Alabama Power Company

Distributed Energy Resources

Technical Interconnection

Requirements Guidebook

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Systems less than or equal to (≤) 100kW

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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Systems greater than (>) 100kW

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): Also known as the Point of Connection (POC) in IEEE1547-2018. 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.

POC (Point of Connection): See POI (Point of Interconnection).

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)

Vehicle to Home (V2H): Energy stored in a Battery Energy Storage System (BESS) onboard a vehicle is utilized to provide power to all or a portion of a facility during an APC distribution system power interruption. At all times when power is exported from the V2H system, a separation is maintained from the APC distribution system by use of a Microgrid Interface Device (MID) meeting the requirements provided in section 6.4 of this Guidebook.

Vehicle to Grid (V2G): Energy stored in a Battery Energy Storage System (BESS) on board a vehicle is utilized to provide power to all or a portion of a facility while operating in parallel with the APC distribution system, without a physical separation between the vehicle BESS and the APC distribution system. V2G system may or may not export power to the APC distribution system.

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. Quantity of inverters, nameplate capacity of each inverter, total inverter kW AC nameplate capacity
b. Quantity of batteries, total kWh rating of battery system, maximum charge and discharge rate of battery system (if applicable)
c. Must clearly indicate which equipment is existing and which equipment is new. For example, if the meter socket and main service panel are existing and will not be replaced, this should be indicated differently than the DER equipment, which is all new. If the main service panel is to be replaced, it should be indicated as new.
d. If the application is for a revision to an existing DER, the entire DER must be shown and must clearly indicate which equipment is existing and which equipment is new. For example, if a battery is being added to an existing PV installation, then the SLD must show the battery components as new and the PV as existing.
e. Manufacturer and model number of all major equipment to be installed (including, but not limited to inverters, batteries, MIDs, and PCS controllers)
f. Customer owned transformer size(s), voltages, impedances, and winding configurations (if applicable)
g. AC Disconnect(s) must state all of the following:
    i. Is lockable in the open position.
    ii. Has visible load break (may be stated as visible blades).
    iii. The mounting location in reference to the utility revenue meter
        (1) If the AC disconnect is within 10' AND line of sight of the utility revenue meter, this must be stated.
        (2) If the AC disconnect is not within 10' AND line of sight of the utility revenue meter, additional labeling is required. See section 6.2 for more details.
    iv. For more detailed information for the requirements of the AC disconnect, see section 6.1.
h. 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.
i. 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 manufacturers 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.
j. While a computer-generated single line diagram is preferred, for Tier I systems an easily legible hand drawn single line diagram is acceptable. Computer generated is required for Tier II or Tier III systems.
k. System designs of greater than (>) 100kW must be stamped by a licensed professional engineer registered in the State of Alabama
l. CT, PT, and relaying information (if applicable, typically for systems over 100kW)
m. 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, PV system only disconnect (if required) and the 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. 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.
   iii. If the inverter is not shown on the CA-21 website to be UL1741 certified, an Authorization to Mark letter of certification will be required to be provided which can be obtained from the manufacturer.
b. 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 shown on the CA-21 website to be UL1741 certified, an Authorization to Mark letter of certification will be required to be provided which can be obtained from the manufacturer.
c. 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.
d. PCS controller
   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 PCS controller is not shown on the CA-21 website to be UL1741 CRD PCS or UL3141 certified, an Authorization to Mark letter of certification may be required to be provided which can be obtained from the manufacturer.

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 requirements 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

The following photographs of existing equipment are required to be submitted along with the interconnection application:

a. Existing utility revenue meter showing an area of 10' on all sides of the meter.
b. 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.
c. Close-up of the revenue meter with meter number legible.

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 to isolate the DER owner equipment from the utility distribution system in the event the DER was 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, is designed to not export power to the APC distribution system, and is UL1741 certified will not require a separate AC disconnect as long as a main disconnect or circuit breaker is external, within 10' 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. 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 7.

6.1.7. Be located within 10' and line of sight of the utility revenue meter **OR** have labeling as required by section 6.2.2 of the labeling requirements section.

6.1.8. 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 (See Appendix 4, example 1, label A)

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 ten feet (10') from **OR** not within line of sight of the utility revenue meter. BOTH conditions must be met to omit this labeling. If the AC disconnect is located more than 10' from the meter but is within line of sight, this labeling is required. If the AC disconnect is located less than 10' from the meter but is not within line of sight, this labeling is required. (see Appendix 4, example 1, label C and example 2).

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. In leu of the engraved letters and wording description, the placard may contain a picture of the facility indicating at minimum the location of the utility meter and AC disconnect. (See Appendix 4, example 2b)
d. 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 AC disconnect must be opened to completely separate the DER system from the APC system (See Appendix 4, example 1, label D, E, and F, example 3, and example 4)
a. A placard affixed to or near the meter socket shall show the location of all disconnects. The label at each disconnect shall also indicate the total number of disconnects and the location of the other disconnects, as required by the NEC.

6.2.4. Required if only 1 AC disconnect is required to completely separate the DER system from the APC system, but other AC disconnects are included in the design for use within the DER system. See Appendix 4, example 1, label B and example 6)
a. The AC disconnect to be used by APC to completely separate the DER system from the APC system must be labeled "For utility use" or similar, to clearly indicate which disconnect is to be opened by the utility. It must have "Utility" in the language of the label.

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 at the nearest practical point to the location of the line side tap, not to exceed 10'. 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, size, and location 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.

i. Note: Some customers contract with APC to perform emergency repairs and/or routine maintenance on customer owned distribution systems. If the customer has such contract with APC, then APC must approve the connection PRIOR to installation and modify such contract as necessary.

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 study costs and protective measures. See section 6.5 for additional information.

(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 and site plan. See Appendix 1, Example 6, 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. Transformer winding configuration

6.5.1. DER system 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 required for ATM and BTM installations. These winding configurations do not hinder the ability to meet the requirements of IEEE1547-2018 and minimize adverse effect on the APC system, therefore minimizing interconnection protection requirements and costs.

Exceptions will be considered on a case-by-case basis where a technically sound reason is presented for use of an alternate winding configuration. Usage of any other winding configuration is likely to require additional study fees and additional protection requirements. Approval of the use of an alternate winding configuration will be the sole discretion of APC.

Transformer winding configuration may not provide a zero-sequence ground source on the APC system during interconnected operation.

6.5.2. Single phase inverters in three phase system

A DER system comprised of single-phase inverters shall not be installed on three phase services and arranged to create a three phase DER system. For example, three single-phase 10kW inverters cannot be installed in a connected manner to create a 30kW three phase DER system. Doing so can create unbalance issues if one or more but not all inverters trip and can also create momentary voltage issues if all 3 inverters trip but not at the exact same time.

Single phase DER may be installed on a three-phase system if the three-phase load is minimal, such as in a residential home with only a three phase HVAC unit, in order to offset the single-phase load. If more than one inverter is installed, all inverters must be installed between the same phases so that if any one, multiple, or all trip, the current between the phases remains balanced. For example, two inverters could be installed connected to phase A and phase C, but could not be installed with one connected to phases A and B and one connected to phases B and C. A singe phase DER system may only be connected to Open Wye – Open Delta banks (two transformers are used to create a three-phase service).

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 the capability to export greater than or equal to (≥) 250kW.

Per IEEE 1547-2018 Section 10, the DER must have provisions for a local DER interface capable of communication to support the information exchange requirements specified in the standard for all applicable functions supported by

the DER. This provision must be a local, physical, interface and may not be remote or cloud based. APC must be able to independently and remotely exchange information with the DER at any time, either continuously or intermittently at APC's sole discretion, without necessary intervention by any other party or physical access on-site. Exchange of information must always be available to APC. APC must be able to communicate with the DER system to set, control, collect information, and manage functions in the DER system remotely by use of a Company owned gateway as further defined below.

APC will provide a communication cabinet (hereinafter referred to as a gateway but also may be referred to as an energy management device in other documents) measuring no larger than 36" tall, 24" wide, and 18" deep and weighing no more than 50lbs. The gateway and all equipment within shall be the property of APC and will remain locked with an APC owned padlock after commissioning. No customer owned equipment may be placed inside or pass through the gateway. The gateway 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, APC will mount the gateway on the Company owned pole for the PCC recloser or primary meter or APC may opt, at APC's sole discretion, to place necessary communication equipment within other control or metering equipment of APC and forego the use of a dedicated gateway cabinet. In this situation, the Company will provide power to the communications equipment housed within the gateway. The method of providing power will vary based on site specific equipment and Company policy.

Unless a PCC recloser is installed or the DER is metered overhead at greater than 600 volts, the DER Owner is responsible for securely installing the gateway at the nearest practical location to the Company's revenue meter, in a mutually agreed-upon and readily accessible location for the Company. The DER Owner will be responsible for providing a 120 volt AC circuit with a minimum ampacity of 15 amps and a disconnect fused at 15 amps to be placed within 24" of the gateway, installed in accordance with applicable codes. The gateway will be provided with three (3) feet of ½" flexible conduit tail and #12awg copper conductor which the DER owner shall connect and terminate in the fused disconnect. The fused disconnect shall be the point of demarcation and the DER owner will provide, own, install, and maintain the fused disconnect and all other equipment required to provide the 120 volt circuit for the APC gateway. APC will provide, own, and maintain the ½" flex conduit and #12awg copper conductor from the fused disconnect to the gateway. The 120 volt circuit to the fused disconnect shall be left energized, with the fused disconnect in the open (off) position. APC shall have the right to operate the fused disconnect as needed for safe and reliable operation of the gateway.

For other unique installations, the gateway will be placed at a mutually agreed upon location. Gateway 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 gateway location, the DER owner shall provide, install, own, and maintain a communication medium acceptable to the Company from the DER system interface to the gateway. Fiber is the only acceptable medium at the point of demarcation. Fiber termination and fanning shall be in a fiber splice box external to the gateway, but within 24" of the gateway, as shown in Appendix 9. Termination within the fiber splice box shall be a minimum 3 pair single modal fiber and terminated with a ST female termination block for connection of APC fiber. The transmit and receive fiber shall be clearly marked. The gateway will be provided with three (3) feet of ½" flexible conduit tail which the DER owner shall connect to the fiber splice box. The fiber splice box shall be the point of demarcation and the DER owner will provide, own, install, and maintain the fiber splice box and all other equipment required to provide the fiber termination for APC. APC will provide, own, install, and maintain the fiber jumper from the fiber splice box to the gateway. APC shall have the right to access the fiber splice box as needed to facilitate termination of APC's fiber jumper.

Attachment of fiber to Company poles is subject to Company specific requirements. A paid up front lease fee per pole will be required to prepay pole space rental for 20 years. 2025 cost is approximately $1,100/pole. Cost may be adjusted as needed and exact cost will be provided for each project. Details of physical space allotment and pole

specification is provided in Appendix 10. Additional costs will apply if modifications are required to provide space for fiber attachment.

The DER owner shall provide the proposed location of the gateway to APC during design. APC will perform a communications signal test to ensure sufficient signal strength for the reliable operation of the APC's communication equipment at the location of the gateway prior to providing the gateway for installation. If sufficient signal strength is not obtainable at the proposed gateway location, an elevated antenna may be required to provide sufficient signal strength. If the gateway 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 also be required to install flexible conduit with coax preinstalled provided by APC from the elevated antenna to the gateway.

6.6.1. Power Plant Controller (PPC) requirement

The local DER interface must support APC's ability to receive DER system monitored information, remotely enable or disable permit service, change the active power level, and provide alarm status for non-matching settings or communication issues. To support this objective, DER systems with multiple DER units and supplemental DER devices capable of exporting 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 RPA.

6.6.2. Communication Protocol and Protocol Converter

The DER owner is responsible for providing, installing, owning, programming, and maintaining all necessary equipment to ensure continuous, active communication between the DER system and the APC gateway. This communication must utilize DNP3.0 protocol and conform to the standard communication parameter point map specified in the APC DER Pointmap (hereinafter referred to as the "Pointmap"). This setup must support active monitoring and management as outlined in Sections 6.6.3 through 6.6.6 below.

6.6.3. Pointmap

The Pointmap will be provided by APC as a separate file or may be placed on the APC website.

The DER system will be designated as small or large based on the decision tree provided in IEEE1547-2018, Annex H, Figure H.1 & H.2. Systems designated as Large are required to implement all parameters specified in the Pointmap. Systems designated as Small are not required to implement parameters marked specifically for Large systems in the "Systems Required" column. However, APC reserves the right to require any or all parameters designated for Large systems to be implemented on Small systems, at its sole discretion, if deemed necessary.

The parameters in the Pointmap are grouped together and a column entitled "Group" is provided which indicates the name of the group of each set of parameters. The groups will be used throughout this document to indicate which settings are required When a group name is provided, it is understood that all parameters designated by the Pointmap to be in that group are required by inclusion of the group name.

6.6.4. Monitored Information

The DER owner shall allow APC to actively monitor specific nameplate and functional ability of the DER system as specified in the Pointmap as groups *nameplate* and *supported functions*.

The DER owner shall allow APC to actively monitor, in real time, specific electrical measurement parameters pertaining to the DER system as specified in the Pointmap as groups *metering-system*, *metering-PCC*, and *alarm*. Data provided to APC shall be updated to actual value of DER system at a rate of no less than once every thirty seconds.

The DER owner shall identify any one (1) inverter of their choice to be designated “Reference Inverter”. The DER system shall be designed such that all parameters pertaining to the DER system as specified in the Pointmap in groups *enter service*, *voltage trip*, *frequency trip*, and *frequency droop* are displayed as set in the Reference Inverter. Data provided to APC shall be updated to actual value of DER system at a rate of no less than once every thirty seconds.

The DER system shall compare each individual setting displayed as shown in the Reference Inverter to the identical setting of all other inverters in the DER system, and if any inverter has a setting that does not match the setting in the Reference Inverter, an alarm shall be triggered, indicated as “alarm_settings” in the Pointmap. Any mismatch of any setting in any inverter shall trigger this alarm.

Further, if the PPC loses communication with any inverter for 30 seconds or more, then an alarm shall be triggered, indicated as “alarm_com” in the Pointmap and the active power limit shall automatically be reduced as specified in the Lost Communication Protocol.

APC will communicate only with the PPC. By means of communication with only the PPC: 1) All monitored parameters shall be aggregated for the DER system and presented to APC as a single value for the DER system 2) All settings for the Reference Inverter shall be displayed individually to APC and 3) The alarm statuses shall be displayed to APC.

6.6.5. Managed Parameters

The DER owner shall allow APC to actively manage the permit service and active power limit parameters. Settings will be maintained in accordance with the Interconnection Agreement between APC and the DER owner. The ability to enable and disable permit service and to change the active power limit shall be available to APC by means of communication with only the PPC.

The DER system shall respond to the disabling of permit service and shall cease to energize and trip in no more than 2 seconds. The DER system shall respond to the enabling of permit service within 2 seconds and adhere to the required ramp rate while returning to production.

For a decrease in the active power limit setting, the DER system shall initiate curtailment of active power export to at or below the designated limit within 2 seconds, adhering to the required ramp rate. For an increase in the active power limit setting, the DER system shall initiate escalation of active power export up to but not above the designated limit within 2 seconds, adhering to the required ramp rate.

For DER systems with an APC PCC recloser, failure to respond according to the operating signal within the specified time may result in the APC PCC recloser opening autonomously to disconnect the DER system for the continued safe and reliable operation of the APC system. Once the PCC recloser opens due to a failure of the DER system to respond, it will not be closed until the DER system response failure is remedied to the sole satisfaction of APC or the DER is disconnected. If the DER is BTM (co-located with load), opening of the PCC reclosure will also de-energize the DER owners load by disconnecting total electric service. If the system without an APC PCC reclosure, APC may dispatch personnel to manually open and lock the DER AC Disconnect until the DER system response failure is remedied.

6.6.6. Permit service

If the DER system is capable of exporting 250kW or more real power to the Company distribution system as defined by the APC Guidebook, APC may direct the DER system to *cease to energize* by changing the Permit service setting to "disable" (which will completely disable generation). This could occur during an APC operating condition such as the DER system being provided service from an abnormal circuit configuration, or any other temporary condition as deemed necessary, for the safe and reliable operation of the Company distribution system. This is expected to be infrequent and of short duration.

6.6.7. Active Power Limit

APC will not modify the active power limit outside the bounds provided in the current Interconnection Agreement between APC and the DER owner, except to the extent necessary to maintain safety and system reliability (e.g., an emergency). APC will manage these settings consistent with Good Utility Practice and on a non-discriminatory basis.

6.6.8. Lost Communication Protocol

The DER system shall be programmed with behavior satisfactory to APC in the event of communication failure. Depending on APC's system at the site-specific location and the DER system parameters, this may include a requirement to curtail power production to a level established by APC. 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. 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.

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 and be subject to witness testing to confirm compliance at APC's sole discretion. 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. Inverter based DER system shall have reactive power capability and voltage regulation performance requirements meeting Category B of IEEE 1547-2018 at the RPA.

iii. Inverter based DER system shall have abnormal voltage and frequency ride-through capability performance of Category III of IEEE 1547-2018 at the RPA.

iv. Inverter based DER systems greater than or equal to (≥) 250kw 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), an example of which is shown in Appendix 11. The actual CFF file is a separate excel file that may be downloaded from APC's website or communicated via email.

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 Setting File Creator (SFC) 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]

iii. Currently, most manufacturers do not offer the CFF file as an automated download. Therefore, the expected use of the CFF file is as follows:

(a) DER owner shall work with the manufacturer to ensure all inverters are set with the settings as provided in the CFF file, which is based on the requirements of the SoCo IP.

(b) After inverter installation and programming is complete, the DER owner shall use a blank CFF file to document each applied setting as taken directly from the inverter for those settings held within the inverters. Since all inverters should be programmed the same, only one (1) form is required for the inverter settings.

(c) After PPC installation and programming is complete (if required), the DER owner shall use a blank CFF file to document each applied setting as taken directly from the PPC for those settings held within the inverters

(d) APC will expect two (2) completed, as built, CFF files from the DER owner: 1) Inverter settings 2) PPC settings (if required).

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 and volt-watt 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 for nor compensate the DER owner 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 and UL1741SB for Tier III (if so indicated). Any inverters not on this list may still be approved but will be required to submit an "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. The Authorization to Mark must be obtained by contacting the manufacturer. In most cases, it is not shown on the website. The general specification page, installation manual, or operating manual is not sufficient.

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. It shall also include the sequence of operation for failure of the microgrid isolation device, failure of the microgrid isolation device control, and failure of the microgrid controller (if different from the microgrid isolation device control). 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.

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

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

6.12.3. 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.

6.12.4. 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.

6.12.5. 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.

6.12.6. Emergency Stop

a. A microgrid is designed and installed for the purpose of continuing to provide electrical power to the backed-up load 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 microgrid 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 microgrids are required to incorporate an emergency stop (E-stop) that, when active, will cause the microgrid to cease to energize all loads.
b. To ensure the safety of first responders, APC requires that an emergency stop be installed on all microgrids.
c. The emergency stop must be shown on the single line diagram and site plan. See Appendix 1, Example 8, 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 or APC revenue meter. Picture of proper placement shown in Appendix 5, example 4.
e. This emergency stop must provide instructions on how to activate 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.

See section 9.3.3 for emergency stop witness test requirements.

Transformer winding configuration may not provide a zero sequence ground source on the APC system during interconnected operation. To satisfy this requirement, the grounding source used during islanded operation must be separated from the APC system during operation while interconnected with the APC system.

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.

6.12. Vehicle to (home, grid, etc.)

Vehicle to Home (V2H), Vehicle to Grid (V2G), etc., refers to the use of the Battery Energy Storage System (BESS) inherent to an electric vehicle to export power from the vehicle BESS to energize electric loads external to the vehicle. Their use is similar to other BESS systems with the additional challenge of being mobile (on wheels) so that they may move from place to place and their interconnection location to the APC distribution system may be different from time to time.

Note that incorporation of any other DER component (i.e. solar, stand alone battery, etc) in conjunction with the vehicle battery may disqualify consideration as Vehicle to Home and cause all portions of the Guidebook to apply as applicable for a fully exporting generator.

Below are the requirements for some common scenarios.

6.12.1. Vehicle to home (V2H)

a. See definition section for a description of the meaning of Vehicle to Home
b. Interconnection requirements for V2H
   i. Application shall be made through the normal interconnection process of APC including all technical application requirements as provided in section 5.3 of this Guidebook.
   ii. An external AC disconnect meeting the requirements of section 6.1 of this Guidebook will be required.
   iii. The Microgrid Interface Device providing separation of the vehicle BESS system from the APC distribution system shall meet all requirements of section 6.4 of this Guidebook.
   iv. An emergency stop shall be provided, adjacent to the AC disconnect, per the requirements of Section 6.1.1.
   v. The vehicle inverter is not required to be UL1741 certified since it will not be operating in parallel with the APC system during exportation of power from the vehicle BESS.
   vi. Any exportation of power from the V2H system or the incorporation of any other source with the V2H system that generates power while operating in parallel with the APC system (MID contactor closed) causes system to become V2G.

6.12.2. Vehicle to grid (V2G)

a. See definition section for a description of the meaning of Vehicle to Grid
b. Interconnection requirements for V2G

i. Application shall be made through the normal interconnection process of APC including all technical application requirements as provided in section 5.3 of this Guidebook.
ii. V2G applications must meet all requirements of the SoCo IP and APC Guidebook since it is capable of operating in parallel with the APC distribution system. This includes the requirement for the vehicle inverter to be UL1741 certified.

6.13. Power Control Systems (a.k.a. software limited export or sell to grid limit)

Inverters and MIDs are available which may be set to limit the export of power to the grid to some amount less than the AC nameplate rating. This is commonly referred to as software limited export or sell to grid limit. APC has not previously accepted this as a means to avoid system upgrades required by the full AC nameplate rating due to the lack of a certified standard to provide confidence in the system performance. There are now certifications of UL1741 CRD PCS and UL3141 which certify the operation of this equipment. However, the export limit is known to sometimes revert back to full export during firmware updates and is sometimes readily adjustable by the owner; therefore, APC is not willing to fully accept this equipment without limit. APC will evaluate each scenario and accept this equipment without the requirements of the backup protection required in section 6.9 if reverting to full export for a short duration of time until corrected is not expected to cause immediate and significant adverse effects to the APC system or other customers of APC.

Therefore, the use of UL1741 CRD PCS or UL3141 type PEL (Power Export Limit) certified equipment may be allowed to limit the export of real power to the APC system to an amount less than the AC nameplate, without the requirement of backup protection to the controls as required in section 6.9, at the sole discretion of APC. This will be based on the potential adverse effect to the APC system by unintentional export up to the AC nameplate rating of the inverters at the site specific to the installation. Due to the varying nature of the characteristics of the electrical system and loading, no absolute guidance can be provided on when it will be accepted and when it may not. Each case will be evaluated independently and either accepted or denied.

The use of an MID system is most often used to create an intentional island to power critical load in the event of a utility outage. Therefore, if the system malfunctions and begins to export more than the contracted amount to APC, use of the already required AC disconnect would also disconnect the customer's critical load from the APC system causing a power interruption to this load. To provide APC a method to stop excessive export while not disconnecting the customer's critical load, use of this functionality will also require an additional AC Disconnect that will disconnect only the PV (solar) portion of the system while leaving the remainder of the system connected to APC. This disconnect is required to be labeled "PV Only AC Disconnect" so that APC can determine the correct disconnect that will isolate the PV only but leave the customer's load connected.

See Appendix 1, example 9. This PV only disconnect is marked with label H in the example. This disconnect must meet all of the requirements of section 6.1 above and marked as having visible blades, lockable in open position, readily accessible, and either within 10' and line of sight of utility revenue meter or placards indicated in section 6.2.2 are required.

If the DER system exports more than the contracted amount to the APC system, APC will attempt to contact the customer and provide a reasonable timeframe for the customer to disable system or correct export limit. However, if APC is unable to contact customer, if customer does not disconnect system or correct the system operation as requested, or if excess export is creating immediate adverse affects on the APC system; APC will dispatch an employee to open the PV only AC disconnect to stop excessive export. If this does not stop the excessive export, APC will have no choice but to disconnect total electrical service. In such case, APC will not be liable for any damage incurred due to the disconnection of electric service.

6.14. Rapid Voltage Change (flicker)

The DER system shall be designed such that at no time will it cause a rapid voltage change of 3% or greater to the APC system. This includes during energization of the interconnection transformers. When multiple large interconnection transformers are energized simultaneously, the aggregate inrush current during energization

may be enough to cause the voltage to change by more than 3% at the PCC. A voltage change of greater than 3% will cause adverse effects to other APC customers and is prohibited. The DER system designer should consider this possibility when multiple interconnection transformers are utilized and design the system to prevent this occurrence as needed.

One way to accomplish this is by segregating the transformers into multiple sections and energizing the transformers sequentially instead of simultaneously to limit the peak inrush current. Sequential switching of transformers must not rely on manual intervention prior to energization but must use an automated system to prevent simultaneous energization since APC will not coordinate energization of the APC system after an outage with the DER owner. Other methods, such as pre-insertion of impedance prior to energizing the transformer may also be effective.

Any method utilized shall be indicated on the system design submitted during the application and shall be approved by APC prior to use.

Any DER system causing a rapid voltage change of 3% or greater will be immediately disconnected from the distribution system and prevented from reconnecting by any means necessary until a remedy, approved by APC, has been installed.

See section 9.1.2 for rapid voltage change witness test requirements.

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 construct 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

The DER system shall not complete initial synchronization, commissioning, nor operate in parallel with the APC system until approved in writing by APC. Doing so without permission may result in APC taking any action necessary to isolate the DER from the APC system, up to and including disconnection of total electric service.

The DER system shall only be operated during times of active commissioning and testing when personnel are onsite. The DER system shall be turned off at all other times. The DER system shall not be allowed to operate without personnel onsite until after the witness test has been completed per the requirements of section 9 and written provisional permission to operate (PTO) has been granted.

A minimum of 30 calendar days prior to the desired initial synchronization date, APC shall be provided, in writing, the intended initial synchronization date. The following minimum information shall be provided with request for approval to synchronize. Any request without this information will be rejected without review.

- As built single line diagram (including if no change from original single line diagram)

- Maximum fault current contribution (non-inverter based systems)
- Manufacturer, model number, and proposed relay settings (for LEG systems, microgrids, and other systems where applicable)
- Sequence of events for microgrids (include normal operation for planned and unplanned islanding, and failure of interface device, interface device control, microgrid control)
- Commissioning equipment sequence (LEG and microgrids)
- Additional information that may be required prior to review based on system design:
    - Three-line diagram showing the current and voltage circuits for all protection relays
    - Intertie breaker DC elementary showing trip and close circuits.

After notification of intended initial synchronization date, APC will review request and provided information within 10 business days and either 1) approve synchronization and commissioning in writing or 2) require additional steps prior to approving requested synchronization and commissioning.

APC may, at its sole discretion, require additional information be provided, require testing of portions of the DER system, require strict beginning and ending dates before approving initial synchronization and commission testing, or have any other requirement deemed necessary for the safe and reliable operation of the APC system.

If additional information is required, the information required will be specified and dates for synchronization and commissioning may not be requested until all required information is provided and approved.

If APC requires testing of a portion of the DER system prior to synchronization and commission testing, details of the required testing will be provided at that time. The most common testing will be of the export limit protection of a LEG system or microgrid grid isolation device and control schemes. Other testing may be required at APC's sole discretion. If required, the DER owner will work with the Company to schedule a mutually agreeable time for the Company to perform pre-commissioning witness testing. Testing will be conducted per the procedure set forth in Section 9 or other testing approved by APC.

If APC requires strict beginning and ending dates for synchronization and commission testing, **it is imperative for the safety of APC employees that the DER owner 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 by APC 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.

If strict testing dates are required, the DER owner 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 10 consecutive business days but may include non-business days adjacent to the business days (Saturday – Sunday), for a total maximum time period of 14 consecutive days. 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 other required information.

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.

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 10 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.

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. This may be collected prior to witness test if DER owner has completed all commissioning and can leave system off for required time, or may be collected after witness test upon mutual agreement of DER owner and APC.

7.2.1. Communication commissioning

After APC grants permission for initial synchronization and commissioning, and if Section 6 requires the DER system to include a communication gateway with APC, the installer shall notify APC once all Section 6 requirements have been fulfilled and the DER system is operational. APC will then complete the power and fiber connections to the gateway and initiate communication with the DER system. APC will complete installation of APC equipment and initiate communication commissioning within 10 business days of request.

The installer shall provide a communications engineer to collaborate with APC to ensure proper communication between APC equipment and the customer's DER system prior to scheduling the onsite witness test.

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. Examples of required photographs shown in Appendix 5.
   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(s) to be clearly legible
   iv. If the AC disconnect is not within 10' 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 10' 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. If the system includes a PCS device to limit export, these settings will need to be temporarily changed to allow some amount of export of the APC system. APC will verify generation is exporting to the APC system be review of the revenue meter display.

v. APC will request the DER owner open (turn off) the DER AC disconnect.

vi. APC will verify the DER system is separated from the APC distribution system by verifying export to the APC system ceases by review of the revenue meter display.

vii. Customer will be requested to close (turn on) the DER AC disconnect to reconnect the DER system to the APC system.

viii. 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 within building, plugged in hair 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 that during winter months, it may not be possible to attain 85% of nameplate. Test will be conducted at peak sun for the time of year and provisional PTO provided if all tests are successful. A re-test will be required during summer months when a minimum of 85% of nameplate can be achieved to attain full PTO.

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.

Important note:

APC has a low volume of DER applications; therefore, APC has a limited number of subject matter experts (SME) to perform material review and witness testing. APC will review each received item and respond within 10 business days. Often some items require multiple revisions and subsequent reviews. Each revision review may take up to 10 business days. APC will respond as soon as possible and may often respond faster than 10 business days; however, the 10 business day timeline allows for unavailability of SME due to vacation or other urgent APC business. It should not be assumed that because some responses are less than 10 business days that all responses will similarly be less than 10 business days. It is the DER owner's responsibility to allow adequate time for revision and subsequent reviews given the expected 10 day timeline for each revision to meet the below incremental deadlines. No exception will be made to the below required deadlines as long as APC meets the 10 business day response obligation for each revision. A nationally recognized holiday is not considered a business day.

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

a. The DER owner may request primary and back-up witness test date at any time to secure calendar dates for witness testing team. Back-up date shall be no less than 10 business days after primary date. Back-up date may be used for weather cancellation of primary date, or re-test due to failure on primary date. The back-up date will not be used if primary date is cancelled due to incomplete pre-testing requirements given below. Dates are subject to APC testing team availability as described below.
b. A minimum of 10 business days prior the scheduled primary test date, the following is required to be completed. If any of the following items are not completed, both primary and back-up test date will be terminated and will not be rescheduled until these items are completed:
    i. **Approved** date for initial synchronization.
    ii. **Approved** witness test plan.
    iii. **Approved** sequence of operation (microgrids only).
    iv. **Receipt** of witness test fee in hand.
    v. **Fully Executed** Interconnection Agreement.
c. A minimum of 5 business days prior to scheduled test date, the following is required to be completed. If any of the following items are not completed, both primary and back-up test date will be terminated and will not be rescheduled until these items are completed:
    i. **Approved** actual, as left, inverter settings downloaded from each inverter including at minimum the serial #, firmware version, and each setting required by the SoCo IP.

ii. **Approved** actual, as left, relay settings (if applicable).

iii. **Approved** post installation photographs of all major equipment showing substantial construction completion (including AC disconnect, inverters, DER system transformer (if applicable), DER system recloser (if applicable), and other equipment as identified by APC. To be approved, photographs must show permanent mounting and conductor termination (no temporary construction allowed) and construction must match approved single line diagram and all design requirements of this Guidebook and the SoCo IP.

iv. **Approved** communication link between the DER owner's communication equipment and APC's communication equipment. To be approved, APC must be receiving data for all required datapoints given in the APC Pointmap. Validity of data and control will be determined at witness test.

v. **Confirmed** export to the APC system via APC remote means of a minimum of 25% of the AC nameplate rating for utility scale systems with no co-sited load.

d. Re-test after test failure

a. **Acceptable** explanation of remedy taken to address cause of test failure to provide reasonable expectation of passing re-test shall be received a minimum of 2 business days prior to re-test date. APC reserves the right to cancel back-up test date if additional information is needed for APC to have a reasonable expectation of re-test being successful.

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.

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 or app and be able to display on the HMI, app, or connected computer that the serial number and settings match those provided in the download for a random sampling of inverters as selected by APC.

9.1.2. Rapid Voltage Change Test

The purpose of this test is to ensure the rapid voltage change at the PCC does not exceed 3% during DER energization or operation. This test is only required for ATM installations 1MW and greater.

The DER system shall be operating as normally intended with all portions of the DER system operational. APC will de-energize the DER system by opening of the APC 3 phase disconnect switch or recloser.

To take the required measurements, APC test equipment may be connected at the PCC by the APC representative with assistance from the installer if needed.

APC will energize the DER system by closing the 3 phase disconnect switch or recloser.

APC will review the data form the test equipment and calculate the percent voltage drop that occurs during energization of the DER system. Voltage change percentage must be less than or equal to (≤) 3% to pass. If voltage change is greater than 3%, the witness test will stop and APC will leave the APC switch or recloser open until a method of mitigation acceptable to APC has been installed.

This test may be required, at APC's sole discretion, to be completed at initial synchronization or APC may elect to use PQ equipment installed at the site prior to initial synchronization to remotely monitor rapid voltage change on an ongoing basis. If at any time APC detects a voltage change of greater than 3%, the site will be immediately disconnected until a method of mitigation acceptable to APC has been installed.

This test may be performed in conjunction with the AC Disconnect Test below.

9.1.3. Open phase disconnect 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 20%, whichever is less. All customer load must be disconnected for this test.

The purpose of this test is to confirm that the DER will recognize when any one (1) phase of the APC system is disconnected by and trip within two (2) seconds as required by section 6.2.2 of IEEE1547-2018. A time period of at least seven (7) minutes will lapse to ensure the DER does not begin to generate with the disconnect open.

a. APC will open a Phase A only by means of a single phase disconnect switch on the APC system to simulate a single phase outage.
a. The installer will be required to demonstrate that the DER recognizes the loss of one (1) phase of power on the APC system and ceases to energize and trip within two (2) seconds.
b. APC will wait seven (7) minutes to ensure the DER system does not begin to energize while the single phase disconnected.
c. APC will close the singe phase disconnect switch, simulating power restoration, and the installer will be required to demonstrate the DER system waits the required five (5) minutes before beginning to energize and then follows the required ramp rate to reach full production.

Steps a-d will be repeated with Phase B only and then with Phase C only.

Above describes the preferred method of testing. However, if the DER design does not include any transformers and 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. If the DER design includes a transformer, this option will 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

9.1.4. AC Disconnect Test

The purpose of this test is to confirm that the DER AC disconnect switch successfully isolates the entire 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 remove all load so that the total DER generation is flowing back into the APC system.
b. The installer will then be required to open the AC disconnect and demonstrate that the generation goes to zero and no power is flowing back into the APC system.

9.1.5. Three (3) phase Disconnect 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 operating at a minimum of 85% of the AC nameplate capacity for the duration of this test. All customer load must be disconnected for this test.

The purpose of this test is to confirm that the DER will recognize when the APC system is disconnected by all three (3) phases and trip within two (2) seconds by section 8.1.1 of IEEE1547-2018. A time period of at least seven (7) minutes will lapse to ensure the DER does not begin to generate with the disconnect open.

b. APC will open a three (3) phase disconnect switch on the APC system to simulate a three (3) phase outage.
c. The installer will be required to demonstrate that the DER recognizes the loss of three (3) phase power on the APC system and ceases to energize and trip within two (2) seconds.
d. APC will wait seven (7) minutes to ensure the DER system does not begin to energize while the three (3) phase disconnect is open.
e. APC will close the three (3) phase disconnect switch, simulating power restoration, and the installer will be required to demonstrate the DER system waits the required five (5) minutes before beginning to energize and then follows the required ramp rate to reach full production.

Above describes the preferred method of testing; however, if a three (3) phase disconnecting means is not available on the APC system and the DER design does not include any transformers, the DER owner will be requested to open the AC disconnect to accomplish this test and may be performed in conjunction with the AC disconnect test in section 9.1.2. If the DER design includes any transformers, utilizing the AC disconnect will not satisfy the requirements of this test and APC will make necessary temporary arrangements on the APC system to accomplish this test at the DER owner's expense.

9.1.6. 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 installer.

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. The three (3) phase disconnect test in 9.1.4 may be used as one (1) of the three (3) required transient overvoltage test.

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.

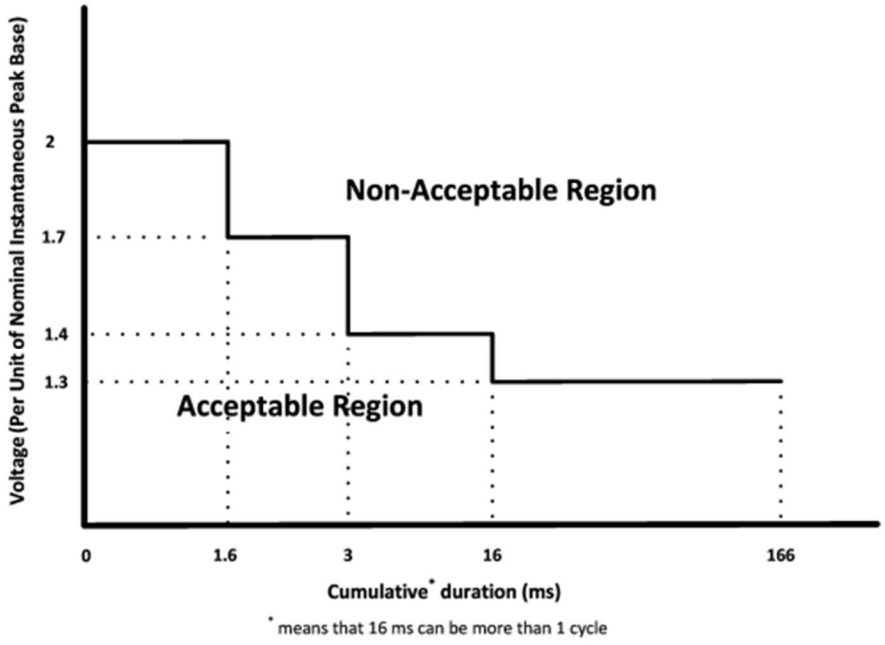


Figure 3 —Transient overvoltage limits

9.1.7. Harmonics Test

The purpose of this test is to confirm the DER does not cause more than 3% total harmonic distortion to the APC system.

After construction of the DER is completed and before the date of the witness test, a power quality recorder will be installed at the RPA by APC. A minimum of 7 consecutive days of data is required with no operation of the DER to establish a baseline of existing total harmonic distortion existing on the APC system.

After successful completion of the remainder of the witness test, the DER owner will be provided provisional permission to operate the DER system while further data is collected. An additional 7 consecutive days of data

is required with the DER fully operational to capture the total harmonic distortion of the APC system with the DER.

After all data is collected, the change in total harmonic distortion will be calculated between the baseline data with the DER not operating and the data with the DER fully operational. The calculated change in total harmonic distortion cannot exceed 3% to pass the harmonics test.

If the total harmonic distortion is greater than 3%, the DER owner will be required to disconnect the DER until changes are made to correct the harmonic distortion caused by the DER. After the DER owner believes the issue has been corrected, the test will be repeated. This process will continue until the level is reduced to below 3%.

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.

9.3.3. Emergency Stop

The test plan for the emergency stop shall demonstrate that while the microgrid is operational, activating the emergency stop shall cause all generation of power and all export of power to the loads to cease.

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. Monitoring, Information, and Control Test

The purpose of this series of tests is to confirm the proper operation of the monitoring, information exchange, and control of the DER system to meet the requirements of section 6.6.

For any of the tests below, APC may elect to make more than one (1) setting or control change as described below for any or all tests until APC is satisfied, at APC’s sole discretion, that the DER system meets all requirements.

9.4.2. Monitored information accuracy test

APC will communicate with the DER system by way of the gateway to read all values expected based on the DER Pointmap groups *metering-system*, *metering-pcc (*if applicable), *nameplate*, and *supported functions*. APC will compare electrical parameter data from the metering groups to the values measured using an APC provided

power quality analyzer. APC will also compare nameplate and supported functions groups to the system information provided in the CFF file.

9.4.3. Setting mismatch test

APC will communicate with the DER system by way of the gateway to read all values expected based on the DER Pointmap groups *enter service*, *voltage trip*, *frequency trip*, and *frequency droop.* APC will also compare the read information to the required settings provided in the CFF file.

The installer will be requested to indicate which physical inverter is designated as the 'Reference Inverter' that provides information setting groups *enter service*, *voltage trip*, *frequency trip*, and *frequency droop* as specified in section 6.6.3. The installer will then be requested to change randomly selected setpoints as identified by APC to values provided by APC in 'Reference Inverter'. APC will then verify the settings displayed to APC change to match new values of the setpoints within sixty seconds.

APC will also verify Alarm Status changes to indicate an alarm since these settings no longer match the settings in the other inverters. The installer will then be requested to change the value back to the correct values. APC will verify that the settings displayed to APC change again back to the original and correct values and that the System Alarm Status changes to indicate no alarm since all values now match.

The installer will then be requested to change randomly selected setpoints as identified by APC in other randomly selected inverters (but not 'reference inverter') as identified by APC. APC will then verify System Alarm Status changes to indicate an alarm since these settings no longer match the settings in 'reference inverter'. The installer will then be requested to change the values back to the correct values. APC will verify that the System Alarm Status changes to indicate no alarm since values now match 'reference inverter' values.

9.4.4. Permit service test

APC will communicate with the DER system by way of the gateway to remove permit service from the DER system. The DER system must respond by ceasing to energize within two (2) seconds. APC will wait at least seven (7) minutes to confirm the DER system does not begin exporting power after the normal five (5) minute enter service delay. APC will then insert permit service to the DER system. The DER system should respond by beginning to energize and export power after the five (5) minute enter service delay and follow the required ramp rate up to the active power limit.

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.

9.4.5. Active power limit test

APC will communicate with the DER system by way of the gateway to change the active power limit to some number below the current maximum output. The DER system must initiate curtailment of active power export to at or below the designated limit within 2 seconds, adhering to the required ramp rate. APC will wait at least ten (10) minutes to confirm the DER system does not exceed this active power limit. APC will then set the active power limit back to system nameplate rating and the DER system should respond by exporting maximum available power after following the required ramp rate.

9.4.6. Lost Communication test

The installer will be required to disable communication by the appropriate method (unplug cable, modem, etc) at locations within the DER system selected by APC and demonstrate the DER system recognizes loss of communication and curtails power export to the maximum limit set by APC in 30 seconds or less.

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.

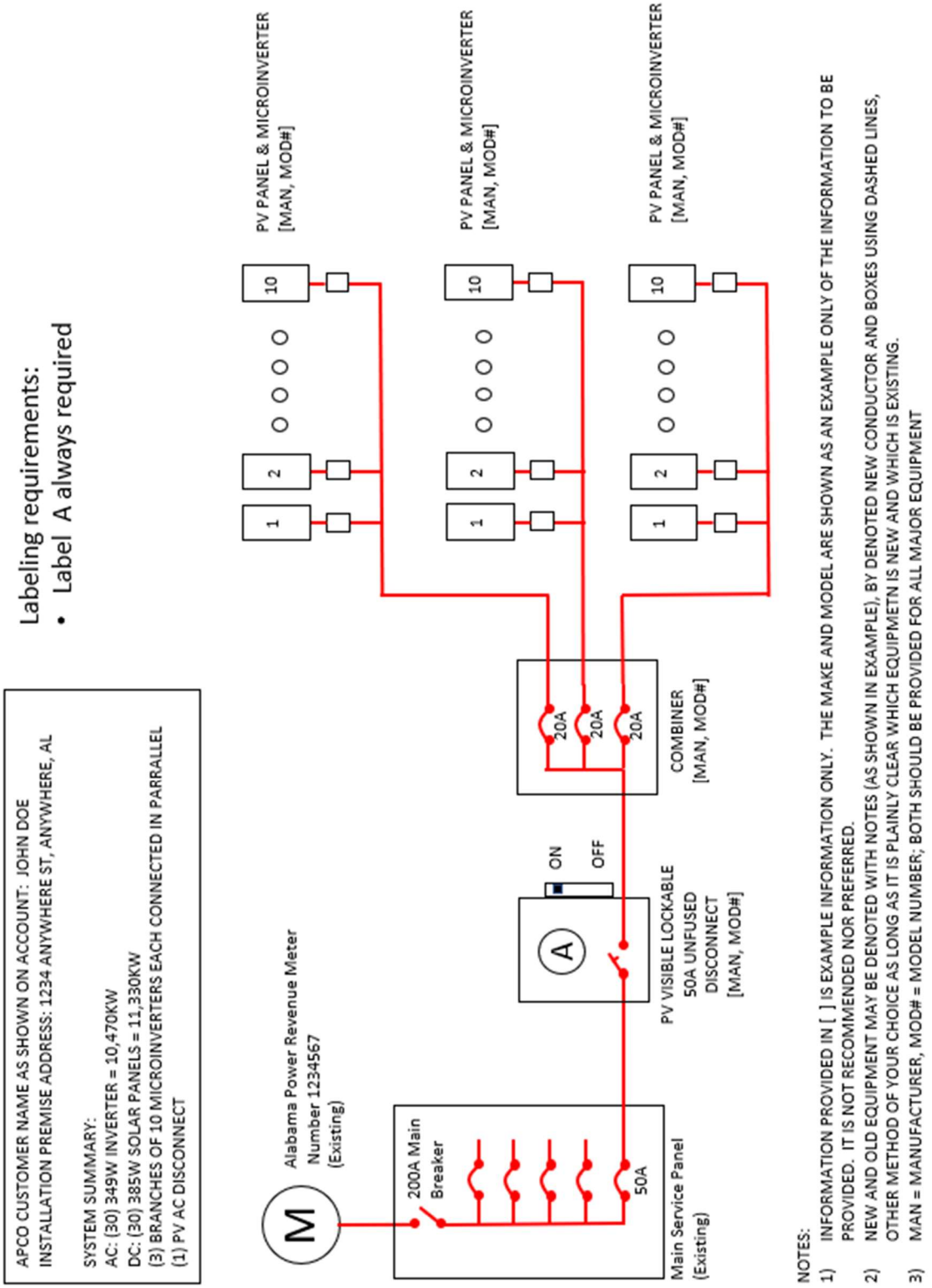
Upon successful completion of all parts of the required witness testing, the witness testing team will complete a witness testing report and provide the report to APC marketing department to be included in the final executed documents.

APPENDICES

Pages below provide examples and are referenced in the applicable sections in the main document body.

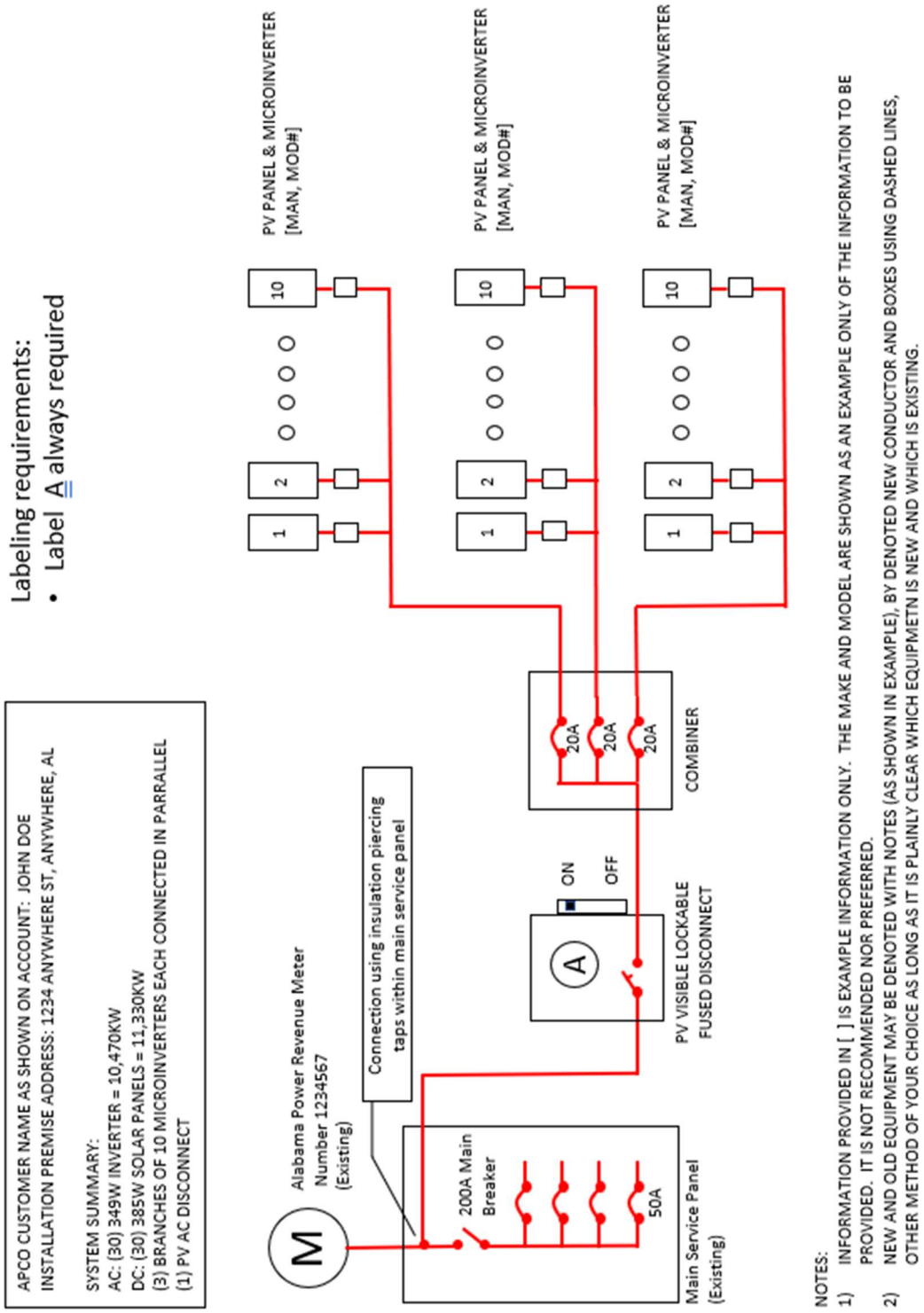
Appendix 1. Single line diagram examples

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



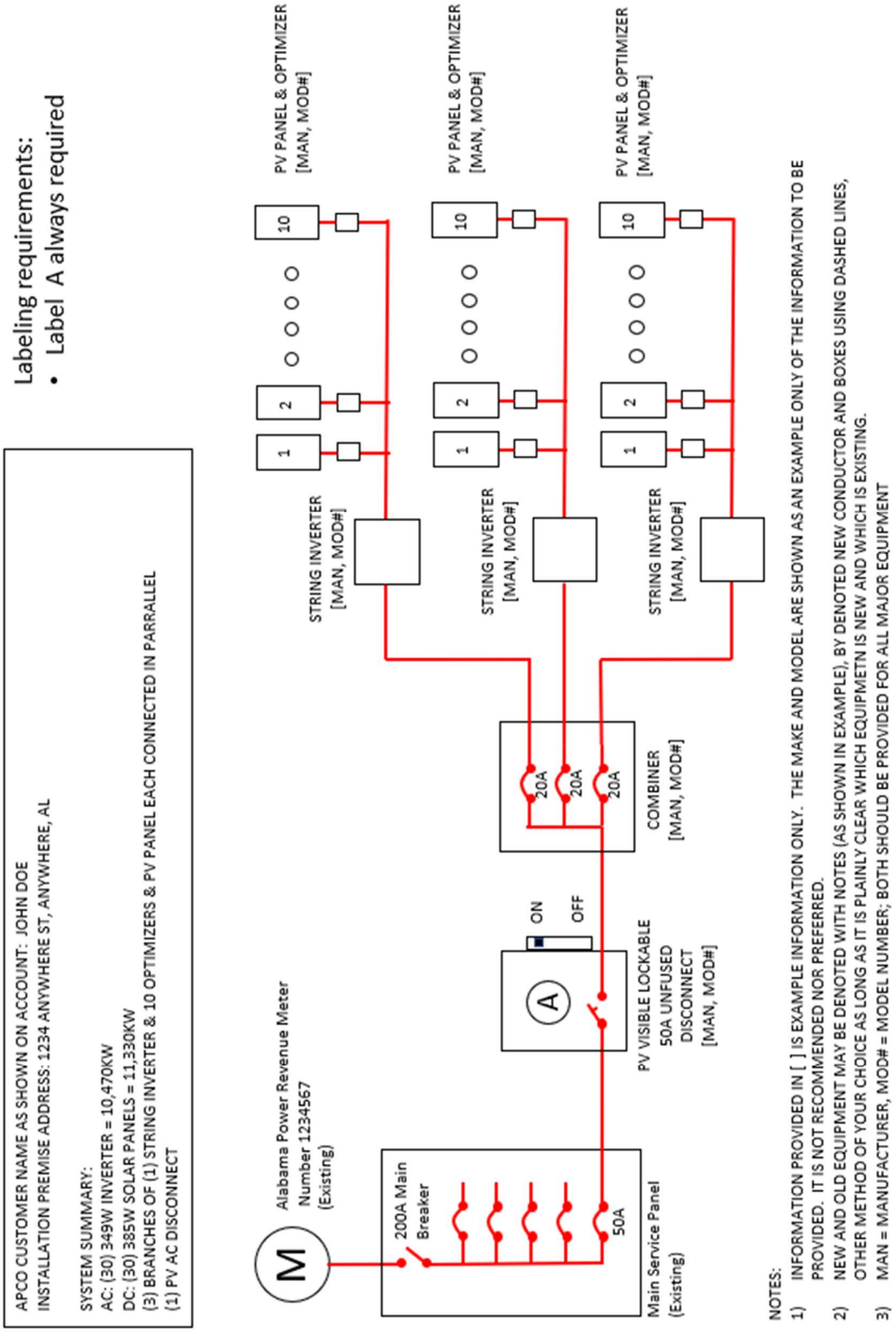
Appendix 1. Single line diagram examples

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



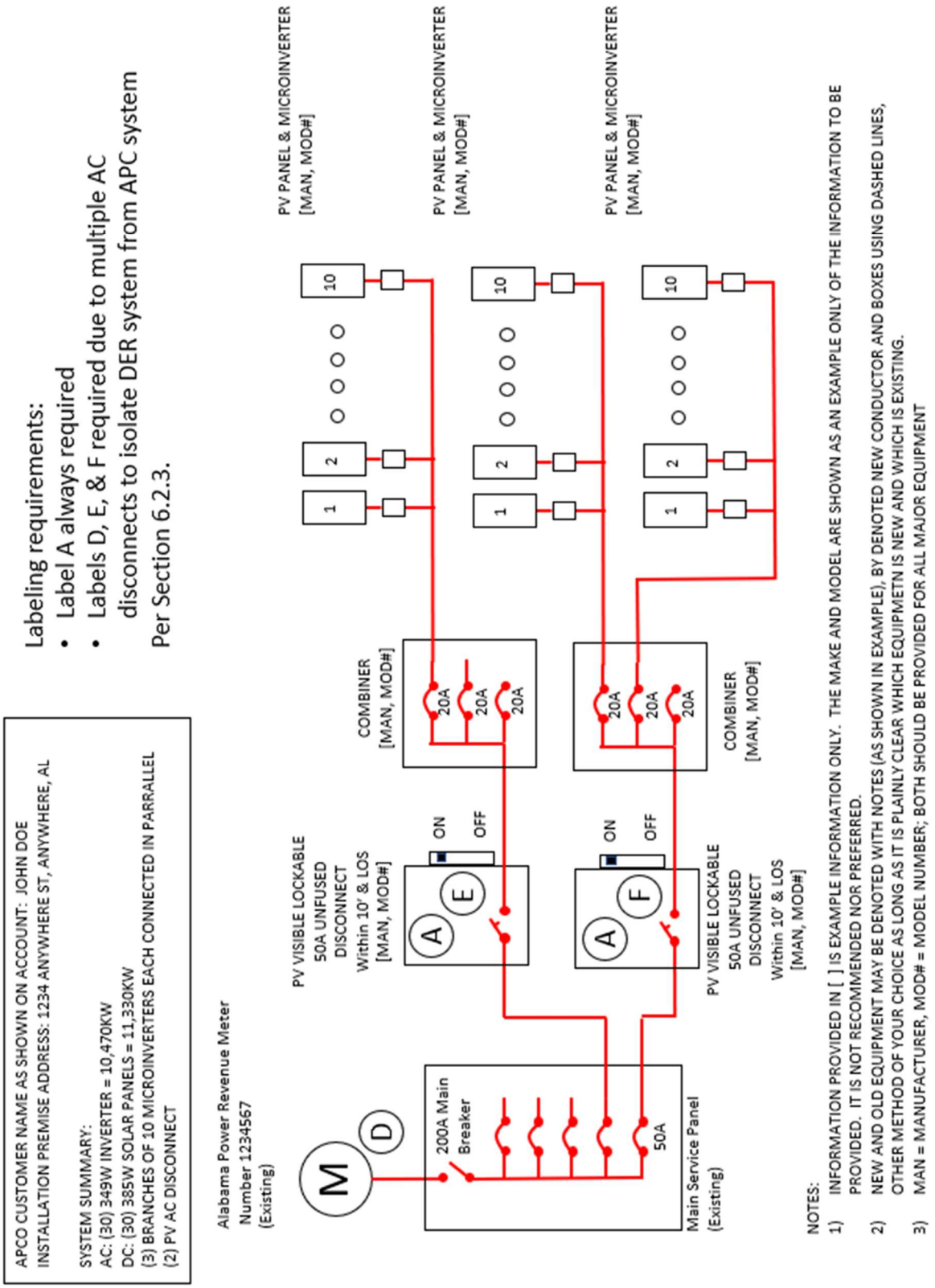
Appendix 1. Single line diagram examples

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



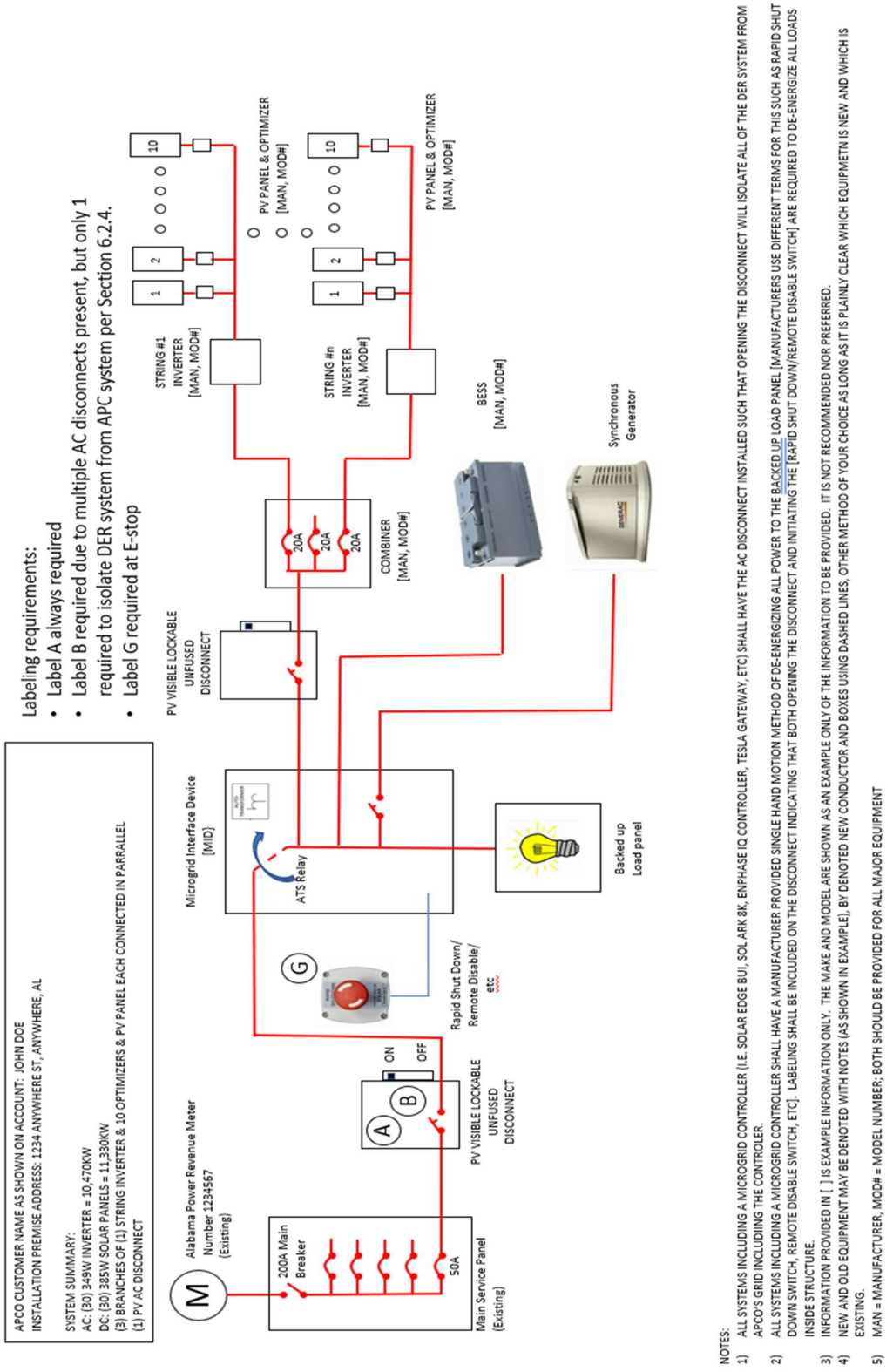
Appendix 1. Single line diagram examples

Example 4: PV with two (2) disconnects required to be opened to isolate the DER system from the APC system



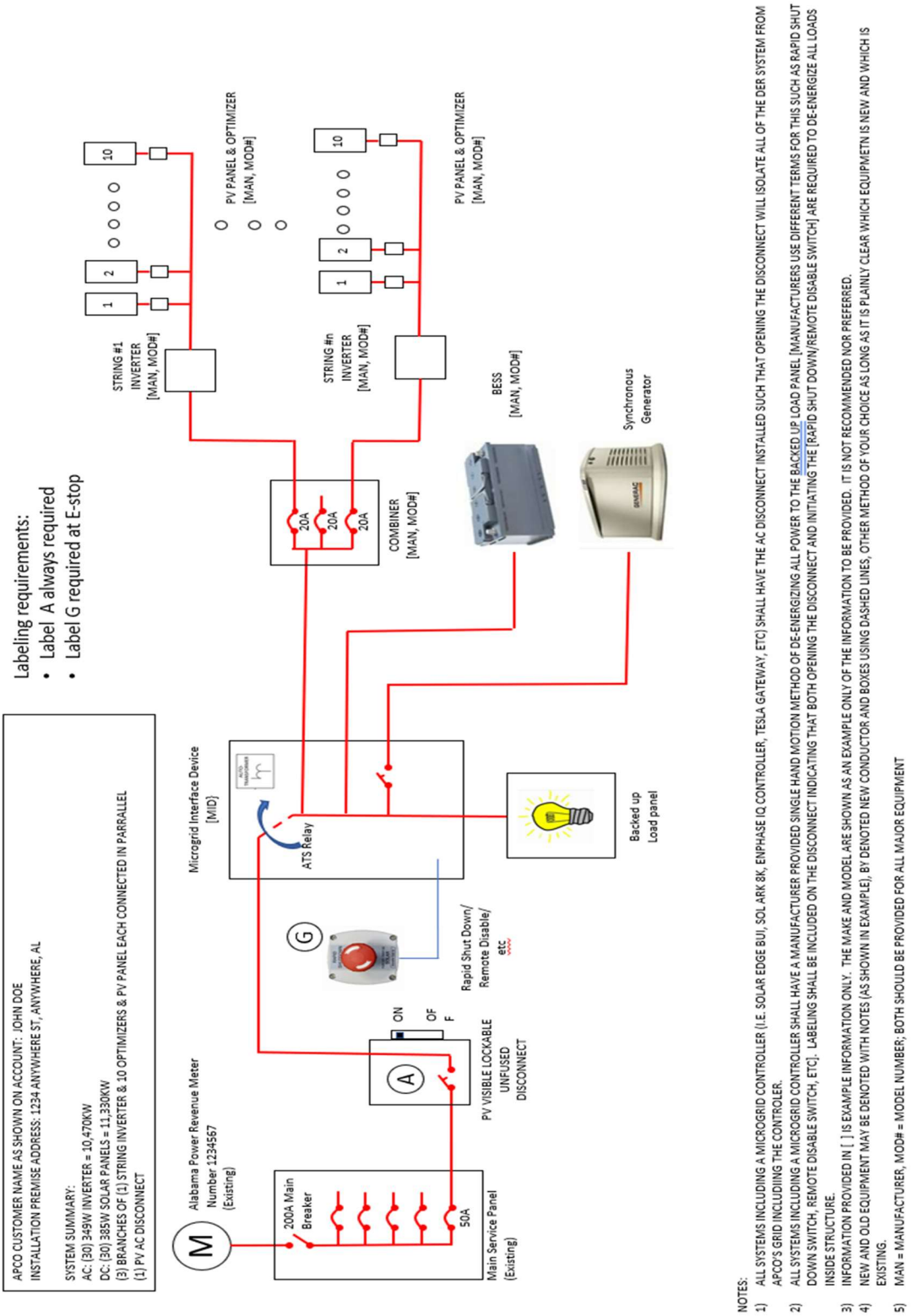
Appendix 1. Single line diagram examples

Example 5: PV with multiple disconnects, but only 1 that must be opened to isolate the DER system from the APC system



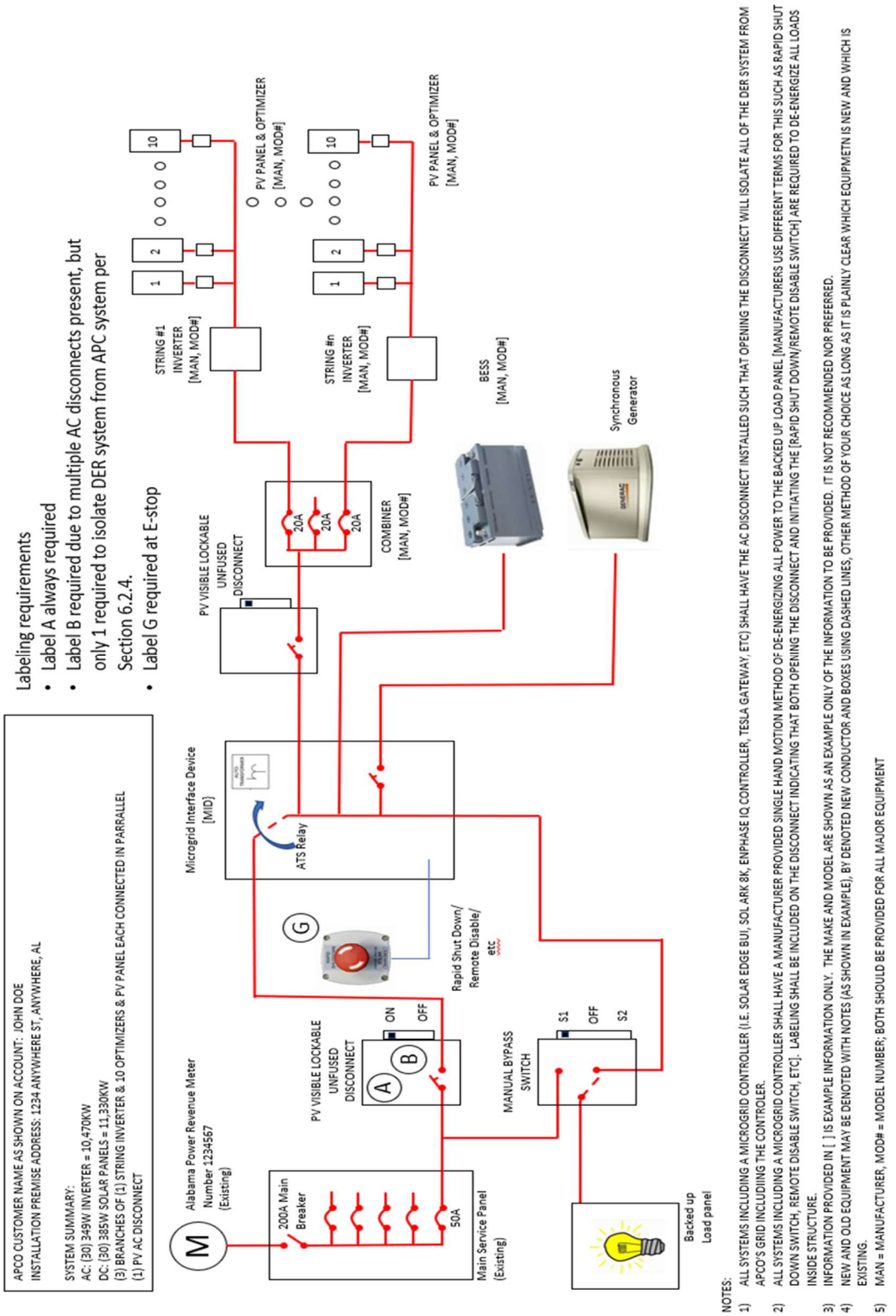
Appendix 1. Single line diagram examples

Example 6: Microgrid Interface Device (MID) with PV + Battery + synchronous generator; with string inverters connected to breaker in existing breaker in main service panel

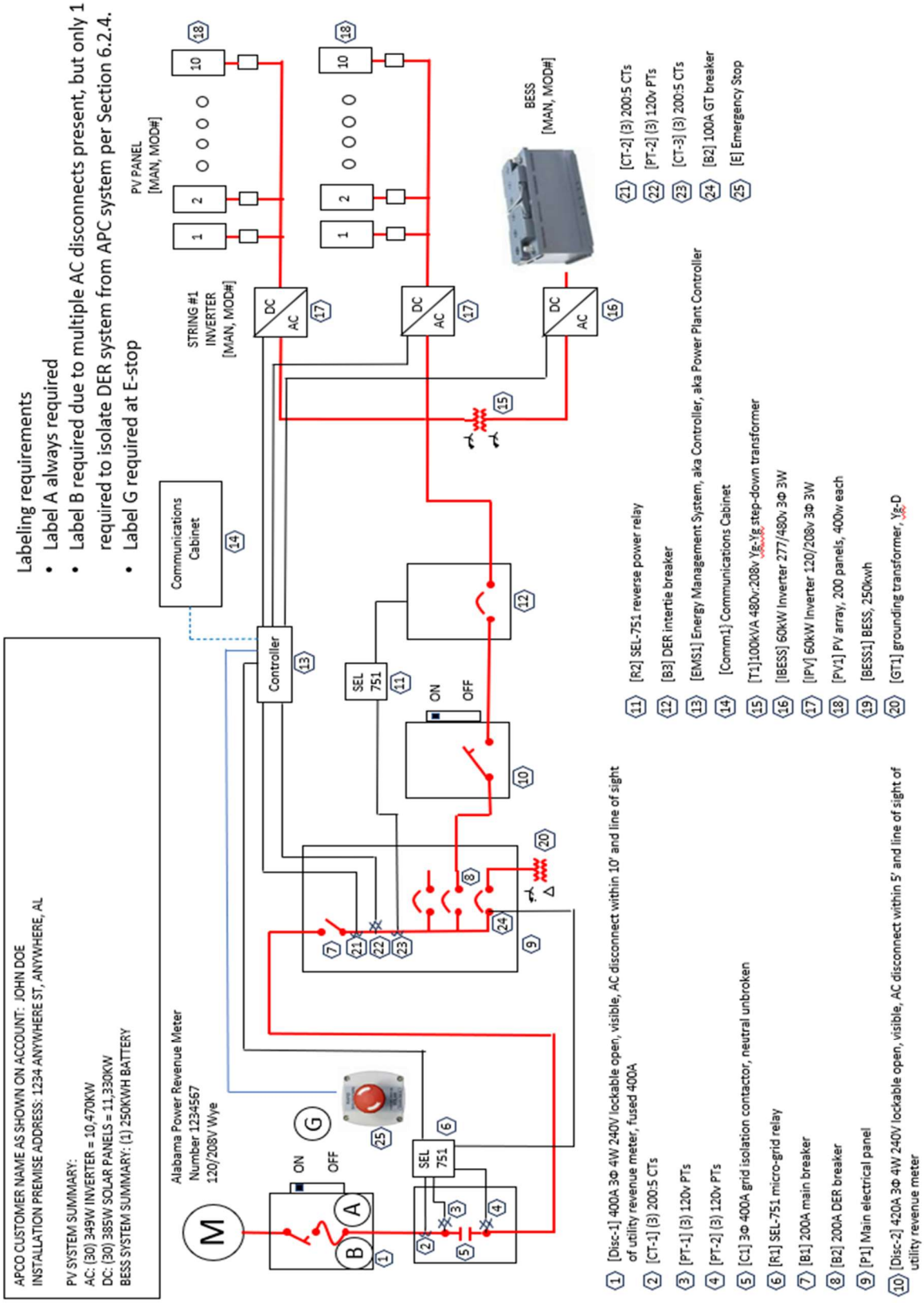


Appendix 1. Single line diagram examples

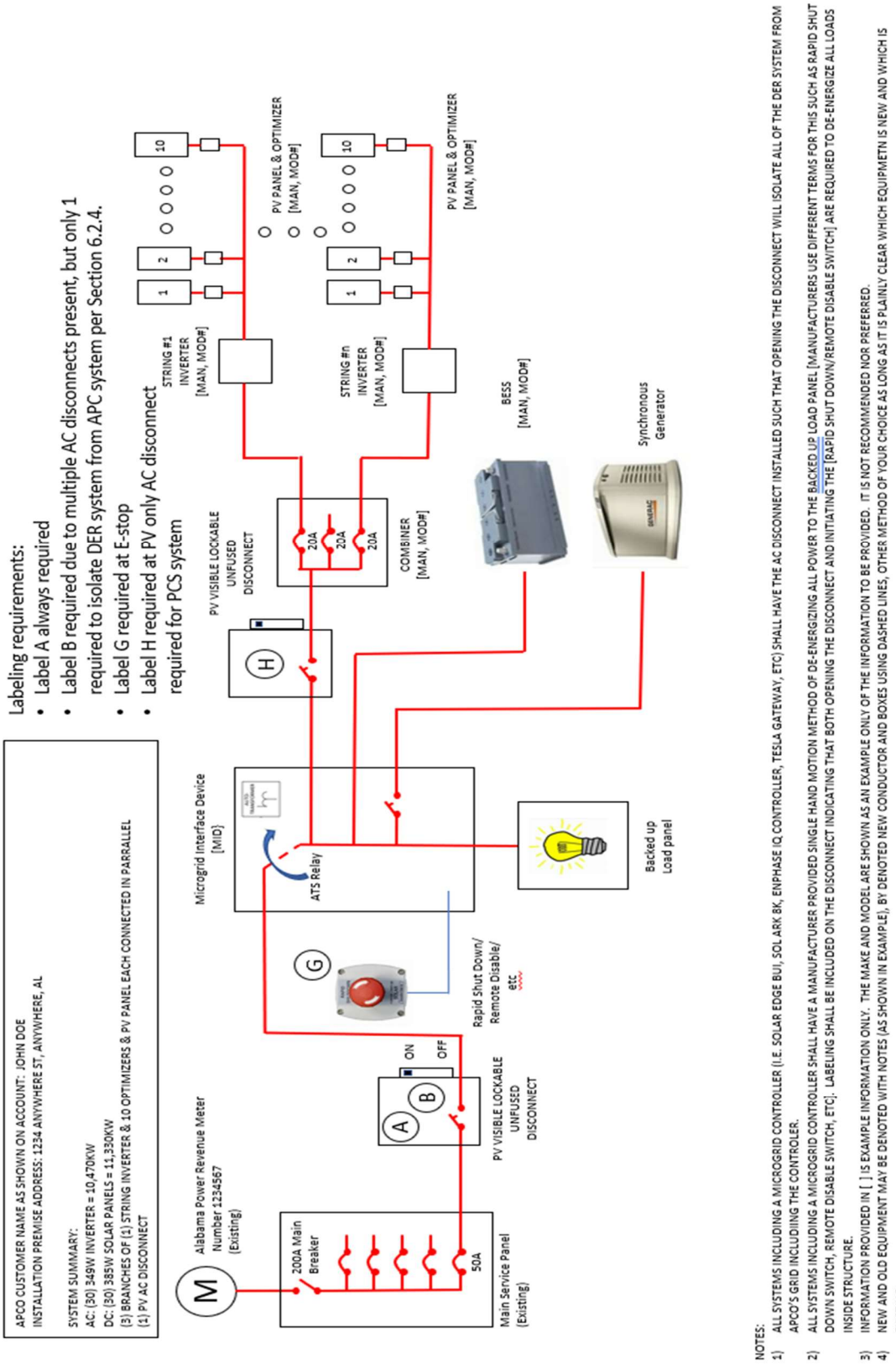
Example 7: Microgrid Interface Device (MID) with PV + Battery + synchronous generator; with string inverters connected to breaker in existing breaker in main service panel; with double throw manual bypass switch to energize backed-up load when DER system is offline



Appendix 1. Single line diagram examples
Example 8: LEG microgrid.

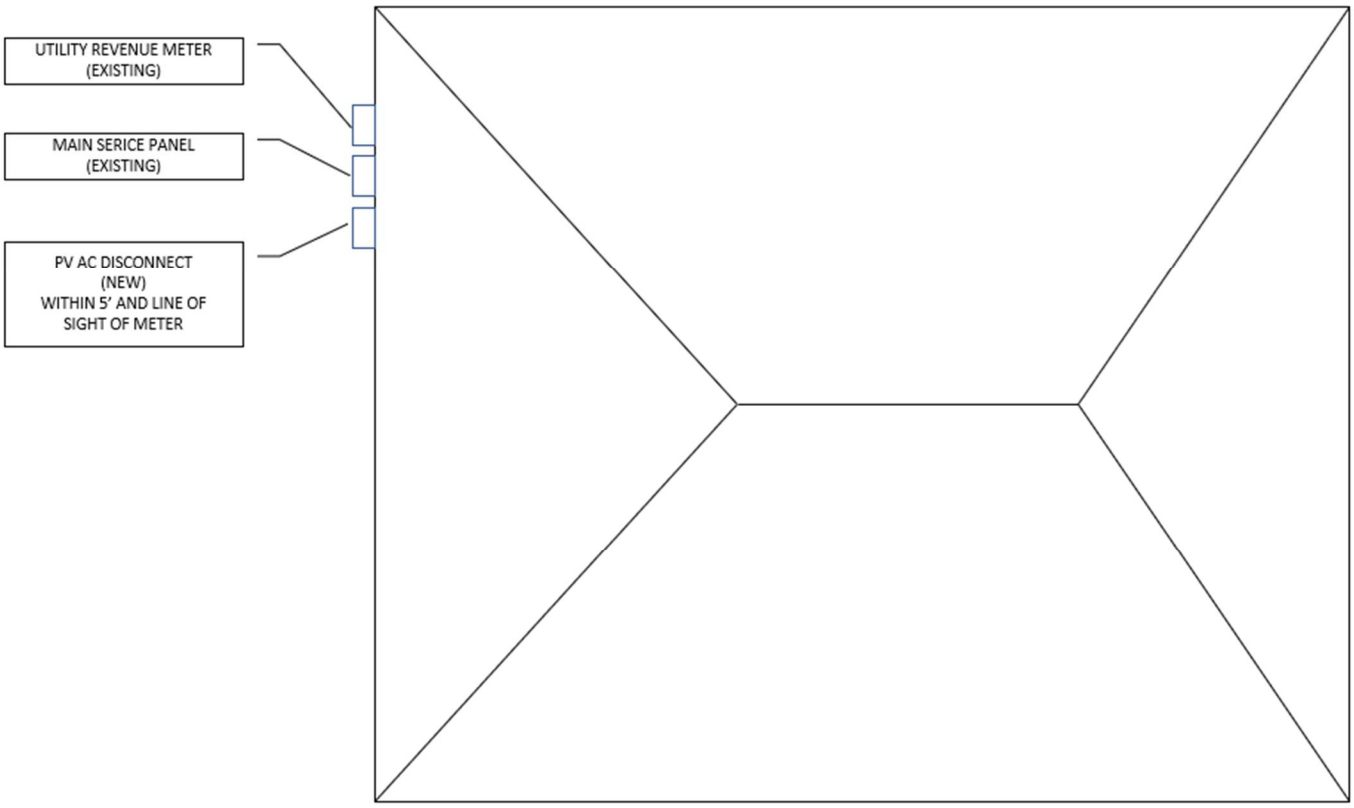


Appendix 1. Single line diagram examples
Example 9: PCS system



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: Examples of required labels. The letter corresponding to each label is shown on the example single line diagrams in appendix 1 to aid in understanding of required placement. Examples provided are intended to provide general understanding of requirements. The specific wording and placement indicated on the application should be site specific to the application and not using generic or example language provided below.

(A)

GENERATION AC DISCONNECT

FOR UTILITY USE

(B)

PV AC DISCONNECT LOCATED ON EAST END OF SOUTH WALL

(C)

2 GENERATION DISCONNECTS PRESENT
PV AC DISCONNECT LOCATED ON EAST END OF SOUTH WALL
BESS AC DISCONNECT LOCATED ON SOUTH END OF EAST WALL

(D)

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

(E)

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

(F)

(G)

PV ONLY
AC DISCONNECT

(H)

Appendix 4. Labeling examples

Example 2a: Example of Label C. Placard required at meter socket if AC disconnect is located more than 10’ from or not within line of sight of utility revenue meter. This example is a placard with only words describing the location. See example 2.b for alternative placard using simplified site diagram.

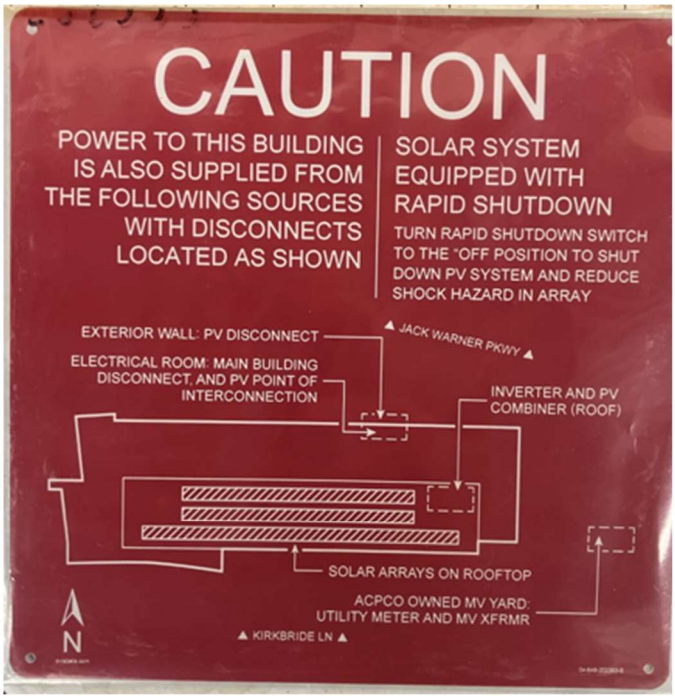
PV AC DISCONNECT
LOCATED ON EAST
END OF SOUTH WALL

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

Below is an example of the type of placard and mounting location only.
Placard should provide location in relation to the structure (such as North wall, East wall, etc) as shown above.

Appendix 4. Labeling examples

Example 2b: Example of Label C. Placard required at meter socket if AC disconnect is located more than 10’ from or not within line of sight of utility revenue meter. This example is a placard with a simplified site plan diagram showing at minimum the location of the utility meter, ac disconnect, and accurate depiction of structure layout including orientation such as “front”, “rear”, etc. See example 2.a for alternative placard using only words.



Example 3: Example of label D. Placard required at meter socket if AC disconnect is located more than 10’ from or not within line of sight of utility revenue meter **AND** if more than one (1) disconnect is required to be opened to isolate the DER system from the APC system. This example is a placard with only words describing the location. See example 3.b for alternative placard using simplified site diagram.

2 GENERATION DISCONNECTS PRESENT
PV AC DISCONNECT LOCATED ON EAST END OF SOUTH WALL
BESS AC DISCONNECT LOCATED ON SOUTH END OF EAST WALL

Below is an example of placard and mounting location.

Appendix 4. Labeling examples

Example 4: Example of label E and F. 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.
Below is an example of placard and mounting location.

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

Appendix 4. Labeling examples

Example 6: Example of Label B. Labeling required if only one (1) AC disconnect is required to isolate the DER system from the APC system, but additional disconnects exist for use by others. This will ensure APC personnel operates the correct disconnect so that APC system isolated without opening all AC disconnects

PV AC DISCONNECT
FOR UTILITY USE

Appendix 5. Picture examples

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

Appendix 5. Picture examples

Example 2: Pre installation picture of existing meter close-up with meter number legible

Appendix 5. Picture examples

Example 3: Post installation picture of meter socket and newly installed PV AC disconnect

Appendix 5. Picture examples
Example 4: 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 8.

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 – 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.

9.1.3 – 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.

9.1.4 – 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.
6. 3ϕ disconnect test in 9.1.2 may be used if it is confirmed to be exporting at lest 85% of nameplate rated power.

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 – 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

9.2.3 – 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).

9.2.4 – 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

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

9.3.2

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.

9.3.3

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.

9.3.4

3. Installer will command the microgrid to begin microgrid operation => microgrid islands and begins operation without adversely affecting the APC system

4. Installer will activate emergency stop and all systems functions will cease and de-energize all load panels.

Appendix 7. Microgrid Sequence of operation example

Example 1: Microgrid sequence of operations for the single line diagram shown in Appendix 1, Example 8.

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.

intertek
Total Quality. Assured.

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.

This Authorization to Mark is for the exclusive use of Intertek's Client and is provided pursuant to the Certification agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this Authorization to Mark. Only the Client is authorized to permit copying or distribution of this Authorization to Mark and then only in its entirety. Use of Intertek's Certification mark is restricted to the conditions laid out in the agreement and in this Authorization to Mark. Any further use of the Intertek name for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. Initial Factory Assessments and Follow up Services are for the purpose of assuring appropriate usage of the Certification mark in accordance with the agreement, they are not for the purposes of production quality control and do not relieve the Client of their obligations in this respect.

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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

Appendix 9. Fiber splice box

Appendix 10. Fiber attachment to APC pole specification

Vertical Clearance Requirements Over Streets, Roads, and Highways
Subject to State Highway Department Standards

The vertical clearance for overhead electric supply and communication lines over streets, roads, and highways subject to State Highway Department Standards shall be not less than the clearance shown in the following chart. The vertical clearance in all cases shall be not less than NESC requirements.

Company		Vertical Clearance Requirement (ft.) *
APC		18
GPC	State Hwy Crossings Requiring Permit	22**
	All Other	18
MPC		18

* For horizontal clearance requirements of supporting structures from streets, roads, and highways, refer to Plates SOA-02.201 through SOA-02.203.

** For communication line applications, the required vertical clearance is not less than 18 feet.

Notes:

1. The vertical clearance for overhead electric supply lines over streets, roads, and highways subject to State Highway Department Standards is to be maintained with the conductor at final sag and under the conditions provided on Plate SOA-01.001.

SUBJECT OVERHEAD DISTRIBUTION

DETAIL CLEARANCES - VERTICAL CONDUCTOR CLEARANCE OVER STREETS, ROADS, AND HIGHWAYS SUBJECT TO STATE HIGHWAY DEPARTMENT STANDARDS

Date 1-9-18 | REVISED 01-03-19, 11-04-19 | Southern Company | A- SOA02101

Alabama Power

Vertical Clearance

The vertical clearances at the supporting structure for line conductors of same or different circuits located at different levels on the same supporting structure are shown in Table 11. Line conductors are defined as overhead supply or communication conductors intended to carry electric currents extending along the route of the line; excluding vertical jumpers and line taps. In no case, however, shall vertical separations between line conductors at the same supporting structure be less than those specified on the construction plates of this manual.

Voltages are phase to ground on effectively grounded circuits				
Above / Below		Neutrals and multiplex conductors 0 - 750V (in.)	Open supply line conductors	
			0 - 8.7kV (in.)	8.7kV - 50kV (in.)
Communication conductors		40 [1, 3]	40 [3]	40 [5]
Neutrals and all supply line conductors 0 - 750V		16 [2]	16 [4]	40 [5]
Open supply line conductors over 750V -8.7kV			16 [4]	40 [5]
Open supply line conductors over 8.7KV - 50KV	Same circuit			40 [5]
	Different circuit			40 [5]

Table 11

Footnotes to Table 11:

1. May be reduced to 30 in. for neutral conductors.
2. No clearance is specified between neutral conductor and insulated communication cables located in the supply space and supported by an effectively grounded messenger.
3. No clearance is specified between fiber-optic supply cables and supply cables and conductors.
4. Where conductors are operated by different utilities, the NESC recommends that these basic vertical clearances at the supporting structure be not less than 40 in.
5. Basic clearance requirement is 40 in., however it may be reduced to 16 in. where both conductors are operated by the same utility.

Additional Notes:

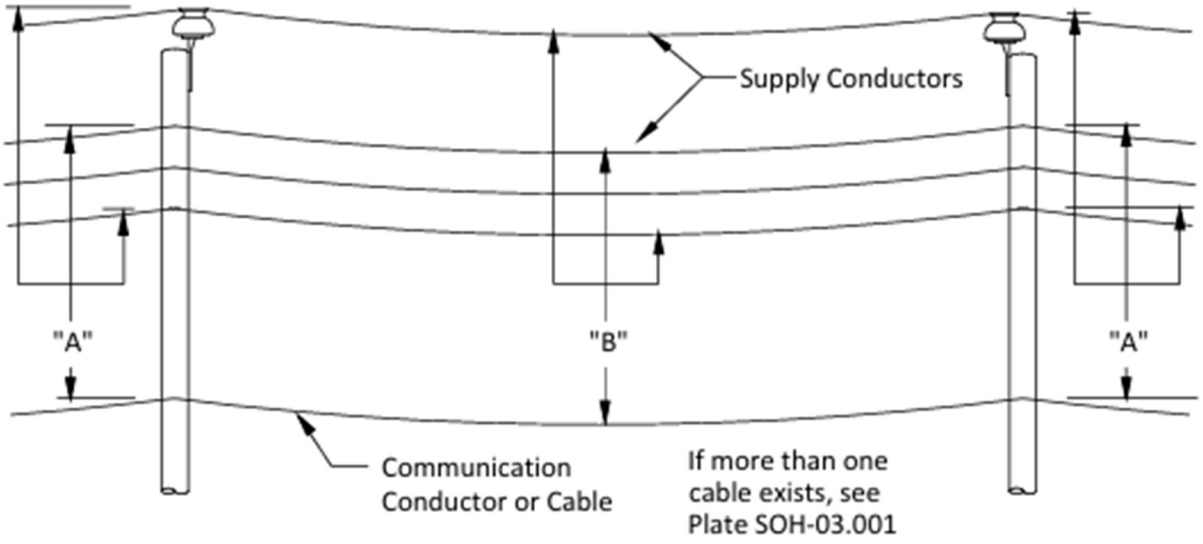
A. The NESC requires that, under certain conditions, vertical clearances greater than those specified in Table 11 be provided at the supporting structure for conductors with different sags on the same support. This rule shall apply to all line wires, conductors, and cables (communication cables included) attached at different levels on the same supporting structure except phase conductors of the same circuit which are of the same size and type. On the distribution system, line conductors of different sags supported at different levels on the same supporting structure shall have vertical clearances at the supporting structures so adjusted that the clearance at any point in the span shall not be less than 75% of the basic vertical clearance required at the supporting structure in Table 11.

(Reference NESC Rule 235, 2017 Edition, for additional information)

SUBJECT OVERHEAD DISTRIBUTION

DETAIL CLEARANCES - CLEARANCES BETWEEN LINE CONDUCTORS CARRIED ON THE SAME SUPPORTING STRUCTURE

Date	REVISED	Southern Company	
02-26-99	09-25-00, 01-26-02, 11-01-06, 12-30-11 01-01-17		A- SOA13001



See Plate SOA-13.001 and 2017 NESC Rule 235C for guidance on how to determine clearances "A" and "B".

SUPPLY CONDUCTOR TYPE/VOLTAGE *	CLEARANCE	
	"A" (in.)	"B" (in.)
Neutral	40**	30***
Secondary	40	30
2400	40	30
4800	40	30
7200	40	30
7620	40	30
7960	40	30
11400	42	32
12000	42	32
13280	42	32
14400	43	33
19900	45	34

* The voltage shown is the phase-to-ground primary voltage.
** 40.0 in. is preferred. This clearance may be reduced to 30.0 in. with Corporate Distribution and Joint Use approval.
*** 30.0 in. is preferred. This clearance may be reduced to 12.0 in. with Corporate Distribution and Joint Use approval.

SUBJECT OVERHEAD DISTRIBUTION

DETAIL JOINT USE - JOINT USE WITH COMMUNICATION FACITLITIES

Date	REVISED	Southern Company	
02/26/99	05-25-00, 01-26-02, 11-01-06, 12-30-11 01-01-17		A- SOH02001

Notes:

1. When CATV and Telephone are attached to the pole, CATV's position is above Telephone (12 in. min.). If additional communication/signal type cables are attached to the pole, their position shall be above Telephone. The spacing between communication messengers should be not less than 12 in. Each CATV and Telephone drop should be not more than 6 in. from their pole-to-pole attachment. Refer to Plate SOH-09.001 for service drop details. Drops shall be 40 in. below supply service or secondary at pole.

2. All cables shall be on same side of pole.

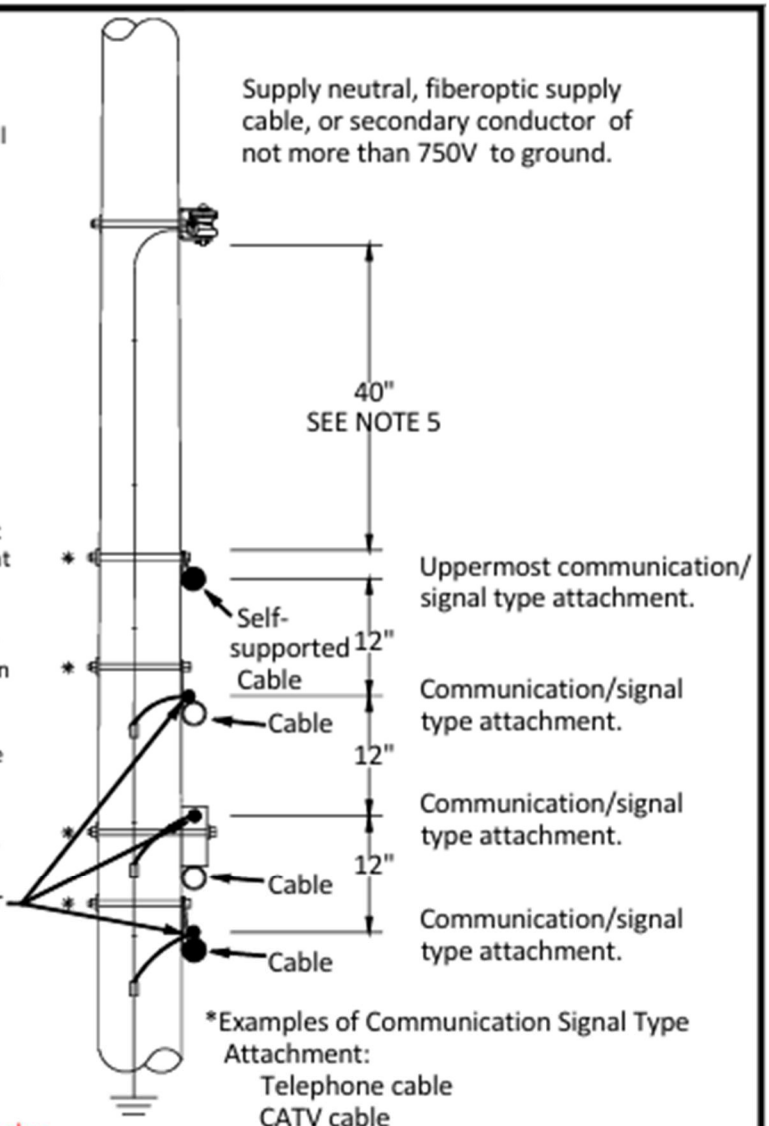
3. Messenger strand shall be bonded to the pole ground, if present. If a separate supply and communication grounding system is installed, the grounding conductors shall be bonded together at the messenger attachment level on the pole and at ground level.

4. If an electric riser is located on the pole, it must be protected by a U-guard or conduit. Such protection must extend not less than 40 in. above the uppermost communications attachment and 6 ft. below the lowest communication attachment.(See SOH-16.001)

5. When lower supply attachment is a supply neutral, or fiber-optic supply cable only, this may be reduced to 30 in.

6. To maintain the strength of a pole, the bolt hole spacing (center-to-center) between any 2 bolt holes, whether parallel or perpendicular, shall be not less than 4 inches. The 4 inch minimum spacing requirement applies to all type poles.

7. For foreign pole attachments to concrete or steel poles, banding is required unless pre-drilled holes are specified when poles are ordered from the manufacturer.



*Examples of Communication Signal Type Attachment:

- Telephone cable
- CATV cable
- Alarm cable (Fire, Police, Water tower level, etc.)
- Traffic signal control cable
- Telegraph cable
- Public or private communication cable

SUBJECT	OVERHEAD DISTRIBUTION
DETAIL	JOINT USE - MULTIPLE COMMUNICATION/SIGNAL TYPE ATTACHMENTS

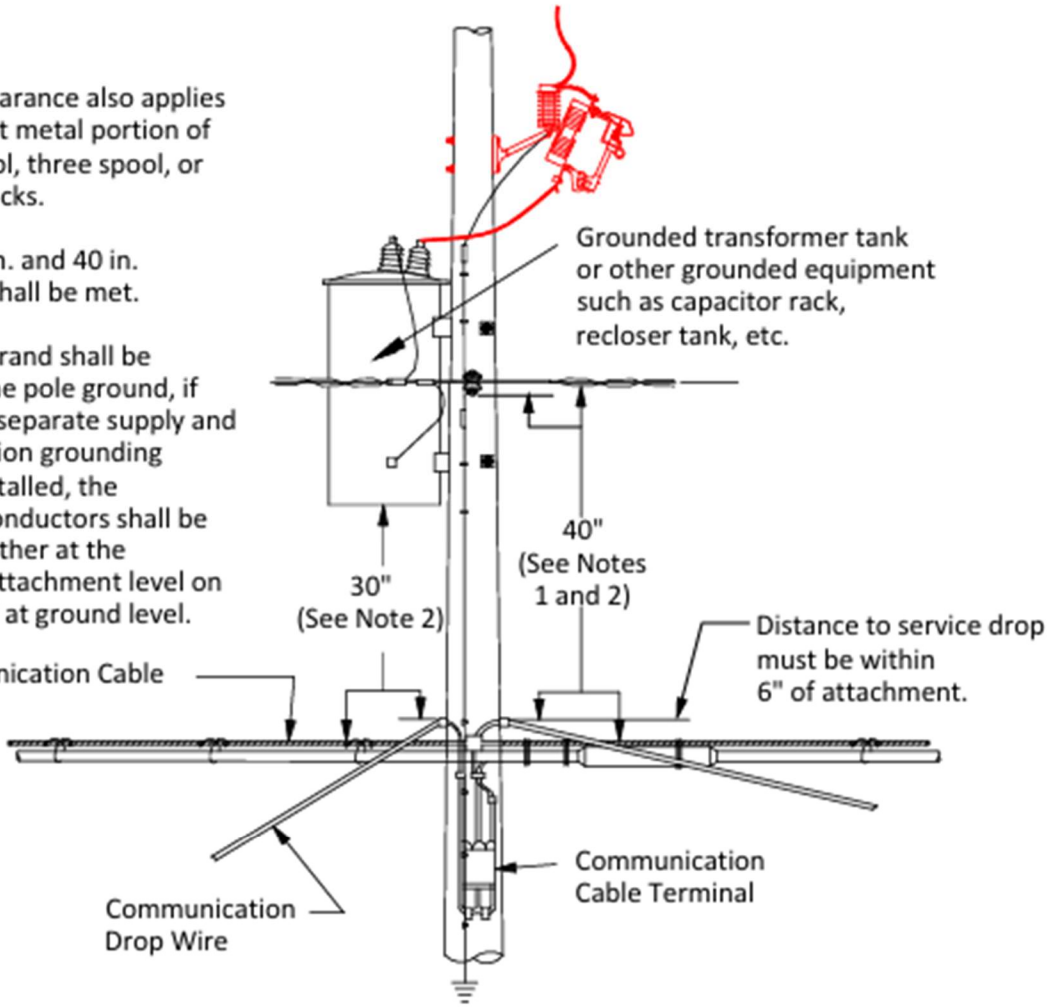
Date 02/26/99	REVISED 09-25-00, 01-26-02, 11-01-06, 12-30-11 07-19-13, 07-09-15, 08-20-15	Southern Company	A- SOH03001

NOTES:

1. This 40 in. clearance also applies to the closest metal portion of any one spool, three spool, or four spool racks.

2. Both the 30 in. and 40 in. clearances shall be met.

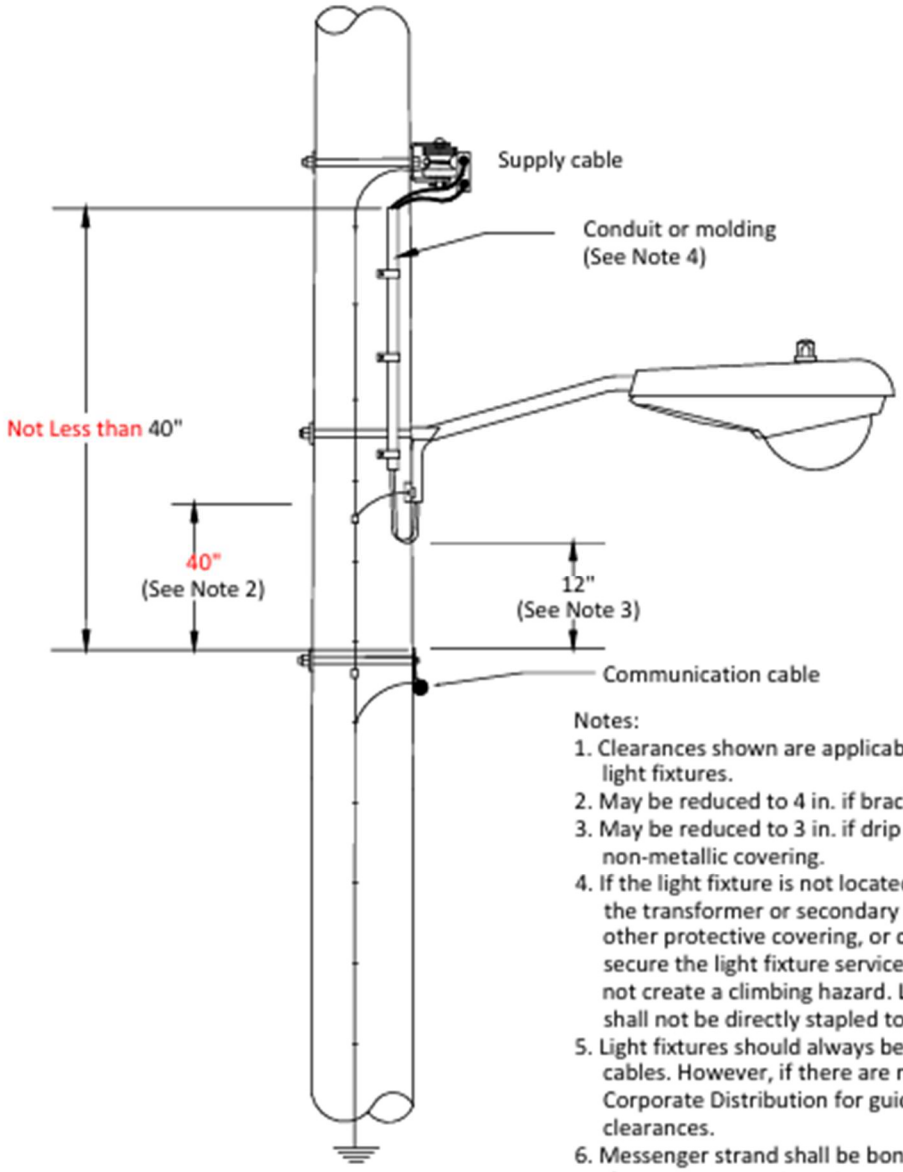
3. Messenger strand shall be bonded to the pole ground, if present. If a separate supply and communication grounding system is installed, the grounding conductors shall be bonded together at the messenger attachment level on the pole and at ground level.



SUBJECT OVERHEAD DISTRIBUTION

DETAIL JOINT USE - TRANSFORMER POLE

Date	REVISED		
02/26/99	09-25-00, 11-01-06, 12-30-11, 06-15-20	Southern Company	A- SOH04001



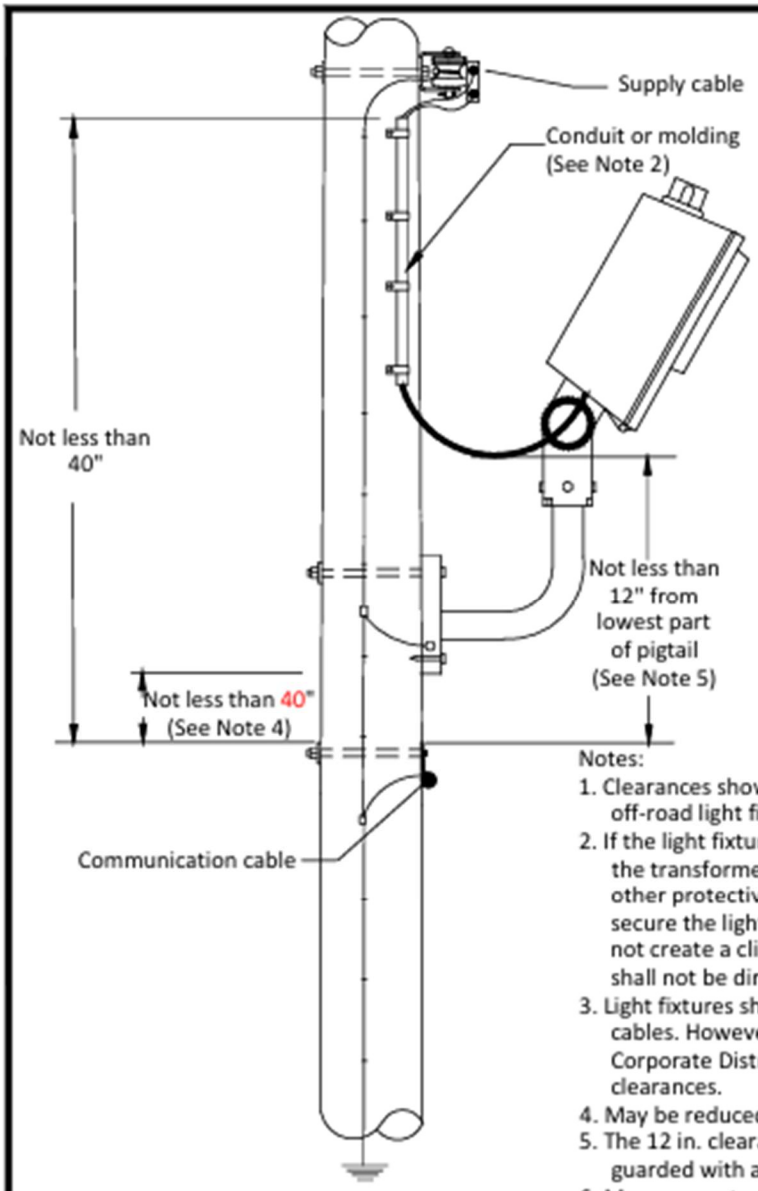
Notes:

1. Clearances shown are applicable to cobra head and open bottom light fixtures.
2. May be reduced to 4 in. if bracket is grounded.
3. May be reduced to 3 in. if drip loop is guarded with a suitable non-metallic covering.
4. If the light fixture is not located within the immediate vicinity of the transformer or secondary conductor, install suitable conduit, other protective covering, or conductor straps to properly secure the light fixture service conductors so the conductors do not create a climbing hazard. Light fixture service conductors shall not be directly stapled to the pole.
5. Light fixtures should always be mounted above communication cables. However, if there are no practical alternatives, contact Corporate Distribution for guidance concerning the required clearances.
6. Messenger strand shall be bonded to the pole ground, if present. If a separate supply and communication grounding system is installed, the grounding conductors shall be bonded together at the messenger attachment level on the pole and at ground level.

SUBJECT OVERHEAD DISTRIBUTION

DETAIL JOINT USE - CATV, TELEPHONE, OTHER SEPARATION FROM LUMINAIRES

Date	REVISED	Southern Company	
02/26/99	09-25-00, 09-17-07, 01-20-11, 12-30-11 6-15-17		A- SOH05001



Notes:

1. Clearances shown are applicable to floodlight fixtures and off-road light fixtures.
2. If the light fixture is not located within the immediate vicinity of the transformer or secondary conductor, install suitable conduit, other protective covering, or conductor straps to properly secure the light fixture service conductors so the conductors do not create a climbing hazard. Light fixture service conductors shall not be directly stapled to the pole.
3. Light fixtures should always be mounted above communication cables. However, if there are no practical alternatives, contact Corporate Distribution for guidance concerning the required clearances.
4. May be reduced to 4 in. if bracket is grounded.
5. The 12 in. clearance can be reduced to 3 in. if the drip loop is guarded with a suitable non-metallic covering.
6. Messenger strand shall be bonded to the pole ground, if present. If a separate supply and communication grounding system is installed, the grounding conductors shall be bonded together at the messenger attachment level on the pole and at ground level.

SUBJECT OVERHEAD DISTRIBUTION

DETAIL JOINT USE - CATV, TELEPHONE, OTHER SEPARATION FROM FLOODLIGHT AND OFF-ROAD LIGHT FIXTURES

Date 01-20-11	REVISED 12-30-11, 03-19-18	Southern Company	A- SOH-06001

Appendix 11. EPRI Common File Format

Example 1: Screen capture of the CFF file to be provided. Actual file to be provided or may be placed on webpage for download. Definition of parameters may be found in the information downloaded from the EPRI website following the instructions provided in section 6.8.2.

PARAMETER	VALUE
NP_P_MAX-SS	
NP_P_MAX_OVER_PF-SS	
NP_OVER_PF-SS	
NP_P_MAX_UNDER_PF-SS	
NP_UNDER_PF-SS	
NP_VA_MAX-SS	
NP_Q_MAX_INJ-SS	
NP_Q_MAX_ABS-SS	
NP_P_MAX_CHARGE-SS	
NP_APPARENT_POWER_CHARGE_MAX-SS	
NP_AC_V_NOM-SS	
AP_LIMIT_ENABLE-SS	ENABLED
AP_LIMIT-SS	1
ES_PERMIT_SERVICE-SS	ENABLED
ES_V_LOW-SS	0.917
ES_V_HIGH-SS	1.05
ES_F_LOW-SS	59.5
ES_F_HIGH-SS	60.1
ES_DELAY-SS	300
ES_RANDOMIZED_DELAY-SS	300
ES_RAMP_RATE-SS	300
CONST_PF_MODE_ENABLE-SS	ENABLED
CONST_PF_EXCITATION-SS	ABS
CONST_PF-SS	1
CONST_Q_MODE_ENABLE-SS	DISABLED
CONST_Q-SS	
QV_MODE_ENABLE-SS	DISABLED
QV_VREF-SS	1
QV_VREF_AUTO_MODE-SS	DISABLED
QV_VREF_TIME-SS	
QV_CURVE_V2-SS	0.97
QV_CURVE_Q2-SS	0
QV_CURVE_V3-SS	1.03
QV_CURVE_Q3-SS	0
QV_CURVE_V1-SS	0.92
QV_CURVE_Q1-SS	0.44
QV_CURVE_V4-SS	1.06
QV_CURVE_Q4-SS	-0.44
QV_OLRT-SS	5

QP_MODE_ENABLE-SS	DISABLED
QP_CURVE_P3_GEN-SS	
QP_CURVE_P2_GEN-SS	
QP_CURVE_P1_GEN-SS	
QP_CURVE_P1_LOAD-SS	
QP_CURVE_P2_LOAD-SS	
QP_CURVE_P3_LOAD-SS	
QP_CURVE_Q3_GEN-SS	
QP_CURVE_Q2_GEN-SS	
QP_CURVE_Q1_GEN-SS	
QP_CURVE_Q1_LOAD-SS	
QP_CURVE_Q2_LOAD-SS	
QP_CURVE_Q3_LOAD-SS	
PV_MODE_ENABLE-SS	DISABLED
PV_CURVE_V1-SS	1.05
PV_CURVE_P1-SS	1
PV_CURVE_V2-SS	1.07
PV_CURVE_P2-SS	0.2
PV_OLRT-SS	10
OV2_TRIP_V-SS	1.2
OV2_TRIP_T-SS	0.16
OV1_TRIP_V-SS	1.1
OV1_TRIP_T-SS	1
UV1_TRIP_V-SS	0.88
UV1_TRIP_T-SS	2
UV2_TRIP_V-SS	0.5
UV2_TRIP_T-SS	0.16
OF2_TRIP_F-SS	62
OF2_TRIP_T-SS	0.16
OF1_TRIP_F-SS	61.2
OF1_TRIP_T-SS	300
UF1_TRIP_F-SS	58.5
UF1_TRIP_T-SS	300
UF2_TRIP_F-SS	56.5
UF2_TRIP_T-SS	0.16
PF_DBOF-SS	0.036
PF_DBUF-SS	0.036
PF_KOF-SS	0.05
PF_KUF-SS	0.05
PF_OLRT-SS	5

Version Number	Effective Date	Author	Owner	Major Revision Topics
1.0	07/01/2024	Rankin Rouse	PD-Interconnections	Original
2.0	08/18/25	Rankin Rouse	PD-Interconnections	Transformer winding configuration options – 6.5 Monitor and control requirements – 6.6 Require use of EPRI CFF – 6.8 V2H/V2G requirements – 6.12 Rapid voltage change – 6.14 Witness test monitor and control requirements – 9.4
3.0	12/15/25	Rankin Rouse	PD-Interconnections	Allow PCS functionality – 6.13 Modify pre-witness test requirements - 9
3.1	12/17/25	Rankin Rouse	PD-Interconnections	Corrected error on Appendix 4, Example 1.

Revision Table