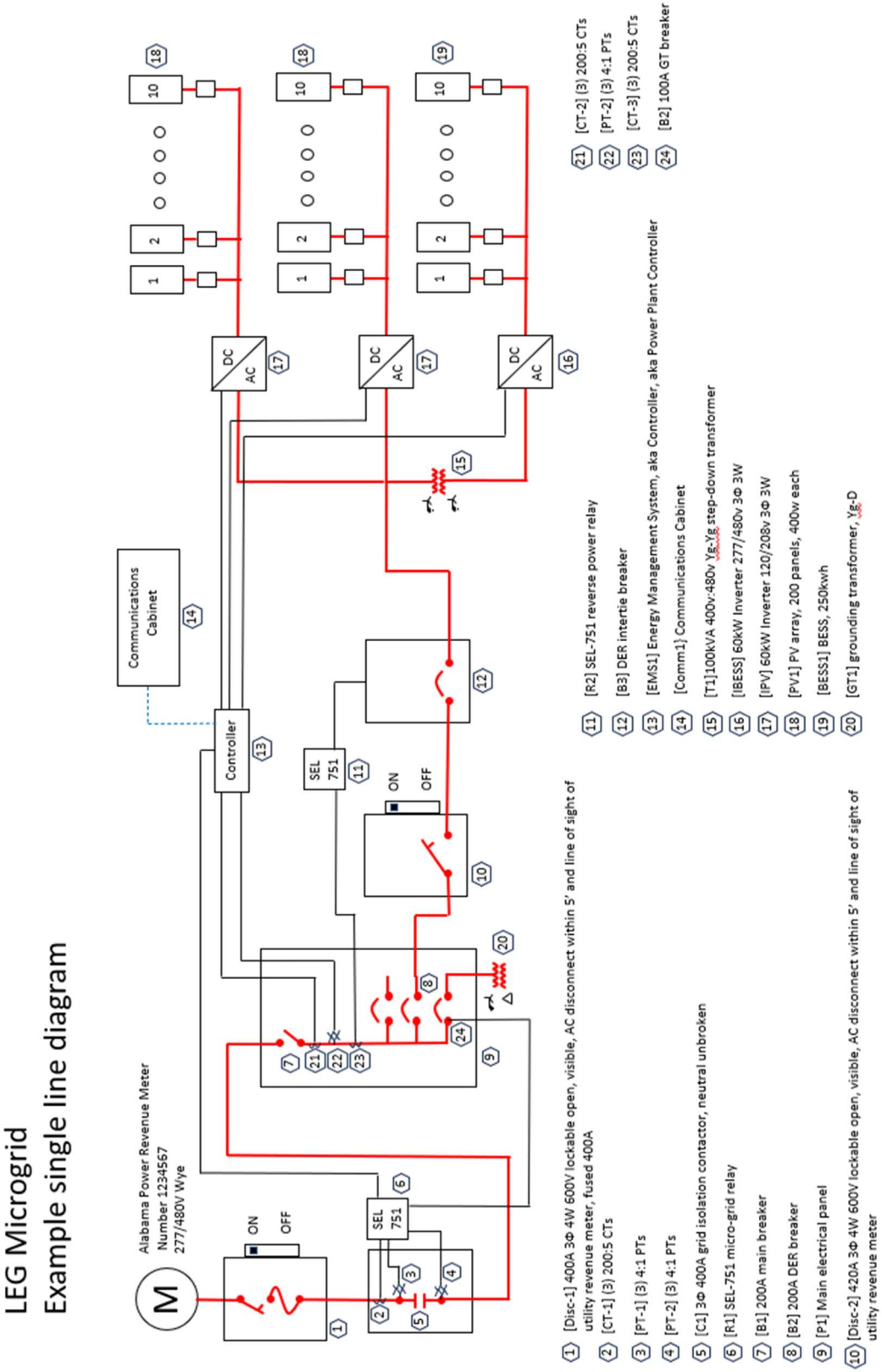


Appendix 1. Single line diagram examples

Example 5: Microgrid Interface Device (MID) with PV + Battery + synchronous generator; with string inverters connected to breaker in existing breaker in main service panel; with doublethrow manual bypass switch to energize backed-up load when DER system is offline

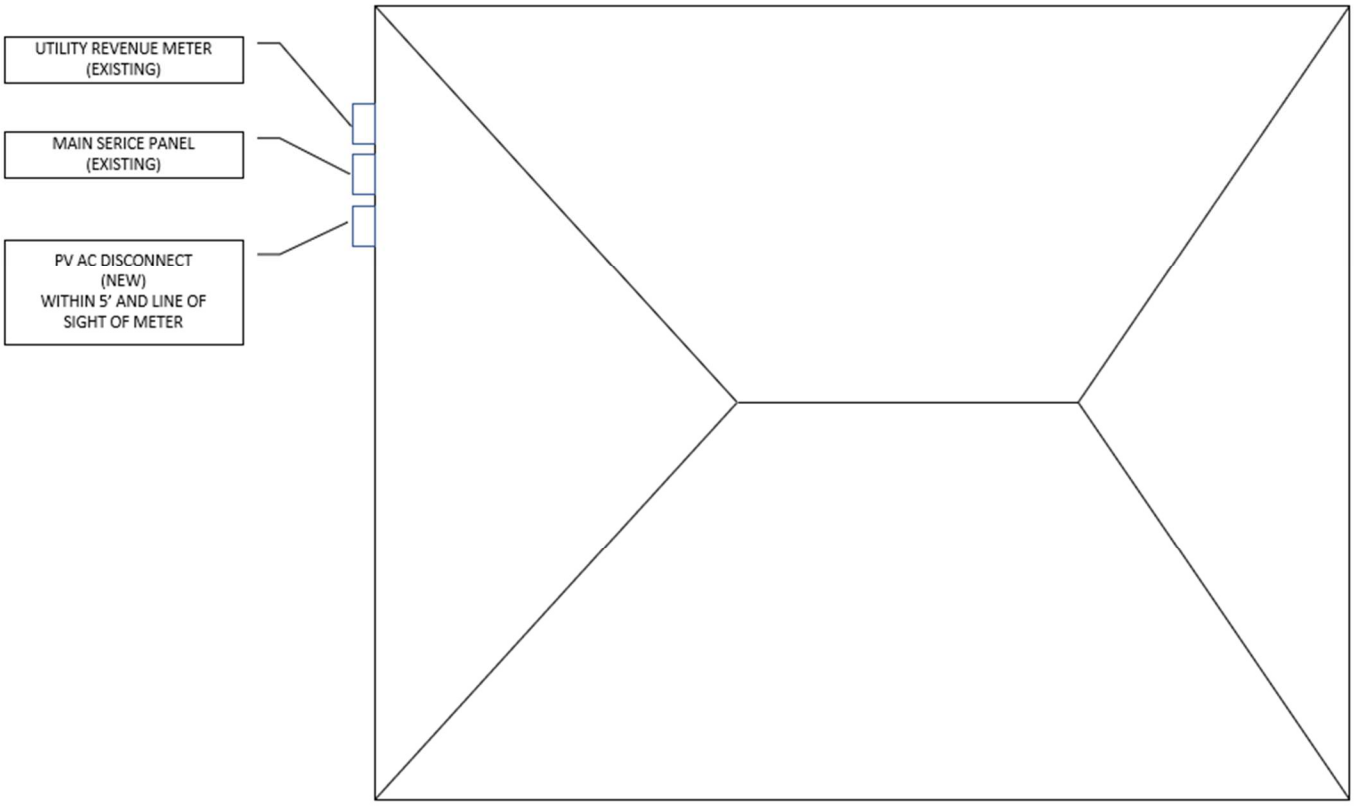


Appendix 1. Single line diagram examples
Example 6: LEG microgrid.



Appendix 2. Site plan examples

Example 1: Hand drawn, or computer generated



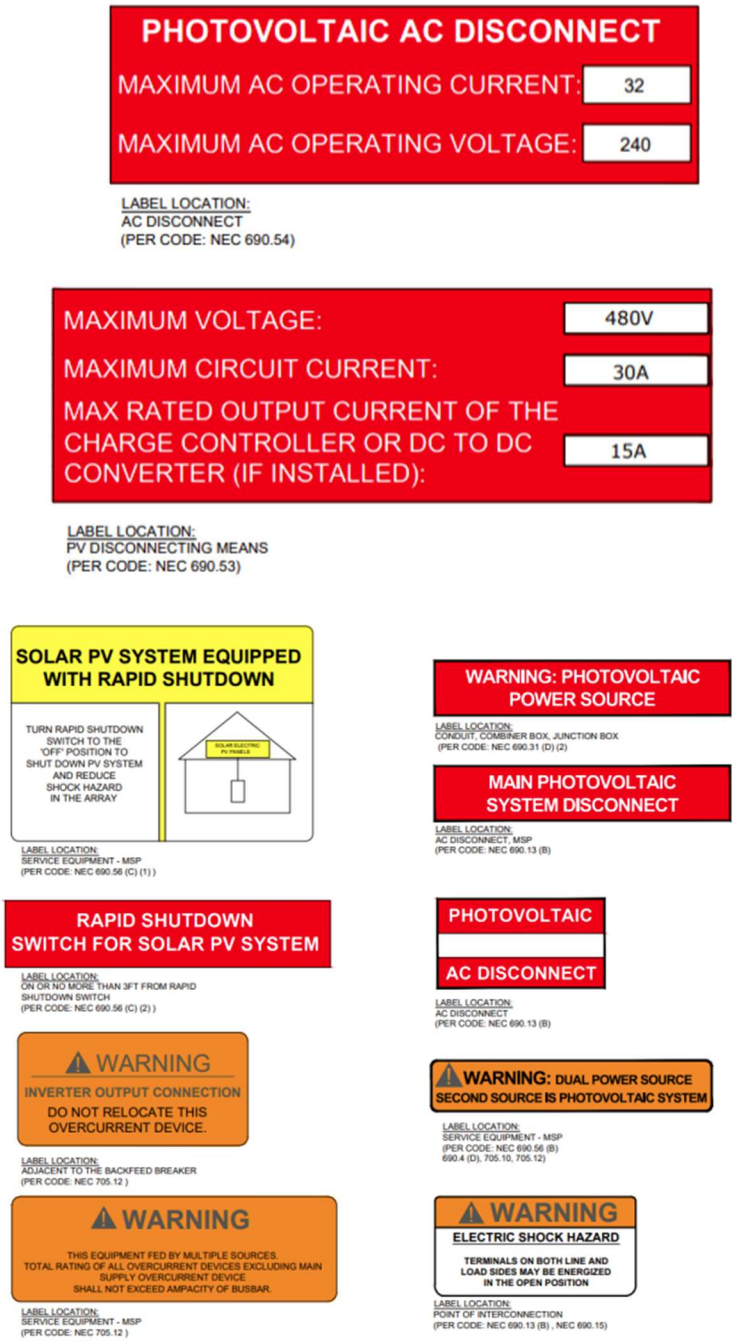
Appendix 2. Site plan examples
Example 1: Aerial picture with labeling added

Appendix 3. Intentionally left blank

This appendix intentionally left blank.

Appendix 4. Labeling examples

Example 1: Typical labeling packet



Appendix 4. Labeling examples

Example 2: Placard required at meter socket if AC disconnect is located more than 5’ from or not within line of sight of utility revenue meter

Located on meter socket (or within 3’ of meter socket)

Appendix 4. Labeling examples

Example 3: Placard required at meter socket if AC disconnect is located more than 5’ from or not within line of sight of utility revenue meter and if more than one (1) disconnect

Example of correct labeling

Appendix 4. Labeling examples
Example 4: Placard required on each AC disconnect if more than one (1) AC disconnect exists

DISCONNECT #1 OF 2
DISCONNECT #2 LOCATED ON EAST END OF SOUTH WALL

Located on disconnect #1

DISCONNECT #2 OF 2
DISCONNECT #1 LOCATED ON NORTH END OF WEST WALL

Located on disconnect #2

Disconnects numbering in the field and on the single line diagram should match.

Example of correct labeling on disconnect.

Appendix 4. Labeling examples
Example 5: Labeling for Emergency Stop switch

Appendix 5. Picture examples

Example 1: Pre installation picture of existing meter and main service panel

Appendix 5. Picture examples

Example 2: Post installation picture of meter socket and newly installed PV AC disconnect

Appendix 5. Picture examples
Example 3: Picture of Emergency Stop placed near AC disconnect

Appendix 6. Sample Test Plan example

Example 1: Sample Test Plan for the single line diagram shown in Appendix 1, Example 6.

FEG witness test plan

9.1.1 – General inspections

1. Installer will show APC representative location of AC disconnects [Disc-1] & [Disc-2].
2. Installer will show APC representative required labeling is present on [Disc-1] & [Disc-2].
3. Installer will show APC representative location of all inverters and APC representative will take pictures of the nameplate of each inverter in PV array [PV1-PVn] where n=# of inverters in system.
4. Installer will show APC representative the location of all major equipment [Disc-1, R1, P1, Disc-2, B3] to allow APC representative to confirm system is built as shown in the provided as-built drawings.
5. Installer will open transformer [T1] allowing APC representative to examine and take pictures of the transformer nameplate and conductor connections.
6. Installer will utilize the HMI of the inverter to demonstrate the settings in the inverter matches the setting report provided to APC on a random sampling of inverters chosen on site by the APC representative in PV array [PV1-PVn} where n=# of inverters in system.

9.1.2 – 3Φ Disconnect test

1. Installer will open the cover of AC disconnect [Disc-2] and allow APC representative to connect PQ monitoring equipment to the terminals in the disconnect. Installer will assist APC representative if needed.
2. Installer will open the AC disconnect [Disc-2]
3. APC presentative to verify the DER ceases to generate within 2 seconds.
4. APC representative will wait a minimum of 7 minutes, and then at their discretion will request installer will close the AC disconnect.
5. APC representative to verify the DER waits a minimum of 5 minutes after the disconnect is closed before beginning to generate and then after beginning to generate follows the require ramp up rate.

9.1.3 – Open phase test

1. Installer will curtail DER output to the minimum allowable for each inverter provided by the manufacturer or 5%, whichever is greater. This shall be no more than 20%.
2. Installer will confirm that all load is disconnected.
3. Installer will notify facility is ready to begin test.
4. The APC representative will open A phase only at the PCC.
5. APC presentative to verify the DER ceases to generate within 2 seconds.
6. APC representative will wait a minimum of 7 minutes, and then at their discretion will close phase A.
7. APC representative to verify the DER waits a minimum of 5 minutes after the disconnect is closed to beginning to generate.
8. Steps 1-4 above will be repeated for open phase B only and open Phase C only.

9.1.4 – Overvoltage test

1. Installer will demonstrate that all inverters are producing at least 85% of nameplate rated power.
2. Installer will confirm all load is disconnected.
3. A power recorder provided and operated by APC will be installed to monitor the voltage and set to record.
4. A 3Φ switch will be opened. If a PCC recloser is installed, it will be utilized
5. Test will be repeated two (2) additional times.

LEG Witness test plan

9.2.1 – General inspections

1. Installer will have the electrical panels removed necessary to show APC representative the CTs [CT3], relays[R2], and associated circuits between the equipment.
2. Installer will utilize the relay [R2] HMI to show the APC representative the settings in the relay match those provided in the relay report for a random selection of settings chosen on site by the APC representative.
3. Installer will connect APC monitoring equipment as instructed by the APC representative. 9 (Where will this be, in P1?)

4. Installer will utilize the relay HMI APC representative will verify the power parameters measured by the APC monitoring equipment matches those shown on the relay HMI.

9.2.2.a – Normal Operations Test
1. Installer will connect a secondary injection kit provided by the installer to relay [R2]
2. Installer will set the secondary injection kit to inject forward direction operating amps and volts typical of the system.
3. Installer will demonstrate on the relay [R2] HMI that the volts and amps read by the relay match those injected by the test kit.
4. DER intertie breaker [B3] should not trip

9.2.2.b – Export Violation Test
1. Installer will inject nominal 3 phase voltage and 0.255 Amps for 60 seconds => breaker [B3] will not trip (85% of pickup)
2. Installer will inject nominal 3 phase voltage and 0.285 Amps for 60 seconds => breaker [B3] will not trip (95% of pickup)
3. Installer will inject nominal 3 phase voltage and 0.315 Amps breaker [B3] will trip after 30 seconds (105% of pickup).

9.2.2.c – Fail safe Operation Test
1. Installer will remove the power source for the relay [R3] => breaker [B3] will trip
2. Installer will remove the power source for the whetting voltage of breaker [b3] => inverters revert to minimal output

9.2.2.d – Event Reporting Test
1. Within 2 business days after testing, installer will provide event reports from relay [R2] for trips generated by above trips

Microgrid Witness Test
9.3.1.a
1. Installer will command the microgrid to begin microgrid operation => microgrid islands and begins operation without adversely affecting the APC system
2. Installer will command the microgrid to exit microgrid operation => microgrid ends operation and reconnects to the APC system without adverse effect

9.3.1.b
1. Installer will request APC representative to open phase “A” only on the APC system => microgrid will recognize loss of phase and automatically isolate from the distribution system within two (2) seconds.
2. Installer will request APC representative to close phase “A” returning the system back to normal state => after a minimum of a 5 minute delay, the microgrid will recognize the APC is back normal, end microgrid operation, and reconnect to the APC system without adverse effect.
3. Steps 1 & 2 above will be repeated with phase “B” only and phase “C” only.

9.3.2.a
1. Installer will remove power from the microgrid isolation device control relay and demonstrate that the DER system will maintain the same IEEE1547-2018 functionality as required during interconnected operations or shall be rendered inoperable when commanded to begin microgrid operation.
2. Installer will remove shunt trip power from the microgrid isolation device and demonstrate that the DER system will maintain the same IEEE1547-2018 functionality as required during interconnected operations or shall be rendered inoperable when commanded to begin microgrid operation.
3. Installer will prevent the grid isolation device from opening and then command the microgrid to begin operation and demonstrate that the DER recognizes the failure of the grid isolation device to open, and the DER system will maintain the same IEEE1547-2018 functionality as required during interconnected operations or shall be rendered inoperable.

Appendix 7. Microgrid Sequence of operation example

Example 1: Microgrid sequence of operations for the single line diagram shown in Appendix 1, Example 6.

Commanded transition to Microgrid operation

1. Operator initiates commanded transition from utility power to microgrid.
2. Controller commands grid isolation device relay [R1] to open.
3. Relay [R1] opens grid isolation device [C1]
4. Controller verifies zero voltage on microgrid bus [PT2] and position indicated on grid isolation device [C1] indicates open.
5. Controller places inverters into grid forming mode.
6. Controller commands BESS inverter to begin generating.
7. Controller manages system energy sources and load within the microgrid.

Commanded transition to end microgrid operation

1. Operator initiates command to transition from microgrid to utility power.
2. Controller commands all inverters to cease to energize.
3. Controllers command all inverters to enter grid following mode
4. Controller verifies zero voltage on the microgrid bus [PT2]
5. Controller commands grid isolation device relay [R1] to close grid isolation device
6. Relay [R1] closes grid isolation device.

Automatic transition from utility power to microgrid operation due to loss of utility power

1. System recognizes loss of utility power within 2 seconds by monitoring voltage on PTs [PT1]
2. Inverters cease to energize per IEEE1547 requirements.
3. Controller verifies zero voltage on microgrid bus [PT2] and position indicated on grid isolation device [C1] indicates open.
4. Controller places inverters into grid forming mode.
5. Controller commands BESS inverter to begin generating.
6. Controller manages system energy sources and load within the microgrid.

Automatic transition from microgrid operation to utility power

1. Controller recognizes return of utility power by monitoring voltage on PTs [PT1]
2. Controller waits 5 minutes after recognizing return of utility power.
3. Controller commands all inverters to cease to energize.
4. Controller command all inverters to enter grid following mode.
5. Controller verifies zero voltage on the microgrid bus [PT2]
6. Controller commands grid isolation device relay [R1] to close grid isolation device
7. Relay [R1] closes grid isolation device.

Appendix 8. Authorization to Mark letter example

Example 1: Authorization to Mark letter provided by the manufacturer. This is typically not on their sales website but must be obtained directly from the manufacturer.

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AUTHORIZATION TO MARK

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listee model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant:	[redacted]	**Manufacturer:**	[redacted]
Address:		**Address:**	
Country:		**Country:**	

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services Shenzhen Limited Guangzhou Branch

Control Number: *5016924* **Authorized by:** for L. Matthew Snyder, Certification Manager

C ETL LISTED US
Intertek

This document supersedes all previous Authorizations to Mark for the noted Report Number.

Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2010 Ed.2+R:16Sep2020] Power Conversion Equipment [CSA C22.2#107.1:2016 Ed.4] Interconnecting Distributed Resources With Electric Power Systems (R2008) [IEEE 1547:2003] Amendment 1 to IEEE 1547 - Interconnecting Distributed Resources With Electric Power Systems [IEEE 1547a:2014] IEEE Standard Conformance Test Procedures For Equipment Interconnecting Distributed Resources With Electric Power Systems [IEEE 1547.1:2005]
Product:	Utility-Interactive Micro Inverter
Brand Name:	[redacted]
Models:	[redacted]

ATM for Report 191120006GZU-001 Page 1 of 1 ATM Issued: 17-Aug-2022
ED 16.3.15 (16-Oct-2021) Mandatory

Version Number	Effective Date	Author	Owner	Major Revision Topics
1.0	07/01/2024	Rankin Rouse	PD-Interconnections	Original

Revision Table