source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING:
SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.

The warning sign(s) or label(s) shall comply with 110.21(B).

Optional standby systems that have a solid (unswitched) neutral in the transfer equipment (nonseparately derived system) rely on the grounding and bonding connections in the normal source supply equipment to ensure that the ground-fault current path is completed from a ground fault to the alternate source. If a main or system bonding jumper is removed [e.g., to perform testing on ground-fault protection of equipment (GFPE) systems], service personnel could inadvertently become part of the current path if a ground fault occurs.

Δ **(C) Power Inlet.** Where a power inlet is used for a temporary connection to a portable generator, a warning sign shall be placed near the inlet to indicate the type of derived system that the system is capable of based on the wiring of the transfer equipment. The sign shall display one of the following warnings:

WARNING:
FOR CONNECTION OF A SEPARATELY DERIVED (BONDED NEUTRAL) SYSTEM ONLY
or
WARNING:
FOR CONNECTION OF A NONSEPARATELY DERIVED (FLOATING NEUTRAL) SYSTEM ONLY

Part II. Wiring

702.10 Wiring Optional Standby Systems. The optional standby system wiring shall be permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring.

702.11 Portable Generator Grounding.

(A) Separately Derived System. Where a portable optional standby source is used as a separately derived system, it shall be grounded to a grounding electrode in accordance with 250.30.

(B) Nonseparately Derived System. Where a portable optional standby source is used as a nonseparately derived system, the equipment grounding conductor shall be bonded to the system grounding electrode.

702.12 Outdoor Generator Sets.

(A) Portable Generators Greater Than 15 kW and Permanently Installed Generators. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

The disconnecting means on an outdoor generator set can be used as the disconnecting means required in 225.31, provided the disconnecting means, and not just the generator, is readily accessible and is within sight of the building.

(B) Portable Generators 15 kW or Less. Where a portable generator, rated 15 kW or less, is installed using a flanged inlet or other cord-and-plug-type connection, a disconnecting means shall not be required where ungrounded conductors serve or pass through a building or structure. The flanged inlet or other cord-and-plug-type connection shall be located outside of a building or structure.

Δ **(C) Power Inlets Rated at 100 Amperes or Greater, for Portable Generators.** Equipment containing power inlets for the connection of a generator source shall be listed for the intended use. Systems with power inlets not rated as a disconnecting means shall be equipped with an interlocked disconnecting means.

Exception: Supervised industrial installations where permanent space is identified for the portable generator located within line of sight of the power inlets shall not be required to have interlocked disconnecting means nor inlets rated as disconnects.

This requirement ensures that a portable generator can be safely disconnected from a power inlet rated 100 amperes or more. A generator that is disconnected (unplugged) under load can present a safety hazard if the inlet is not rated for load break. The power inlet is required to be equipped with an interlocked disconnecting means to ensure that the disconnecting means is opened prior to disengaging the inlet. The exceptions recognize power inlets that are load break rated and those installed in supervised industrial installations where certain conditions exist.

ARTICLE 705

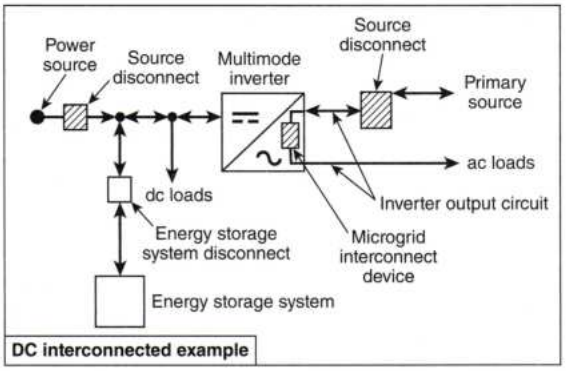
Interconnected Electric Power Production Sources

Part I. General

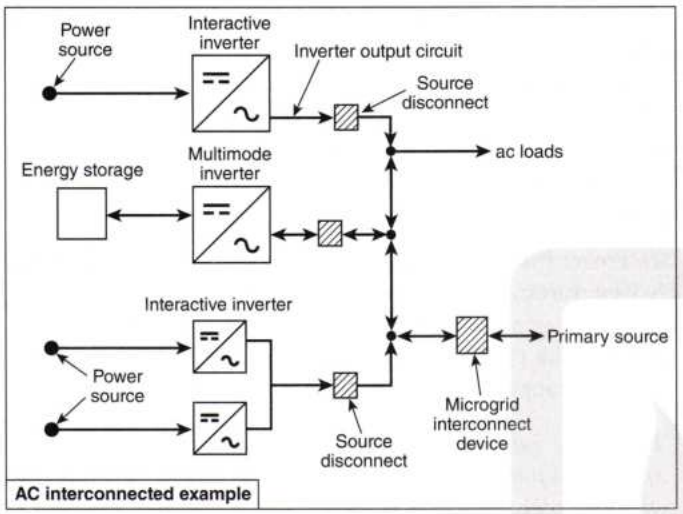
705.1 Scope. This article covers installation of one or more electric power production sources operating in parallel with a primary source(s) of electricity.

Informational Note No. 1: Examples of the types of primary sources include a utility supply or an on-site electric power source(s).

Informational Note No. 2: See Informational Note Figure 705.1.



DC interconnected example



AC interconnected example

Notes:
(1) These diagrams are intended to be a means of identification for power source components, circuits, and connections.
(2) The power source disconnect in these diagrams separates the power source from other systems.
(3) Equipment disconnecting means not shown.
(4) System grounding and equipment grounding are not shown.
(5) Custom designs occur in each configuration, and some components are optional.

N ***INFORMATIONAL NOTE FIGURE 705.1*** *Identification of Power Source Components in Common Configurations*

Article 705 contains requirements for interconnecting power production sources that operate in parallel as distributed generation. It does not cover sources that are connected by a transfer switch that permits operation of a single source. The primary source is not required to be a utility source. The requirements of Article 705 are not dependent on the type of generating source employed. These installations are subject to the entire *NEC*®, as detailed in 90.3.

Δ **705.5 Parallel Operation.**

N **(A) Output Compatibility.** Power production sources operating in parallel with a primary source of electricity or other power production sources shall have compatible voltage, wave shape, and frequency ratings.

N **(B) Synchronous Generators.** Synchronous generators operating in parallel with a primary power source shall be installed with the required synchronizing equipment.

Informational Note: See IEEE 1547, *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces,* and UL 1741, *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources,* for utility interconnection.

Control of the power production source should include real power, reactive power, and harmonic content of the output. The output characteristics of a rotating generator are significantly different from those of a solid-state power source.

The parallel operation of generators is a complex balance of several variables that are design parameters and therefore beyond the scope of the *NEC*.

Some inverters, uninterruptible power supplies (UPS), or solid-state variable-speed drives may produce harmonic currents. (See Exhibit 705.1.) The multiples of the basic supply frequency (usually 60 hertz) can cause additional heating, which could require derating of generators, transformers, cables, and motors. Special generator voltage control systems are required to avoid erratic operation or destruction of control devices. Circuit breakers could require derating if the higher harmonics become significant.

In Exhibit 705.1 (middle), motors and transformers will be driven by harmonic-rich voltage and might require derating. In Exhibit 705.1 (bottom), the source generator could require derating, and special voltage control might be needed.

Δ **705.6 Equipment Approval.** Interconnection and interactive equipment intended to connect to or operate in parallel with power production sources shall be listed for the required interactive function or be evaluated for the interactive function and have a field label applied, or both.

Informational Note No. 1: See UL 1741, *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources*, for evaluating interconnected equipment. Sources identified as stand-alone, interactive, or multimode are specifically identified and certified to operate in these operational modes. Stand-alone sources operate in island mode, interactive sources operate in interactive mode, and multimode sources operate in either island mode or interactive mode. Stand-alone sources are not evaluated for interactive capabilities.

Informational Note No. 2: An interactive function is common in equipment such as microgrid interconnect devices, power control systems, interactive inverters, synchronous engine generators, ac energy storage systems, and ac wind turbines.

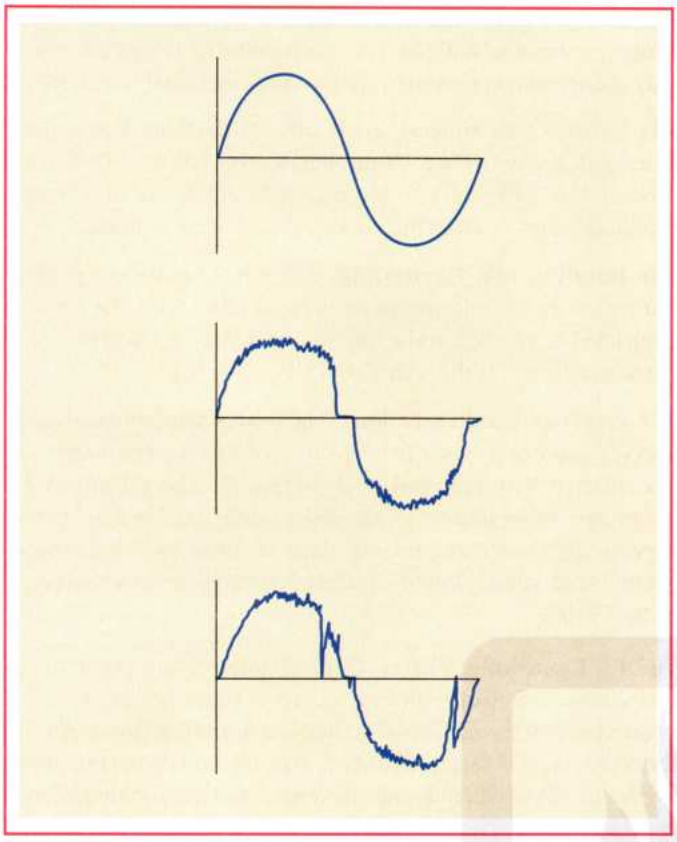


EXHIBIT 705.1 Typical output wave shapes: *(top)* with rotating generator and system wave shape normally encountered with motor, lighting, and heating loads; *(middle)* with inverter source; and *(bottom)* with variable speed drive, rectifier, and uninterruptible power to supply loads.

705.8 System Installation. Installation of one or more electrical power production sources operating in parallel with a primary source(s) of electricity shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of *Qualified Person*.

Interconnected power production sources introduce hazards unique to systems operating in parallel. Installation and maintenance personnel must be qualified in parallel operation of electrical systems. The *NEC* defines a qualified person but does not detail the additional training necessary to be deemed a qualified person (see *NFPA 70E®, Standard for Electrical Safety in the Workplace®*). Special training for persons working on interconnected systems is key to ensuring that personnel can work safely on these systems.

Δ **705.10 Identification of Power Sources.** Permanent plaques, labels, or directories shall be installed at each service equipment location, or at an approved readily visible location in accordance with the following:

(1) Denote the location of each power source disconnecting means for the building or structure.

Exception: Installations with multiple colocated power production sources shall be permitted to be identified as a group(s). The plaque, label, or directory shall not be required to identify each power source individually.

(2) Indicate the emergency telephone numbers of any off-site entities servicing the power source systems.

Informational Note: See NFPA 1-2021, *Fire Code*, 11.12.2.1.5 for installer information.

(3) Be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER." The marking shall comply with 110.21(B).

Δ **705.11 Source Connections to a Service.**

Electric power production sources are permitted to be connected on the supply side of the service disconnecting means, or they can be connected on the load side. See Exhibit 705.2.

N **(A) Service Connections.** An electric power production source shall be permitted to be connected to a service by one of the following methods:

(1) To a new service in accordance with 230.2(A)
(2) To the supply side of the service disconnecting means in accordance with 230.82(6)
(3) To an additional set of service entrance conductors in accordance with 230.40, Exception No. 5

These connections shall comply with 705.11(B) through (F).

Δ **(B) Conductors.** Service conductors connected to power production sources shall comply with the following:

(1) The ampacity of the service conductors connected to the power production source service disconnecting means shall not be less than the sum of the power production source maximum circuit current in 705.28(A).
(2) The service conductors connected to the power production source service disconnecting means shall be sized in accordance with 705.28 and not be smaller than 6 AWG copper or 4 AWG aluminum or copper-clad aluminum.
(3) The ampacity of any other service conductors to which the power production sources are connected shall not be less than that required in 705.11(B).

(C) Connections. Connections to service conductors or equipment shall comply with 705.11(C)(1) through (C)(3).

N **(1) Splices or Taps.** Service conductorsplices and taps shall be made in accordance with 230.33 or 230.46 and comply with all applicable enclosure fill requirements.

N **(2) Existing Equipment.** Any modifications to existing equipment shall be made in accordance with the manufacturer's instructions, or the modification must be field evaluated for the application and be field labeled.

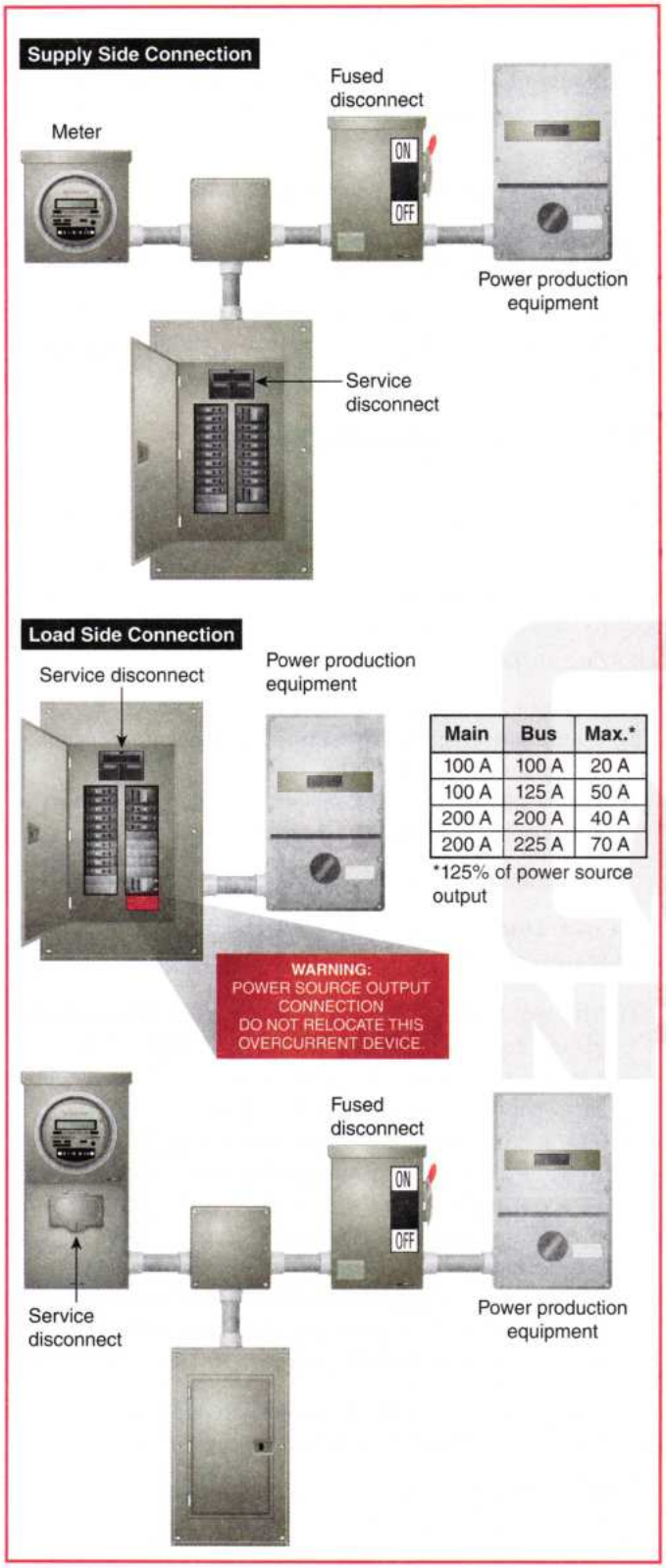


EXHIBIT 705.2 The points of interconnection permitted by 705.11 and 705.12.

N **(3) Utility-Controlled Equipment.** For meter socket enclosures or other equipment under the exclusive control of the electric utility, only connections approved by the electric utility shall be permitted.

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N **(D) Service Disconnecting Means.** A disconnecting means in accordance with Parts VI through VII of Article 230 shall be provided to disconnect all ungrounded conductors of a power production source from the conductors of other systems.

N **(E) Bonding and Grounding.** All metal enclosures, metal wiring methods, and metal parts associated with the service connected to a power production source shall be bonded in accordance with Parts II through V and VIII of Article 250.

Δ **(F) Overcurrent Protection.** The power production source service conductors shall be protected from overcurrent in accordance with Part VII of Article 230. The rating of the overcurrent protection device of the power production source service disconnecting means shall be used to determine if ground-fault protection of equipment is required in accordance with 230.95.

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Δ **705.12 Load-Side Source Connections.** The output of an interconnected electric power source shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment or feeders are fed simultaneously by a primary source of electricity and one or more other power source(s), the feeders or distribution equipment shall comply with relevant sections of 705.12(A) and (B). Currents from power source connections to feeders or busbars shall be based on the maximum circuit currents calculated in 705.28(A). The ampacity of feeders and taps shall comply with 705.12(A), and the ampere ratings of busbars shall comply with 705.12(B).

(A) Feeders and Feeder Taps. Where the power source output connection is made to a feeder, the following shall apply:

(1) The feeder ampacity is greater than or equal to 125 percent of the power-source output circuit current.

(2) Where the power-source output connection is made at a location other than the opposite end of the feeder from the primary source overcurrent device, that portion of the feeder on the load side of the power source output connection shall be protected by one of the following:

a. The feeder ampacity shall be not less than the sum of the rating of the primary source overcurrent device and 125 percent of the power-source output circuit current.
b. An overcurrent device at the load side of the power source connection point shall be rated not greater than the ampacity of the feeder.

(3) For taps sized in accordance with 240.21(B)(2) or (B)(4), the ampacity of taps conductors shall not be less than one-third of the sum of the rating of the overcurrent device protecting the feeder plus the ratings of any power source overcurrent devices connected to the feeder.

(B) Busbars. For power source connections to distribution equipment with no specific listing and instructions for combining multiple sources, one of the following methods shall be used to determine the required ampere ratings of busbars:

(1) The sum of 125 percent of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the busbar ampere rating.

Informational Note: This general rule assumes no limitation in the number of the loads or sources applied to busbars or their locations.

(2) Where two sources, one a primary power source and the other another power source, are located at opposite ends of a busbar that contains loads, the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the busbar ampere rating. The busbar shall be sized for the loads connected in accordance with Article 220. A permanent warning label shall be applied to the distribution equipment adjacent to the back-fed breaker from the power source that displays the following or equivalent wording:

WARNING:
POWER SOURCE OUTPUT
DO NOT RELOCATE THIS OVERCURRENT DEVICE.

The warning sign(s) or label(s) shall comply with 110.21(B).

(3) The sum of the ampere ratings of all overcurrent devices on panelboards, both load and supply devices, excluding the rating of the overcurrent device protecting the busbar, shall not exceed the ampacity of the busbar. The rating of the overcurrent device protecting the busbar shall not exceed the rating of the busbar. Permanent warning labels shall be applied to distribution equipment displaying the following or equivalent wording:

WARNING:
EQUIPMENT FED BY MULTIPLE SOURCES.
TOTAL RATING OF ALL OVERCURRENT DEVICES
EXCLUDING MAIN SUPPLY OVERCURRENT DEVICE
SHALL NOT EXCEED AMPACITY OF BUSBAR.

The warning sign(s) or label(s) shall comply with 110.21(B).

(4) A connection at either end of a center-fed panelboard in dwellings shall be permitted where the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar does not exceed 120 percent of the busbar ampere rating.

(5) Connections shall be permitted on busbars of panelboards that supply lugs connected to feed-through conductors or are supplied by feed-through conductors. The feed-through conductors shall be sized in accordance with 705.12(A). Where an overcurrent device is installed at either end of the feed-through conductors, panelboard busbars on either side of the feed-through conductors shall be permitted to be sized in accordance with 705.12(B)(1) through (B)(3).

(6) Connections shall be permitted on switchgear, switchboards, and panelboards in configurations other than those permitted in 705.12(B)(1) through (B)(5) where designed under engineering supervision that includes available fault-current and busbar load calculations.

Informational Note: Specifically designed equipment exists, listed to UL 1741, *Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*, for the combination and distribution of sources to supply loads. The options provided in 705.12(B) are for equipment with no specific listing for combining sources.

The required ampacity of a feeder or bus connected to the interactive inverter is based on the inverter output circuit current, rather than on the overcurrent protective device (OCPD) in the inverter. Except where 705.12(A)(2)(b) and (B)(3) apply, the required conductor ampacity is determined by adding the ampacity of the primary OCPD protecting a busbar or feeder and 125 percent of inverter output current.

Where a tap is made to a feeder supplied by the inverter and the normal source, the calculated sum is used as the rating of the overcurrent device to determine the ampacity of the tap conductors in 240.21(B).

Unlike in service equipment where the number or rating of overcurrent devices is not limited, 705.12(B)(3) places a limit on panelboard overcurrent devices. The sum of the ratings of all overcurrent devices (excluding the main overcurrent device) supplying and/or being supplied by the panelboard is limited to the busbar rating. In addition, the main overcurrent device also must be limited to the ampacity of the busbar.

• Δ **705.13 Energy Management Systems (EMS).** An EMS in accordance with 750.30 shall be permitted to limit current and loading on the busbars and conductors supplied by the output of one or more interconnected electric power production or energy storage sources.

Informational Note: A listed power control system (PCS) is a type of EMS that is capable of monitoring multiple power sources and controlling the current on busbars and conductors to prevent overloading. See UL 1741, *Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources*, and UL 916, *Energy Management Equipment*, for information on PCS and EMS.

The use of a power control system (PCS) (see Exhibit 705.3) that involves monitoring and control of all the individual sources can prevent the feeder or busbar from being overloaded while making efficient use of the variable resources.

• Δ **705.20 Source Disconnecting Means.** Means shall be provided to disconnect power source output conductors of electric power production equipment from conductors of other systems. A single disconnecting means shall be permitted to disconnect multiple power sources from conductors of other systems.

Informational Note: See 480.7, Part II of Article 445, Part III of Article 690, Part III of Article 692, Part III of Article 694, and Part II of Article 706 for specific source disconnecting means requirements.

EXHIBIT 705.3 PCS for monitoring and controlling individual power sources. *(Courtesy of ASCO Power Technologies)*

The disconnecting means shall comply with the following:

(1) Be one of the following types:

a. A manually operable switch or circuit breaker
b. A load-break-rated pull-out switch
c. A power-operated or remote-controlled switch or circuit breaker that is manually operable locally and opens automatically when control power is interrupted
d. A device listed or approved for the intended application

(2) Simultaneously disconnect all ungrounded conductors of the circuit
(3) Located where readily accessible
(4) Externally operable without exposed live parts
(5) Plainly indicate whether in the open (off) or closed (on) position
(6) Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals
(7) Where the line and load terminals are capable of being energized in the open position, be marked with the following words or equivalent:

WARNING
ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

Informational Note: With interconnected power sources, some equipment, including switches and fuses, is capable of being energized from both directions.

705.25 Wiring Methods. Power source output conductors shall comply with 705.25(A) through (C).

Δ **(A) General.** Wiring methods and fittings listed for use with power production systems shall be permitted in addition to general wiring methods and fittings permitted elsewhere in this *Code*.

Δ **(B) Flexible Cords and Cables.** Flexible cords and cables, where used to connect the moving parts of power production equipment, or where used for ready removal for maintenance and repair, shall be listed and identified as DG cable, or other cable suitable for extra hard use, and shall be water resistant. Cables exposed to sunlight shall be sunlight resistant. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A).

(C) Multiconductor Cable Assemblies. Multiconductor cable assemblies used in accordance with their listings shall be permitted.

Informational Note: See UL 3003, *Distributed Generation Cables*, and UL 9703, *Outline of Investigation for Distributed Generation Wiring Harnesses*, for additional information on DG cable (distributed generation cable) and harnesses. An ac module harness is one example of a multiconductor cable assembly.

705.28 Circuit Sizing and Current.

(A) Power Source Output Maximum Current. Where not elsewhere required or permitted in this *Code*, the maximum current for power sources shall be calculated using one of the following methods:

(1) The sum of the continuous output current ratings of the power production equipment at the circuit nominal system voltage
(2) For power production equipment controlled by an EMS, the current setpoint of the EMS
(3) Where sources controlled by an EMS are combined with other sources on the same power source output circuit, the sum of 705.28(A)(1) and (A)(2)

(B) Conductor Ampacity. Where not elsewhere required or permitted in this *Code*, the power source output conductors shall have an ampacity not less than the larger of the following and comply with 110.14(C):

(1) The maximum currents in 705.28(A) multiplied by 125 percent without adjustment or correction factors

Exception No. 1: If the assembly, including the overcurrent devices protecting the circuit, is listed for operation at 100 percent of its rating, the ampacity of the conductors shall be permitted to be not less than the calculated maximum current of 705.28(A).

Exception No. 2: Where a portion of a circuit is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an ampacity not less than the calculated maximum current of 705.28(A). No portion of the circuit installed under this exception shall extend into an enclosure containing either the circuit supply or the circuit load terminations, as covered in 110.14(C)(1).

Exception No. 3: Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the calculated maximum current of 705.28(A).

(2) The maximum currents in 705.28(A) after the application of adjustment and correction factors in accordance with 310.14
(3) Where connected to feeders, if smaller than the feeder conductors, the ampacity as calculated in 240.21(B) based on the over-current device protecting the feeder

(C) Neutral Conductors. Neutral conductors shall be permitted to be sized in accordance with either 705.28(C)(1) or (C)(2).

(1) Single-Phase Line-to-Neutral Power Sources. Where not elsewhere required or permitted in this *Code*, the ampacity of a neutral conductor to which a single-phase line-to-neutral power source is connected shall not be smaller than the ampacity in 705.28(B).

(2) Neutral Conductor Used Solely for Instrumentation, Voltage, Detection, or Phase Detection. A power production equipment neutral conductor used solely for instrumentation, voltage detection, or phase detection shall be permitted to be sized in accordance with 250.102.

705.30 Overcurrent Protection.

Power production sources and conductors are required to follow the applicable article for determining overcurrent protection. These installations are subject to the entire *NEC*, as detailed in 90.3.

Δ **(A) Circuit and Equipment.** Power source output conductors and equipment shall be provided with overcurrent protection. Circuits connected to more than one electrical source shall have overcurrent devices located to provide overcurrent protection from all sources.

(B) Overcurrent Device Ratings. The overcurrent devices in other than generator systems shall be sized to carry not less than 125 percent of the maximum currents as calculated in 705.28(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C).

Exception: Circuits containing an assembly together with its overcurrent device(s) that is listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

N **(C) Marking.** Equipment containing overcurrent devices supplied from interconnected power sources shall be marked to indicate the presence of all sources.

N **(D) Suitable for Backfeed.** Fused disconnects, unless otherwise marked, shall be considered suitable for backfeed. Circuit breakers not marked "line" and "load" shall be considered suitable for backfeed. Circuit breakers marked "line" and "load" shall be considered suitable for backfeed or reverse current if specifically rated.

N **(E) Fastening.** Listed plug-in-type circuit breakers backfed from electric power sources that are listed and identified as interactive shall be permitted to omit the additional fastener normally required by 408.36(D) for such applications.

Δ **(F) Transformers.** The following apply to the installation of transformers:

(1) For the purpose of overcurrent protection, the primary side of transformers with sources on each side shall be the side connected to the largest source of available fault current.

(2) Transformer secondary conductors shall be protected in accordance with 240.21(C).

705.32 Ground-Fault Protection. Where ground-fault protection of equipment is installed in ac circuits as required elsewhere in this *Code*, the output of interconnected power production equipment shall be connected to the supply side of the ground-fault protection equipment.

Exception: Connection of power production equipment shall be permitted to be made to the load side of ground-fault protection equipment where installed in accordance with 705.11 or where there is ground-fault protection for equipment from all ground-fault current sources.

705.40 Loss of Primary Source. The output of interactive electric power production equipment shall be automatically disconnected from all ungrounded conductors of the primary source when one or more of the phases of the primary source to which it is connected opens. The interactive electric power production equipment shall not be reconnected to the primary source until all the phases of the primary source to which it is connected are restored. This requirement shall not be applicable to electric power production equipment providing power to an emergency or legally required standby system.

Exception: A listed interactive inverter shall trip or shall be permitted to automatically cease exporting power when one or more of the phases of the interconnected primary source opens and shall not be required to automatically disconnect all ungrounded conductors from the primary source. A listed interactive inverter shall be permitted to automatically or manually resume exporting power to the interconnected system once all phases of the source to which it is connected are restored.

Informational Note No. 1: Risks to personnel and equipment associated with the primary source could occur if an interactive electric power production source can operate as an intentional island. Special detection methods are required to determine that a primary source supply system outage has occurred and whether there should be automatic disconnection. When the primary source supply system is restored, special detection methods are typically required to limit exposure of power production sources to out-of-phase reconnection.

Informational Note No. 2: Induction-generating equipment connected on systems with significant capacitance can become self-excited upon loss of the primary source and experience severe overvoltage as a result.

Interactive power production equipment shall be permitted to operate in island mode to supply loads that have been disconnected from the electric utility or other electric power production and distribution network.

When two interconnected power systems separate, they can drift out of synchronization. Damage to the system(s) can occur if restoration of one system occurs out of phase with the other system(s). If the reconnection is out of phase, violent

electromechanical stresses can destroy mechanical components such as gears, couplings, and shafts and can displace coils.

See Part II of Article 705 for microgrid system requirements, including the necessary interconnect device if a microgrid system is operating in stand-alone mode (islanded).

705.45 Unbalanced Interconnections.

(A) Single Phase. Single-phase power sources in interactive systems shall be connected to 3-phase power systems in order to limit unbalanced voltages at the point of interconnection to not more than 3 percent.

Informational Note: For interactive power sources, unbalanced voltages can be minimized by the same methods that are used for single-phase loads on a 3-phase power system. See ANSI/C84.1-2016, *Electric Power Systems and Equipment — Voltage Ratings (60 Hertz)*.

(B) Three Phase. Three-phase power sources in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result.

Part II. Microgrid Systems

The requirements in Article 705 apply to power production systems that operate in parallel with a primary supply. Section 705.40 requires that the ungrounded conductors of the power production source be automatically disconnected from the ungrounded conductors of the primary source. Section 705.40 permits inverters to provide the disconnection of the load from the primary source and the power production source to operate as a stand-alone system.

705.50 System Operation. Interconnected microgrid systems shall be capable of operating in interactive mode with a primary source of power, or electric utility, or other electric power production and distribution network. Microgrid systems shall be permitted to disconnect from other sources and operate in island mode.

Informational Note No. 1: Microgrid systems often include a single source or a compatible interconnection of multiple sources such as engine generators, solar PV, wind, or ESS.

Informational Note No. 2: See Article 517 for health care facilities incorporating microgrids.

705.60 Primary Power Source Connection. Connections to primary power sources that are external to the microgrid system shall comply with the requirements of 705.11, 705.12, or 705.13. Power source conductors connecting to a microgrid system, including conductors supplying distribution equipment, shall be considered as power source output conductors.

705.65 Reconnection to Primary Power Source. Microgrid systems that reconnect to primary power sources shall be provided with the necessary equipment to establish a synchronous transition.

Δ **705.70 Microgrid Interconnect Devices (MID).** Microgrid interconnect devices shall comply with the following:

(1) Be required for any connection between a microgrid system and a primary power source
(2) Be evaluated for the application and have a field label applied or be listed for the application
(3) Have overcurrent devices located to provide overcurrent protection from all sources

Informational Note: MID functionality is often incorporated in an interactive or multimode inverter, energy storage system, or similar device identified for interactive operation.

N **705.76 Microgrid Control System (MCS).** Microgrid control systems shall comply with the following:

(1) Coordinate interaction between multiple power sources of similar or different types, manufacturers, and technologies (including energy storage)
(2) Be evaluated for the application and have a field label applied, or be listed, or be designed under engineering supervision
(3) Monitor and control microgrid power production and power quality
(4) Monitor and control transitions with a primary source external to the microgrid

Informational Note: MID functionality is often incorporated in an interactive or multimode inverter, energy storage system, or similar device identified for interactive operation.

N Part III. Interconnected Systems Operating in Island Mode

N **705.80 Power Source Capacity.** For interconnected power production sources that operate in island mode, capacity shall be calculated using the sum of all power source output maximum currents for the connected power production source.

N **705.81 Voltage and Frequency Control.** Power sources operating in island mode shall be controlled so that voltage and frequency are supplied within limits compatible with the connected loads.

N **705.82 Single 120-Volt Supply.** Systems operating in island mode shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt distribution equipment where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the sum of the ratings of the power sources shall be less than the rating of the neutral bus in the distribution equipment. This equipment shall be marked with the following words or equivalent:

WARNING: SINGLE 120-VOLT SUPPLY
DO NOT CONNECT MULTIWIRE
BRANCH CIRCUITS

The warning sign(s) or label(s) shall comply with 110.21(B).