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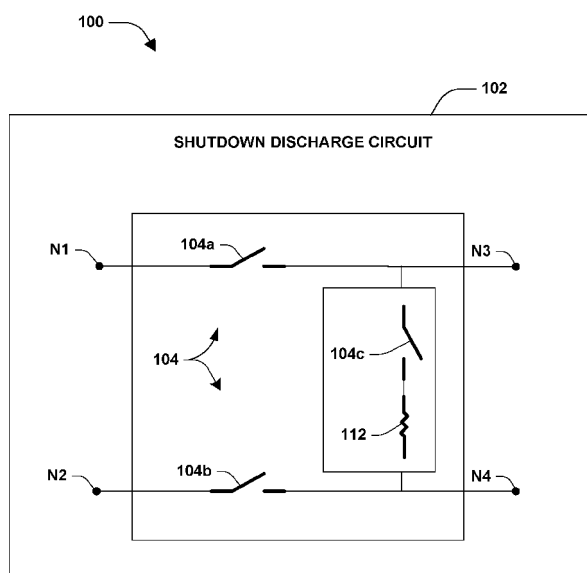
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(54) **Title:** ENERGY PANEL ARRANGEMENT POWER DISSIPATION**FIG. 1**

(57) **Abstract:** One or more techniques and/or systems are provided for facilitating shutdown of output power from an energy panel arrangement to a power converter. A shutdown implementation module is coupled between an energy panel arrangement and a power converter that converts DC power from the energy panel arrangement to AC power for an AC power grid. Responsive to identifying a power shutdown condition, the shutdown implementation module shuts down output power from the energy panel arrangement to the power converter. A power dissipating device is invoked to dissipate power associated with the shutdown of the output power (e.g., residual power within energy storage devices, such as capacitors, associated with the power converter). The shutdown implementation module may be located within a threshold distance from the energy panel arrangement (e.g., within about 10 feet) so that the output power may be shut off within a threshold timespan (e.g., within about 10 seconds).

ENERGY PANEL ARRANGEMENT POWER DISSIPATION

REFERENCE TO RELATED APPLICATION

[0001] This application claims priority of U.S. Provisional Application No. 62/092,469 entitled “ENERGY PANEL ARRANGEMENT POWER DISSIPATION”, filed December 16, 2014, which is incorporated herein by reference.

FIELD

[0002] The invention relates to an energy panel arrangement.

BACKGROUND

[0003] Many buildings may utilize energy panel arrangements, such as photovoltaic systems comprising solar panels that absorb and convert sunlight into electricity, for power generation. A power converter may be configured to convert DC power from an energy panel arrangement to AC power for an AC power grid that may supply power to a building. The energy panel arrangement may be installed outside of the building, such as on a roof of the building. A DC power line may couple the energy panel arrangement to the power converter. The power converter may be installed in a different location of the building than the energy panel arrangement, such as in a basement of the building where electrical service enters the building into an electrical panel. The energy panel arrangement may provide DC power over the DC power line to the power converter. In the event an issue arises, such as a fire in the building, an arc flash, a need to shut down power to the building, etc., the DC power line may need to be shut down and de-energized. For example, electrical standards may specify that conductors of a photovoltaic system are to discharge to a reduced output power within about 10 seconds at a distance of about 10 feet or less from the solar panels. Unfortunately, the power converter may be installed further than 10 feet from the solar panels.

SUMMARY

[0004] Among other things, one or more systems and/or techniques for facilitating a shutdown of output power from an energy panel arrangement to a power converter

are provided herein. A shutdown discharge circuit is coupled between an energy panel arrangement and a power converter (e.g., an inverter, a device that charges batteries, or any other converter device) that is configured to convert DC power from the energy panel arrangement to AC power for an AC power grid. In an example, the shutdown discharge circuit may be implemented near the energy panel arrangement (e.g., near a roof or other structure upon which the energy panel arrangement is installed). In an example, the shutdown discharge circuit may be implemented near the power converter (e.g., the shutdown discharge circuit may be connected to a power supply unit within the power converter; the shutdown discharge circuit may be implemented within a shutdown implementation module that is implemented without a communication module, a power module, a processor, and/or a power line communication interface). The shutdown discharge circuit comprises a switching arrangement configured to direct power, associated with shutting down output power from the energy panel arrangement to the power converter, through a power dissipating device such as a resistor, a positive temperature coefficient (PTC) device, etc. For example, during shutdown, power within one or more energy storage components, such as capacitors associated with the power converter, may be dissipated through the power dissipating device.

[0005] In a specific embodiment, there is provided a system for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:

a shutdown discharge circuit coupled between an energy panel arrangement and a power converter that is configured to convert DC power from the energy panel arrangement to AC power for an AC power grid, the shutdown discharge circuit comprising:

a switching arrangement configured to direct power, associated with shutting down output power from the energy panel arrangement to the power converter, through a power dissipating device; and

the power dissipating device configured to dissipate the power associated with shutting down the output power from the energy panel arrangement to the power converter; and

a shutdown implementation module configured to:

establish a communication connection, over a power-line communication line between the energy panel arrangement and the power

converter, with a shutdown controller associated with the power converter;
and

responsive to identifying a power shutdown condition:

initiate shutdown of output power from the energy panel
arrangement to the power converter; and

invoke the power dissipating device to dissipate the power associated with
shutting down the output power.

[0006] A shutdown implementation module, associated with the shutdown discharge circuit, may establish a communication connection, over a power-line communication line between the energy panel arrangement and the power converter, with a shutdown controller associated with the power converter. The shutdown implementation module may identify a power shutdown condition (e.g., an arc-fault, a power converter failure, a loss of the communication connection, a shutdown instruction received over the power-line communication line from the shutdown controller, etc.). Responsive to the power shutdown condition, the shutdown implementation module may initiate shutdown of output power from the energy panel arrangement to the power converter. The shutdown implementation module may invoke the power dissipating device to dissipate the power associated with shutting down the output power. For example, the shutdown implementation module may open one or more switches, of a switching arrangement, between the energy panel arrangement and the power converter to shut down the output power, and may close a switch used to direct power (e.g., residual power from the capacitors associated with the power converter) through the power dissipating device to dissipate the power.

[0007] In another embodiment, there is provided a method for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:

establishing a communication connection, over a power-line communication line between an energy panel arrangement and a power converter, between a shutdown implementation module and a shutdown controller associated with the power converter, the shutdown implementation module coupled between the energy panel arrangement and the power converter; and

responsive to at least one of identifying a loss of the communication connection or receiving a shutdown instruction over the power-line communication

line from the shutdown controller:

initiating a shutdown of output power from the energy panel arrangement to the power converter; and

invoking a switching arrangement to direct power, associated with the shutdown of output power, through a power dissipating device for power dissipation.

[0008] In another embodiment, there is provided a system for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:

a shutdown controller associated with a power converter that is configured to convert DC power from an energy panel arrangement to AC power for an AC power grid, the shutdown controller configured to:

establish a communication connection, over a power-line communication line between the energy panel arrangement and the power converter, with a shutdown implementation module coupled between the energy panel arrangement and the power converter; and

responsive to identifying a power shutdown condition, send a shutdown instruction over the power-line communication line to the shutdown implementation module, the shutdown instruction instructing the shutdown implementation module to:

initiate a shutdown of output power from the energy panel arrangement to the power converter; and

invoke a switching arrangement to direct power, associated with the shutdown of output power, through a power dissipating device for power dissipation.

[0009] To the accomplishment of the foregoing and related ends, the following description and annexed drawings set forth certain illustrative aspects and implementations of embodiments of the invention. These are indicative of but a few of the various ways in which one or more aspects may be employed. Other aspects, advantages, and novel features of the disclosure will become apparent from the following detailed description when considered in conjunction with the annexed drawings.

DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is a component block diagram illustrating an exemplary system comprising a shutdown discharge circuit.

[0011] Fig. 2A is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter.

[0012] Fig. 2B is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter.

[0013] Fig. 2C is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon a loss of a communication connection.

[0014] Fig. 2D is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon a shutdown instruction.

[0015] Fig. 2E is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon an arc-fault notification instruction.

[0016] Fig. 2F is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon a power loss of an AC power grid.

[0017] Fig. 2G is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon detection of a power converter failure.

[0018] Fig. 2H is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter based upon an operational alert.

[0019] Fig. 2I is a component block diagram illustrating an exemplary system for facilitating a shutdown of output power from an energy panel arrangement to a power converter.

[0020] Fig. 3 is a flow diagram illustrating an exemplary method of facilitating a

shutdown of output power from an energy panel arrangement to a power converter.

[0021] Fig. 4 is an illustration of an exemplary computing device-readable medium wherein processor-executable instructions configured to embody one or more of the provisions set forth herein may be comprised.

[0022] Fig. 5 illustrates an exemplary computing environment wherein one or more of the provisions set forth herein may be implemented.

DETAILED DESCRIPTION

[0023] The invention is now described with reference to the drawings, wherein like reference numerals are generally used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide an understanding of the claimed subject matter. It may be evident, however, that the claimed subject matter may be practiced without these specific details. In other instances, structures and devices are illustrated in block diagram form in order to facilitate describing the claimed subject matter.

[0024] A photovoltaic (PV) system comprises several components collectively configured to convert solar energy into storable or usable electricity. In an example, a portion of the PV system may be situated on and/or around a building such as a residential or commercial building (e.g., mounted on a rooftop of the building, mounted on a side of the building, etc.). In an effort to efficiently collect solar energy (e.g. achieve a desired angle with respect to the sun, maximize available space, etc.), a configuration of solar panels is mounted on and/or around the building. The PV system may be a grid-connected system where the PV system is configured to supply power to a grid, such as a power grid that is configured to provide power to a load (e.g., an end user, a business, a city, or other load). The grid may be an alternating current (AC) grid. The PV system may comprise circuitry configured to convert a first power that is supplied by the configuration of solar panels to a second power that may be provided to the grid. The first power may be a direct current (DC) power and the second power may be an AC power. A power converter (e.g., an inverter, a device that charges batteries, or any other converter device) may be connected between the configuration of solar panels and the grid. The power converter may be used to convert the DC power to the AC power. In an example, the power converter may be located in a different location of the building than the solar panels.

[0025] In order to protect people and property from electrical hazards, the PV system is configured to reduce a power of a group of controlled conductors comprised within the PV system when the power converter is disconnected from the grid, such as during an emergency shutdown of the PV system. Section 690.12 of the National Electrical Code ® (NEC) specifies that the group of controlled conductors is to be de-energized responsive to an emergency shutdown. The group of controlled conductors may be located a threshold distance from the solar panels, such as at a distance of 10 feet or more. A power corresponding to the group of controlled conductors may be reduced to a reduced power below a threshold power, such as to a state of about 30 volts or less and/or about 240 volt-amps or less, within a threshold timespan such as within about 10 seconds or less. One or more systems and/or techniques for efficiently shutting down output power from an energy panel arrangement to a power converter, while dissipating power associated with the shutdown of output power (e.g., dissipating power within the group of controlled conductors) are provided.

[0026] Fig. 1 illustrates an example of a system 100 comprising a shutdown discharge circuit 102. The shutdown discharge circuit 102 may comprise one or more nodes used to couple the shutdown discharge circuit 102 between an energy panel arrangement (e.g., energy panel arrangement 202 of Figs. 2A-2H) and a power converter (e.g., power converter 208 of Figs. 2A-2H) that is configured to convert DC power from the energy panel arrangement to AC power for an AC power grid. For example, a first node N1 and the second node N2 may connect to the energy panel arrangement. The first node N1 may be positioned in series along a first portion (e.g., a positive polarity line) of a power-line communication line such as a DC power line over which the DC power is provided by the energy panel arrangement to the power converter. The second node N2 may be positioned in series along a second portion (e.g., a negative polarity line) of the power-line communication line. A third node N3 and a fourth node N4 may connect to the power converter. The third node N3 may be positioned in series along the first portion (e.g., the positive polarity line) of the power-line communication line. The fourth node N4 may be positioned in series along the second portion (e.g., the negative polarity line) of the power-line communication line.

[0027] The shutdown discharge circuit 102 may comprise a switching arrangement 104. The switching arrangement 104 comprises a first switch 104a, a second switch 104b, a third switch 104c, and/or other switching devices (e.g., a

semiconductor arrangement, a mechanical switch, a relay switching device, or any other switch). In an example, the first switch 104a may be positioned in series along the first portion of the power-line communication line between the first node N1 and the third node N3. The second switch 104b may be positioned in series along the second portion of the power-line communication line between the second node N2 and the fourth node N4. The third switch 104c may be positioned between the third node N3 and the fourth node N4 and may be positioned in series with a power dissipating device 112. The power dissipating device 112 is configured to dissipate power associated with shutting down output power from the energy panel arrangement to the power converter. When output power is to be supplied from the energy panel arrangement to the power converter, the first switch 104a and the second switch 104b may be in a closed position and the third switch 104c may be in an opened position to allow current to flow from the energy panel arrangement to the power converter and not through the power dissipating device 112.

[0028] Responsive to identifying a power shutdown condition (e.g., a shutdown implementation module 204 of Figs. 2A-2H may identify the power shutdown condition, such as receipt of a shutdown instruction, a loss of a communication connection, a power converter failure, a power loss of an AC grid, etc.), the shutdown discharge circuit 102 may be invoked to dissipate power associated with shutting down output power from the energy panel arrangement to the power converter. For example, the first switch 104a and the second switch 104b may be transitioned into an opened position to shut off current from the energy panel arrangement to the power converter in order to shut down the output power. The third switch 104c may be transitioned into a closed position to direct residual power, such as power stored within energy storage components (e.g., capacitors associated with the power converter), through the power dissipating device 112 for power dissipation.

[0029] Figs. 2A-2I illustrate examples of a system 200 for facilitating a shutdown of output power from an energy panel arrangement 202 to a power converter 208. In an example, the system 200 may comprise a shutdown implementation module 204. In another example, the system 200 may comprise a shutdown controller 210. In another example, the system 200 may comprise the shutdown implementation module 204 and the shutdown controller 210.

[0030] Fig. 2A illustrates the shutdown implementation module 204 coupled

between the energy panel arrangement 202 (e.g., a photovoltaic system mounted on a roof of a building) and the power converter 208 (e.g., a power converter box located within a basement of the building, such as where an electrical panel connects to electrical power entering the building). The power converter 208 may be configured to convert DC power from the energy panel arrangement 202 to AC power for an AC power grid 240 illustrated in Fig. 2B. The DC power may be received over a DC power line connected between the energy panel arrangement 202 and the power converter 208, such as a power-line communication line 206.

[0031] Fig. 2B illustrates the shutdown implementation module 204 comprising a power module 222, a processor 224, a power line communication interface 226, and/or a shutdown discharge circuit 102. The power module 222 may be configured to provide power to the shutdown implementation module 204 based upon power provided by the energy panel arrangement 202. The shutdown implementation module 204 may be coupled to the power-line communication line 206 between the energy panel arrangement 202 and the power converter 208 located within a power converter box 230. The processor 224 may be configured to control the shutdown implementation module 204, such as to control the shutdown discharge circuit 102, implement instructions from the shutdown controller 210 (e.g., an instruction to shutdown output power from the energy panel arrangement 202 to the power converter 208), evaluate the power converter 208 for faults, perform self-evaluations, update software such as firmware, etc. The shutdown discharge circuit 102 may be invoked to discharge current (e.g., current from capacitors of the photovoltaic system) associated with shutting down the output power (e.g., a mechanical switch and/or a semiconductor arrangement may direct current through a resistor, a positive temperature coefficient (PTC) device, or other discharge mechanism for discharge of the output power). The shutdown implementation module 204 may be located a threshold distance from the energy panel arrangement 202, such as within about 10 feet or less, and may be capable of reducing the output power to a reduced output power within a threshold timespan (e.g., within about 10 seconds or less) using the shutdown discharge circuit 102.

[0032] The power line communication interface 226 may establish a communication connection 242 over the power-line communication line 206. The power line communication interface 226 may facilitate communication between the shutdown implementation module 204 (e.g., the processor 224 of the shutdown

implementation module 204) and the shutdown controller 210 (e.g., a processor 234 of the shutdown controller 210). In an example where the power-line communication line 206 comprises a DC power line over which DC power is supplied from the energy panel arrangement 202 to the power converter 208, communication signals may be sent over the DC power line by modulating higher frequency signals as the communication signals.

[0033] The shutdown controller 210 may comprise the processor 234, a power line communication interface 244, an emergency stop 236, and/or a control power supply 232. The power line communication interface 244 may establish the communication connection 242 over the power-line communication line 206 with the power line communication interface 226 of the shutdown implementation module 204. The processor 234 may be configured to send instructions and/or information over the power-line communication line 206 (e.g., using the communication connection 242) to the shutdown implementation module 204 (e.g., a shutdown instruction, an arc-flash notification instruction, a software update, a heartbeat signal indicating that output power should be provided to the power converter 208 by the energy panel arrangement 202, etc.). The control power supply 232 may power the shutdown controller 210 based upon AC power provided by the power converter 208. The shutdown controller 210 may be configured to identify a power shutdown condition based upon various triggers, such as a user invoking the emergency stop 236, the user utilizing the DC disconnect 228 to disconnect the power-line communication line 206 from the power converter 208, utilizing an AC disconnect 238 to disconnect power from the AC power grid 240 (e.g., resulting in a power loss of the shutdown controller 210 such that the shutdown controller 210 does not provide the heartbeat signal to the shutdown implementation module 204, which may trigger the shutdown implementation module 204 to shut down the output power from the energy panel arrangement 202 to the power converter 208), etc.

[0034] Fig. 2C illustrates an example of the shutdown implementation module 204 initiating a shutdown 248 of output power from the energy panel arrangement 202 to the power converter 208 based upon a loss 246 of the communication connection 242 over the power-line communication line 206. In an example, the power line communication interface 226 of the shutdown implementation module 204 may receive a heartbeat signal over the power-line communication line 206, such as over the communication connection 242, from the shutdown controller 210. The

processor 224 may be configured to maintain the output power from the energy panel arrangement 202 to the power converter 208 so long as the heartbeat signal is received. The loss 246 of the communication connection 242 may be detected based upon a loss of the heartbeat signal. In another example, the communication loss 246 may occur based upon an opening of the DC disconnect 228 associated with the power converter 208. Accordingly, the processor 224 of the shutdown implementation module 204 may initiate shutdown 248 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102 (e.g., mechanical switches and/or semiconductor arrangements of the shutdown discharge circuit 102 may be used to direct current through a resistor to discharge output power).

[0035] Fig. 2D illustrates an example of the shutdown implementation module 204 initiating a shutdown 254 of output power from the energy panel arrangement 202 to the power converter 208 based upon receipt of a shutdown instruction 252. In an example, a user may invoke the emergency stop 236 of the shutdown controller 210 (e.g., push a button, pull a lever, etc.). The processor 234 of the shutdown controller 210 may utilize the power line communication interface 244 to send the shutdown instruction 252 through the power-line communication line 206, such as over the communication connection 242, to the shutdown implementation module 204 based upon the invocation of the emergency stop 236. Accordingly, the processor 224 of the shutdown implementation module 204 may initiate shutdown 254 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102.

[0036] Fig. 2E illustrates an example of the shutdown implementation module 204 initiating a shutdown 264 of output power from the energy panel arrangement 202 to the power converter 208 based upon receipt of an arc-fault notification instruction 262. In an example, the processor 234 of the shutdown controller 210 may identify an arc-fault associated with the power converter box 230 or other component associated with providing AC power over the AC power grid 240. The processor 234 of the shutdown controller 210 may utilize the power line communication interface 244 to send the arc-fault notification instruction 262 through the power-line communication line 206, such as over the communication connection 242, to the shutdown implementation module 204 based upon the arc-fault. Accordingly, the processor 224 of the shutdown implementation module 204 may initiate shutdown

264 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102.

[0037] Fig. 2F illustrates an example of the shutdown implementation module 204 initiating a shutdown 270 of output power from the energy panel arrangement 202 to the power converter 208 based upon a power loss 268 of the AC power grid 240. For example, the shutdown implementation module 204 may identify the power loss 268 of the AC power grid 240 based upon an opening of an AC disconnect 238 between the power converter 208 and the AC power grid 240. Accordingly, the processor 224 of the shutdown implementation module 204 may initiate shutdown 270 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102.

[0038] Fig. 2G illustrates an example of the shutdown implementation module 204 initiating a shutdown 278 of output power from the energy panel arrangement 202 to the power converter 208 based upon a detection 276 of a power converter failure 276 of the power converter 208. For example, the shutdown implementation module 204 may evaluate operational health statistics of the power converter 208 that are obtained through the power-line communication line 206, such as over the communication connection 242 (e.g., the shutdown implementation module 204 may measure and/or collect operational health statistics and/or the shutdown controller 210 may provide operational health statistics over the communication connection 242 to the shutdown implementation module 204). Responsive to the operational health statistics indicating a power converter failure or degraded performance, the processor 224 of the shutdown implementation module 204 may initiate shutdown 278 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102.

[0039] Fig. 2H illustrates an example of the shutdown implementation module 204 initiating a shutdown 286 of output power from the energy panel arrangement 202 to the power converter 208 based upon an operational alert 284 for the shutdown implementation module 204. For example, the shutdown implementation module 204 may perform a self-evaluation utilizing a temperature sensor, an electrical parameter measurement sensor (e.g., a current sensor), and/or various other sensors used to determine whether the shutdown implementation module 204 is operating within spec or out of spec (e.g., a failure, degraded performance, etc.). Responsive to the self-

evaluation resulting in the operational alert 284 (e.g., an unsafe operating temperature) for the shutdown implementation module 204, the shutdown implementation module 204 may initiate shutdown 286 of output power from the energy panel arrangement 202 to the power converter 208 using the shutdown discharge circuit 102. Responsive to identifying a resolution of an operational issue (e.g., the shutdown implementation module 204 may cool down from the unsafe operating temperature to a safe operating temperature), startup of output power from the energy panel arrangement 202 to the power converter 208 may be initiated.

[0040] In an example, the shutdown implementation module 204 may be implemented with the shutdown discharge circuit 102 without the need for a communication module, a power module, a processor, and/or a power line communication interface, as illustrated in Fig. 2I. Accordingly, the shutdown discharge circuit 102 may be connected to a power supply unit 298 of an inverter 296, in an example.

[0041] An embodiment of facilitating a shutdown of output power from an energy panel arrangement to a power converter is illustrated by an exemplary method 300 of Fig. 3. At 302, a communication connection may be established over a power-line communication line between an energy panel arrangement (e.g., a photovoltaic system comprising solar panels configured to convert sunlight into DC power) and a power converter (e.g., a power converter configured to convert DC power from the energy panel arrangement to AC power for an AC power grid). The communication connection may be established between a shutdown implementation module and a shutdown controller. The shutdown implementation module may be coupled between the energy panel arrangement and the power converter (e.g., the shutdown implementation module may be located within a threshold distance, such as about 30 feet or less, from the energy panel arrangement, which may satisfy an electrical specification for photovoltaic systems even though the solar panels may be located further away from the power converter, such as where the solar panels are on a roof of a building and the power converter is inside the building such as in the basement). In an example, the energy panel arrangement may supply the DC power to the power converter over the power-line communication line (e.g., a DC power line).

[0042] At 304, responsive to identifying a loss of the communication connection and/or receiving a shutdown instruction over the power-line communication line from

the shutdown controller, a shutdown of output power (e.g., to a reduced output power below a threshold and/or within a threshold timespan specified by the electrical specification, such as within about 30 seconds or less) from the energy panel arrangement to the power converter may be initiated. The loss of the communication connection may correspond to an opening of a DC disconnect of the power converter that closes the communication connection over the power-line communication line, a loss of a heartbeat signal received over the power-line communication line from the shutdown controller, etc. The shutdown instruction may correspond to an instruction sent by the shutdown controller over the power-line communication line to the shutdown implementation module (e.g., an instruction that is based upon the shutdown controller receiving a shutoff status input signal such as from a user invoking a shutoff button, lever, or other mechanism associated with a power converter box housing the power converter; an instruction that is based upon the shutdown controller detecting an arc fault associated with the power converter box; etc.). The output power may be shut down by opening a first switch and a second switch, of a switching arrangement, that are in series along the power-line communication line over which the energy panel arrangement provides the output power to the power converter.

[0043] The shutdown implementation module may comprise a shutdown discharge circuit configured to discharge power associated with the shutdown of the output power. The shutdown discharge circuit may close a third switch (e.g., a switch positioned in series with a power dissipating device, such as a resistor connected between two lines, such as a positive line and a negative line, of the power-line communication line) of the switching arrangement to direct power (e.g., residual power within energy storage devices, such as capacitors, associated with the power converter and/or the photovoltaic system) through the power dissipating device for power dissipation.

[0044] Still another embodiment involves a computer-readable medium comprising processor-executable instructions configured to implement one or more of the techniques presented herein. An example embodiment of a computer-readable medium or a computer-readable device is illustrated in Fig. 4, wherein the implementation 400 comprises a computer-readable medium 408, such as a CD-R, DVD-R, flash drive, a platter of a hard disk drive, etc., on which is encoded computer-readable data 406. This computer-readable data 406, such as binary data

comprising at least one of a zero or a one, in turn comprises a set of computer instructions 404 configured to operate according to one or more of the principles set forth herein. In some embodiments, the processor-executable computer instructions 404 are configured to perform a method 402, such as at least some of the exemplary method 300 of Fig. 3, for example. In some embodiments, the processor-executable instructions 404 are configured to implement a system, such as at least some of the exemplary system 100 of Fig. 1 and/or at least some of the exemplary system 200 of Figs. 2A-2H, for example. Many such computer-readable media are devised by those of ordinary skill in the art that are configured to operate in accordance with the techniques presented herein.

[0045] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing at least some of the claims.

[0046] As used in this application, the terms "component," "module," "system", "interface", and/or the like are generally intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a controller and the controller can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers.

[0047] Furthermore, the claimed subject matter may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. Of course, many modifications may be made to this configuration without departing from the scope or spirit of the claimed subject matter.

[0048] Fig. 4 and the following discussion provide a brief, general description of a

suitable computing environment to implement embodiments of one or more of the provisions set forth herein. The operating environment of Fig. 4 is only one example of a suitable operating environment and is not intended to suggest any limitation as to the scope of use or functionality of the operating environment. Example computing devices include, but are not limited to, personal computers, server computers, hand-held or laptop devices, mobile devices (such as mobile phones, Personal Digital Assistants (PDAs), media players, and the like), multiprocessor systems, consumer electronics, mini computers, mainframe computers, distributed computing environments that include any of the above systems or devices, and the like.

[0049] Although not required, embodiments are described in the general context of “computer readable instructions” being executed by one or more computing devices. Computer readable instructions may be distributed via computer readable media (discussed below). Computer readable instructions may be implemented as program modules, such as functions, objects, Application Programming Interfaces (APIs), data structures, and the like, that perform particular tasks or implement particular abstract data types. Typically, the functionality of the computer readable instructions may be combined or distributed as desired in various environments.

[0050] Fig. 4 illustrates an example of a system 400 comprising a computing device 412 configured to implement one or more embodiments provided herein. In one configuration, computing device 412 includes at least one processing unit 416 and memory 418. Depending on the exact configuration and type of computing device, memory 418 may be volatile (such as RAM, for example), non-volatile (such as ROM, flash memory, etc., for example) or some combination of the two. This configuration is illustrated in Fig. 4 by dashed line 414.

[0051] In other embodiments, device 412 may include additional features and/or functionality. For example, device 412 may also include additional storage (e.g., removable and/or non-removable) including, but not limited to, magnetic storage, optical storage, and the like. Such additional storage is illustrated in Fig. 4 by storage 420. In one embodiment, computer readable instructions to implement one or more embodiments provided herein may be in storage 420. Storage 420 may also store other computer readable instructions to implement an operating system, an application program, and the like. Computer readable instructions may be loaded in memory 418 for execution by processing unit 416, for example.

[0052] The term “computer readable media” as used herein includes computer storage media. Computer storage media includes volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions or other data. Memory 418 and storage 420 are examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, Digital Versatile Disks (DVDs) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by device 412. Computer storage media does not, however, include propagated signals. Rather, computer storage media excludes propagated signals. Any such computer storage media may be part of device 412.

[0053] Device 412 may also include communication connection(s) 426 that allows device 412 to communicate with other devices. Communication connection(s) 426 may include, but is not limited to, a modem, a Network Interface Card (NIC), an integrated network interface, a radio frequency transmitter/receiver, an infrared port, a USB connection, or other interfaces for connecting computing device 412 to other computing devices. Communication connection(s) 426 may include a wired connection or a wireless connection. Communication connection(s) 426 may transmit and/or receive communication media.

[0054] The term “computer readable media” may include communication media. Communication media typically embodies computer readable instructions or other data in a “modulated data signal” such as a carrier wave or other transport mechanism and includes any information delivery media. The term “modulated data signal” may include a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal.

[0055] Device 412 may include input device(s) 424 such as keyboard, mouse, pen, voice input device, touch input device, infrared cameras, video input devices, and/or any other input device. Output device(s) 422 such as one or more displays, speakers, printers, and/or any other output device may also be included in device 412. Input device(s) 424 and output device(s) 422 may be connected to device 412 via a wired connection, wireless connection, or any combination thereof. In one embodiment, an input device or an output device from another computing device may

be used as input device(s) 424 or output device(s) 422 for computing device 412.

[0056] Components of computing device 412 may be connected by various interconnects, such as a bus. Such interconnects may include a Peripheral Component Interconnect (PCI), such as PCI Express, a Universal Serial Bus (USB), firewire (IEEE 1394), an optical bus structure, and the like. In another embodiment, components of computing device 412 may be interconnected by a network. For example, memory 418 may be comprised of multiple physical memory units located in different physical locations interconnected by a network.

[0057] Those skilled in the art will realize that storage devices utilized to store computer readable instructions may be distributed across a network. For example, a computing device 430 accessible via a network 428 may store computer readable instructions to implement one or more embodiments provided herein. Computing device 412 may access computing device 430 and download a part or all of the computer readable instructions for execution. Alternatively, computing device 412 may download pieces of the computer readable instructions, as needed, or some instructions may be executed at computing device 412 and some at computing device 430.

[0058] Various operations of embodiments are provided herein. In one embodiment, one or more of the operations described may constitute computer readable instructions stored on one or more computer readable media, which if executed by a computing device, will cause the computing device to perform the operations described. The order in which some or all of the operations are described should not be construed as to imply that these operations are necessarily order dependent. Alternative ordering will be appreciated by one skilled in the art having the benefit of this description. Further, it will be understood that not all operations are necessarily present in each embodiment provided herein. Also, it will be understood that not all operations are necessary in some embodiments.

[0059] Further, unless specified otherwise, "first," "second," and/or the like are not intended to imply a temporal aspect, a spatial aspect, an ordering, etc. Rather, such terms are merely used as identifiers, names, etc. for features, elements, items, etc. For example, a first object and a second object generally correspond to object A and object B or two different or two identical objects or the same object.

[0060] Moreover, "exemplary" is used herein to mean serving as an example,

instance, illustration, etc., and not necessarily as advantageous. As used herein, "or" is intended to mean an inclusive "or" rather than an exclusive "or". In addition, "a" and "an" as used in this application are generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form. Also, at least one of A and B and/or the like generally means A or B and/or both A and B. Furthermore, to the extent that "includes", "having", "has", "with", and/or variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprising".

[0061] Also, although the disclosure has been shown and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art based upon a reading and understanding of this specification and the annexed drawings. The disclosure includes all such modifications and alterations and is limited only by the scope of the following claims. In particular regard to the various functions performed by the above described components (e.g., elements, resources, etc.), the terms used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure. In addition, while a particular feature of the disclosure may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.

What is claimed is:

1. A system for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:

a shutdown discharge circuit coupled between an energy panel arrangement and a power converter that is configured to convert DC power from the energy panel arrangement to AC power for an AC power grid, the shutdown discharge circuit comprising:

a switching arrangement configured to direct power, associated with shutting down output power from the energy panel arrangement to the power converter, through a power dissipating device; and

the power dissipating device configured to dissipate the power associated with shutting down the output power from the energy panel arrangement to the power converter; and

a shutdown implementation module configured to:

establish a communication connection, over a power-line communication line between the energy panel arrangement and the power converter, with a shutdown controller associated with the power converter; and

responsive to identifying a power shutdown condition:

initiate shutdown of output power from the energy panel arrangement to the power converter; and

invoke the power dissipating device to dissipate the power associated with shutting down the output power.

2. The system of claim 1, wherein the power dissipating device comprises at least one of a resistor or a positive temperature coefficient (PTC) device.

3. The system of claim 1 or claim 2, wherein the switching arrangement comprises:

a first switch configured to direct output power between the energy panel arrangement and the power converter when closed.

4. The system of claim 3, wherein the switching arrangement comprises:

a second switch configured to direct output power between the energy panel arrangement and the power converter when closed.

5. The system of claim 4, wherein the switching arrangement comprises:
a third switch configured to direct the power through the power dissipating device during shutdown of the output power based upon at least one of the first switch or the second switch being open.
6. The system of claim 5, wherein the third switch is configured to:
transition into an open state for triggering at least one of the first switch or the second switch to transition into a closed position for directing output power from the energy panel arrangement to the power converter.
7. The system of claim 5, wherein the third switch comprises at least one of a semiconductor arrangement, a mechanical switch, or a relay switching device.
8. The system of any one of claims 1 to 7, wherein the power dissipating device is configured to dissipate the power from an energy storage component associated with the power converter during shutdown of the output power.
9. The system of claim 8, wherein the energy storage component comprises a capacitor located a threshold distance from the energy panel arrangement.
10. The system of claim 1, the shutdown implementation module configured to:
perform a self-evaluation utilizing at least one of a temperature sensor or an electrical parameter measurement sensor.
11. The system of claim 1, the power shutdown condition corresponding to an arc-fault notification instruction received over the power-line communication line from the shutdown controller.
12. The system of claim 1, the power shutdown condition corresponding to a loss of the communication connection.

13. The system of claim 12, the shutdown implementation module configured to:
identify the loss of the communication connection based upon loss of a heartbeat signal, received over the power-line communication line, from the shutdown controller.
14. The system of claim 1, the power shutdown condition corresponding to shutdown instruction received over the power-line communication line from the shutdown controller.
15. The system of claim 1, the power shutdown condition corresponding to a power loss of the AC power grid.
16. The system of claim 1, the power shutdown condition corresponding to a power converter failure of the power converter.
17. The system of any one of claim 10 to 16, the shutdown implementation module configured to:
identify the power shutdown condition based upon the self-evaluation resulting in an operational alert for the shutdown implementation module.
18. The system of any one of claims 1 to 17, the energy panel arrangement comprising one or more photovoltaic (PV) strings.
19. A method for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:
establishing a communication connection, over a power-line communication line between an energy panel arrangement and a power converter, between a shutdown implementation module and a shutdown controller associated with the power converter, the shutdown implementation module coupled between the energy panel arrangement and the power converter; and
responsive to at least one of identifying a loss of the communication connection or receiving a shutdown instruction over the power-line communication line from the shutdown controller:
initiating a shutdown of output power from the energy panel

arrangement to the power converter; and

invoking a switching arrangement to direct power, associated with the shutdown of output power, through a power dissipating device for power dissipation.

20. A system for facilitating a shutdown of output power from an energy panel arrangement to a power converter, comprising:

a shutdown controller associated with a power converter that is configured to convert DC power from an energy panel arrangement to AC power for an AC power grid, the shutdown controller configured to:

establish a communication connection, over a power-line communication line between the energy panel arrangement and the power converter, with a shutdown implementation module coupled between the energy panel arrangement and the power converter; and

responsive to identifying a power shutdown condition, send a shutdown instruction over the power-line communication line to the shutdown implementation module, the shutdown instruction instructing the shutdown implementation module to:

initiate a shutdown of output power from the energy panel arrangement to the power converter; and

invoke a switching arrangement to direct power, associated with the shutdown of output power, through a power dissipating device for power dissipation.

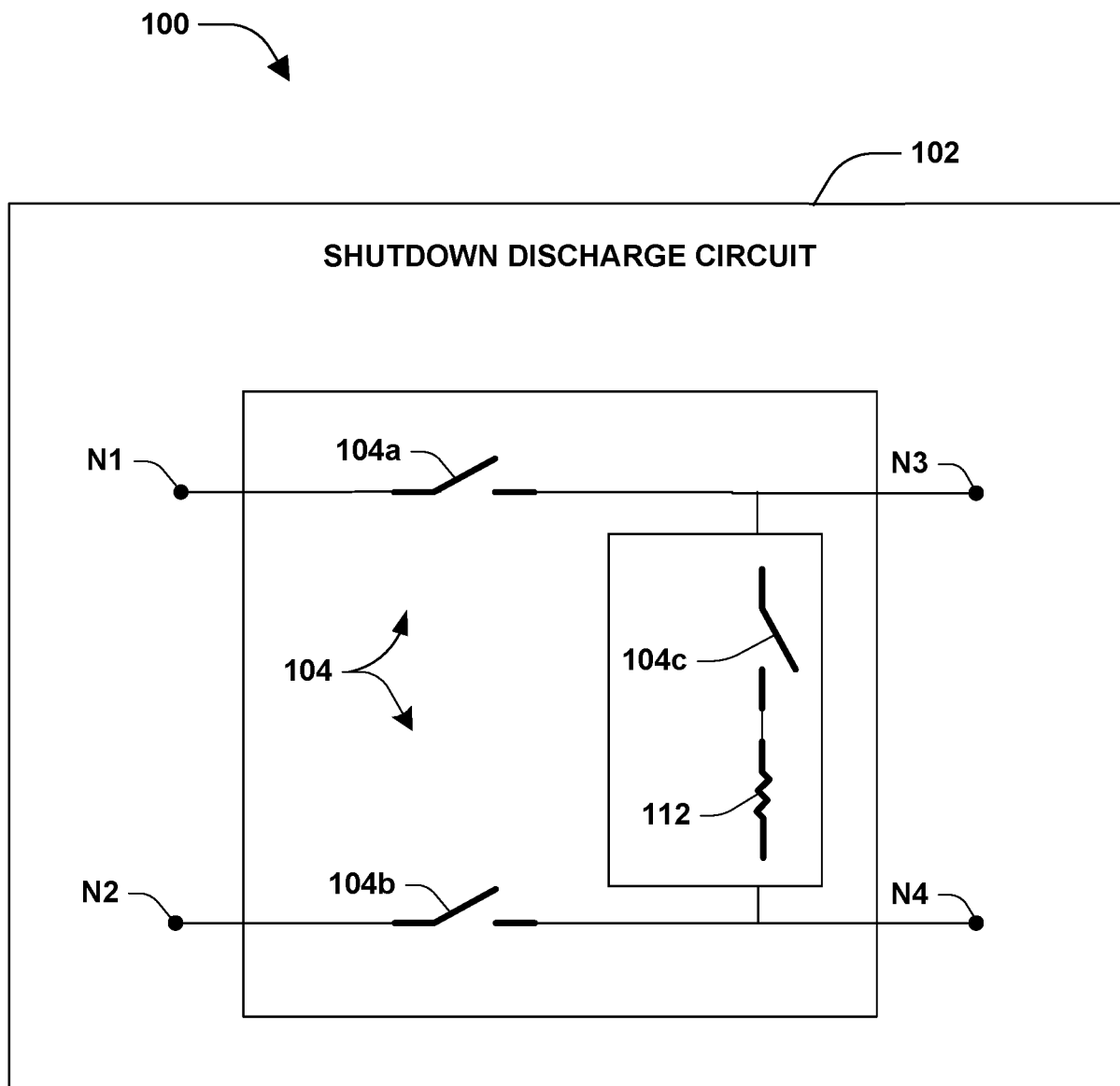


FIG. 1

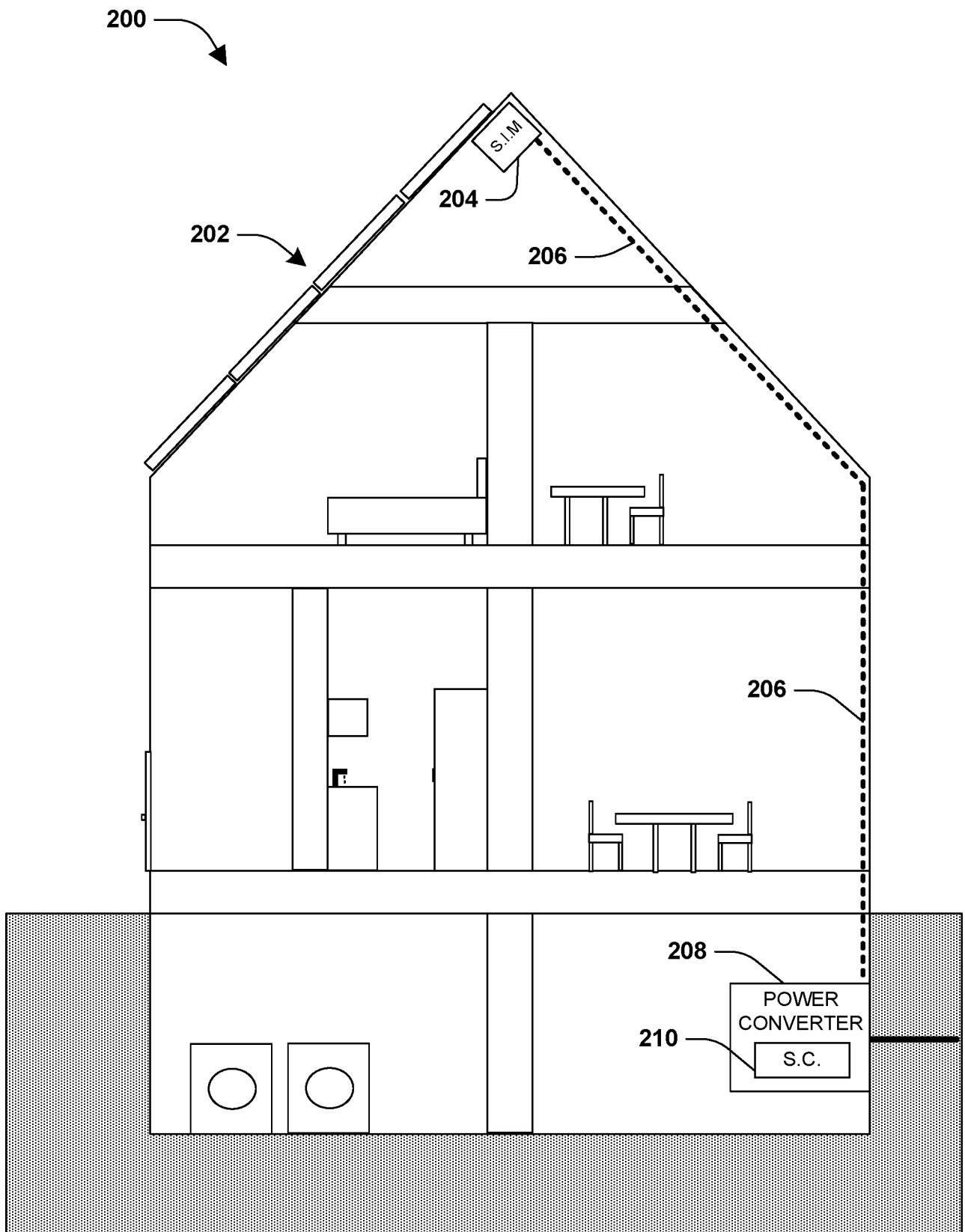


FIG. 2A

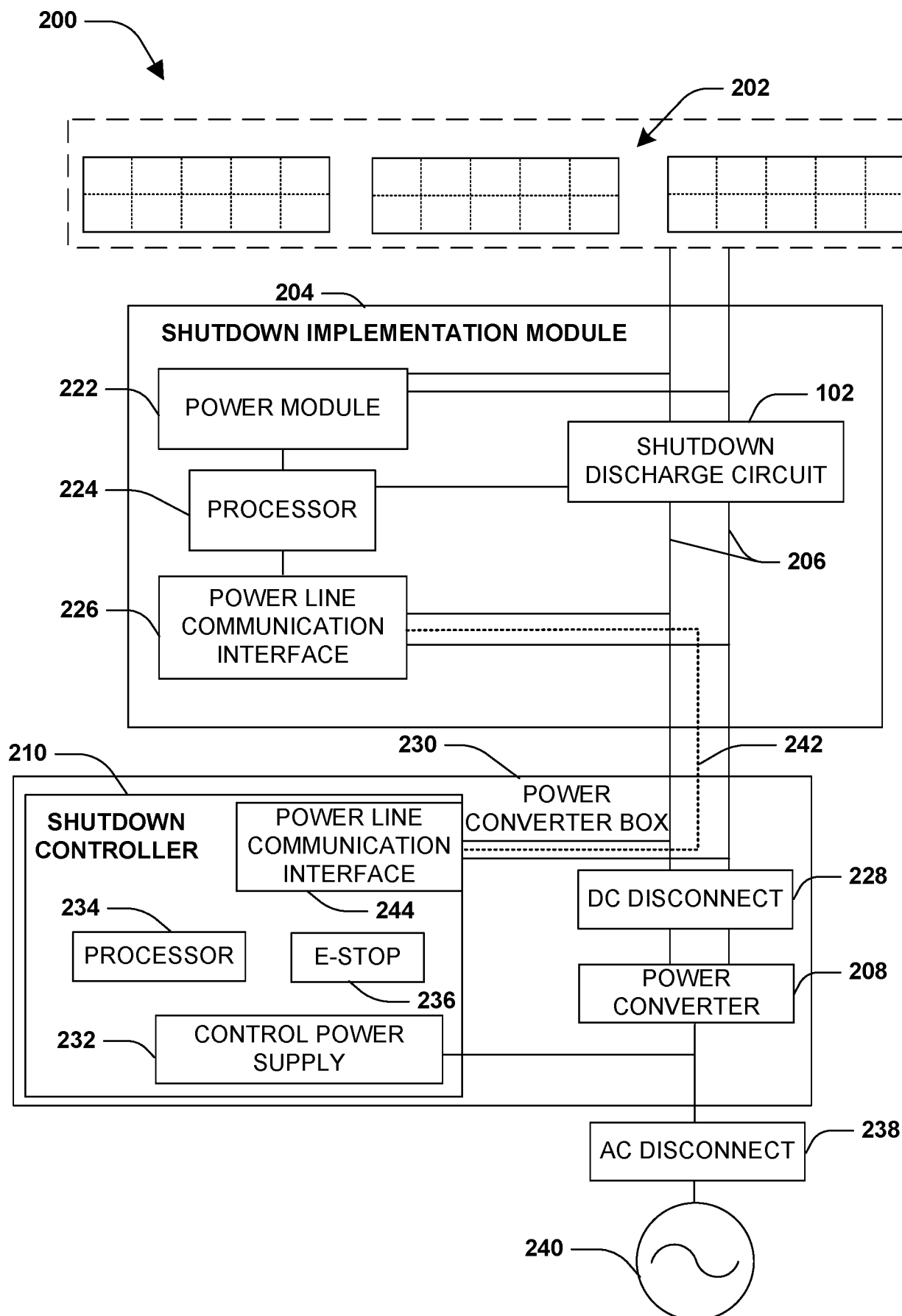


FIG. 2B

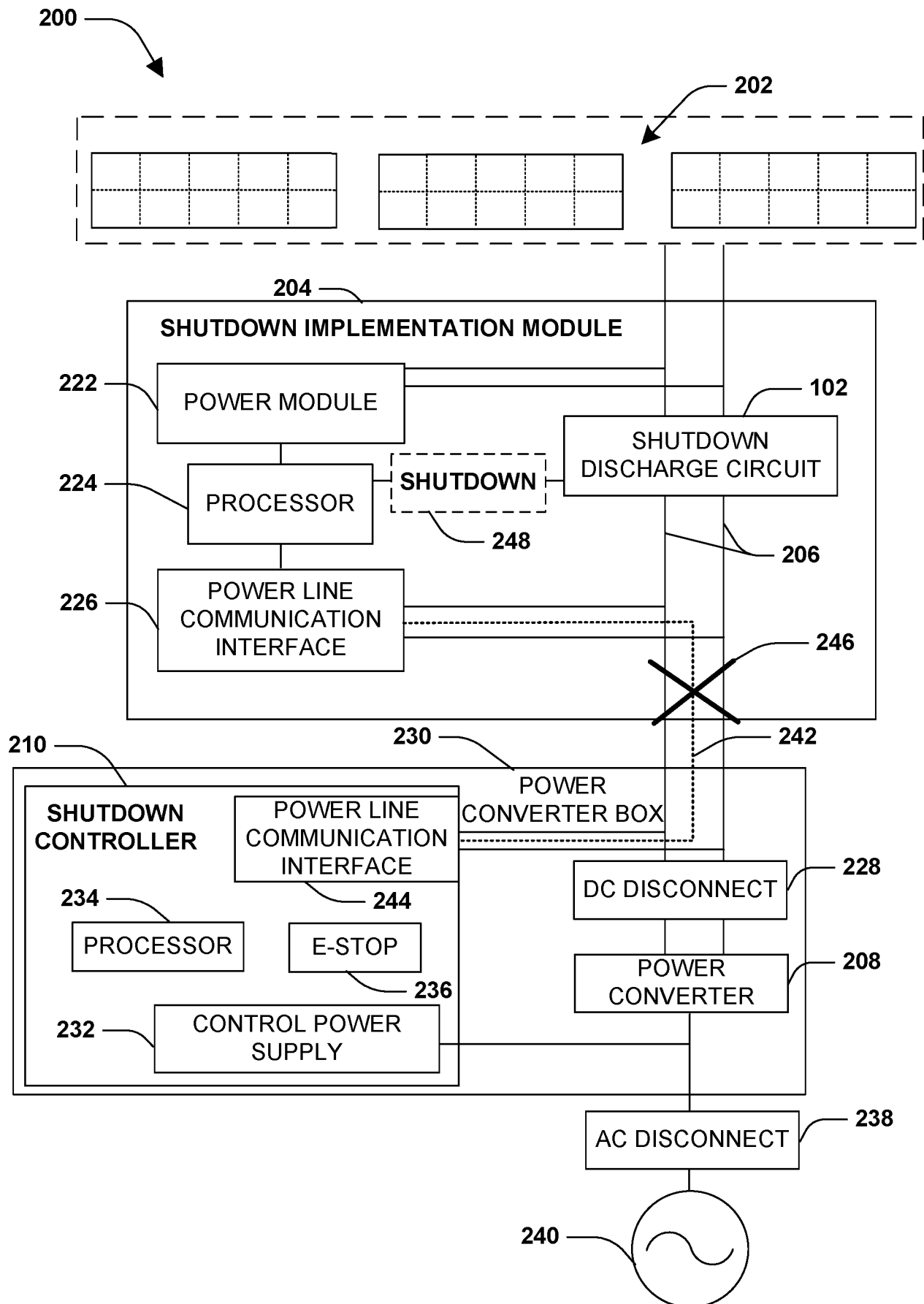


FIG. 2C

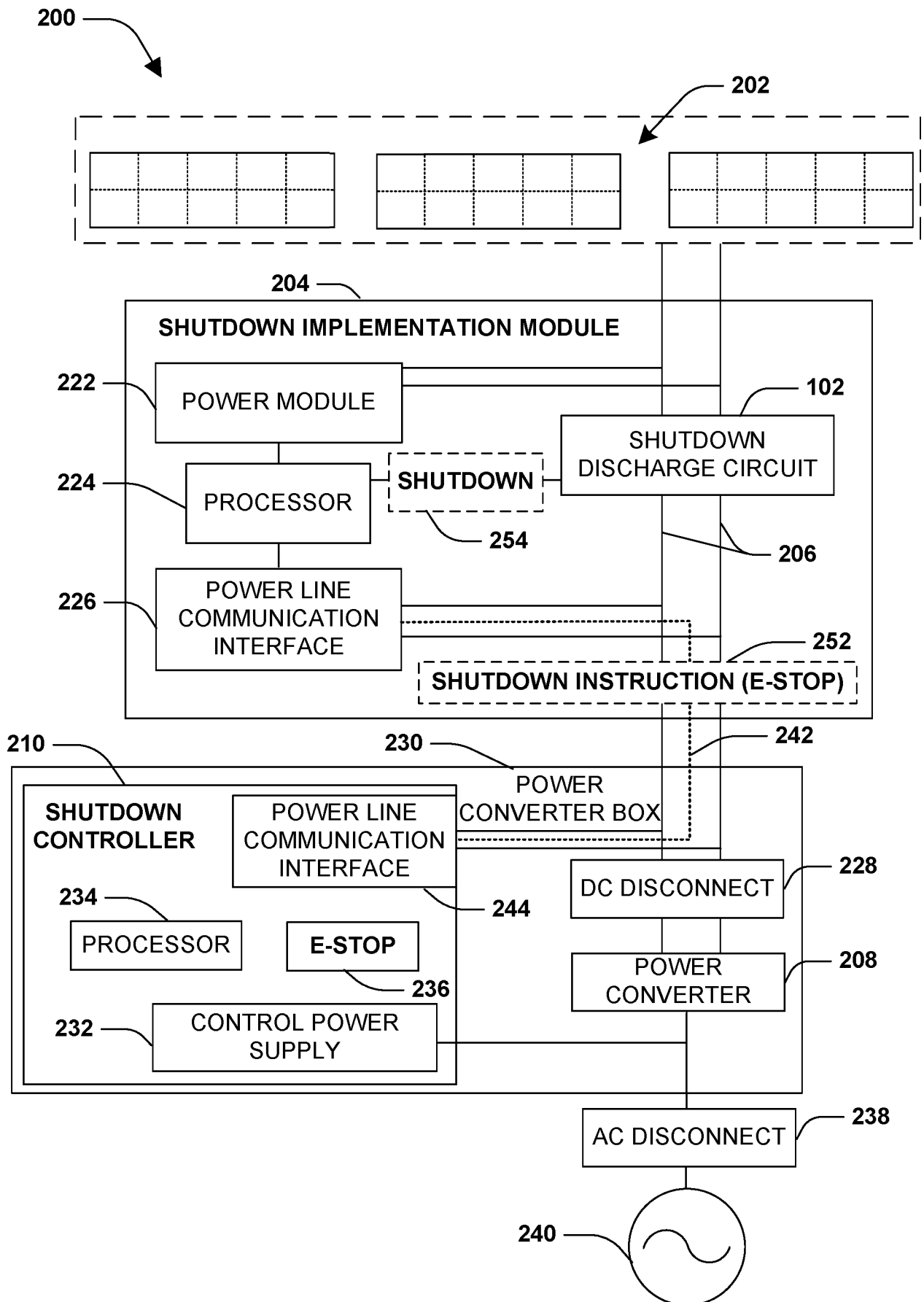


FIG. 2D

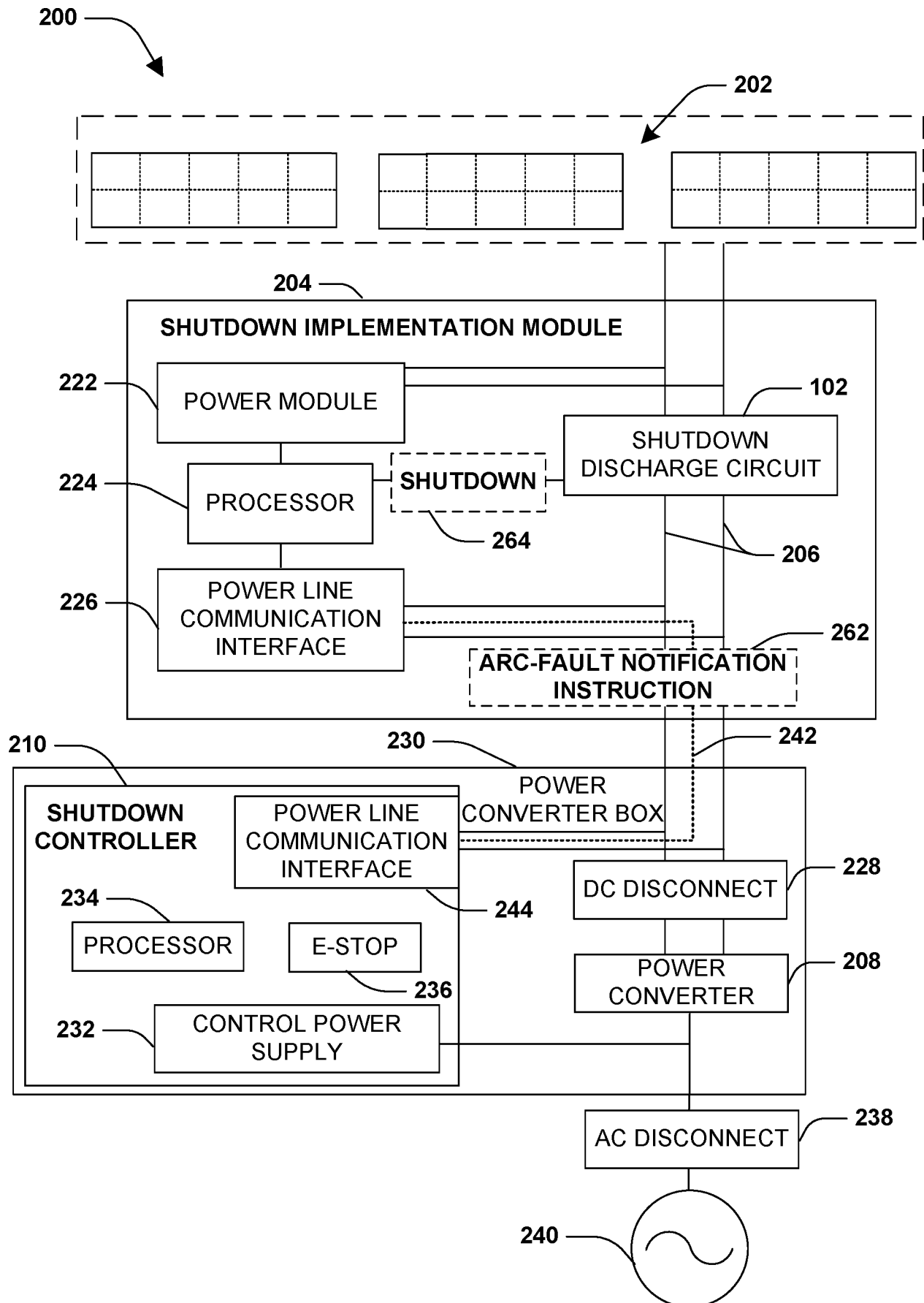


FIG. 2E

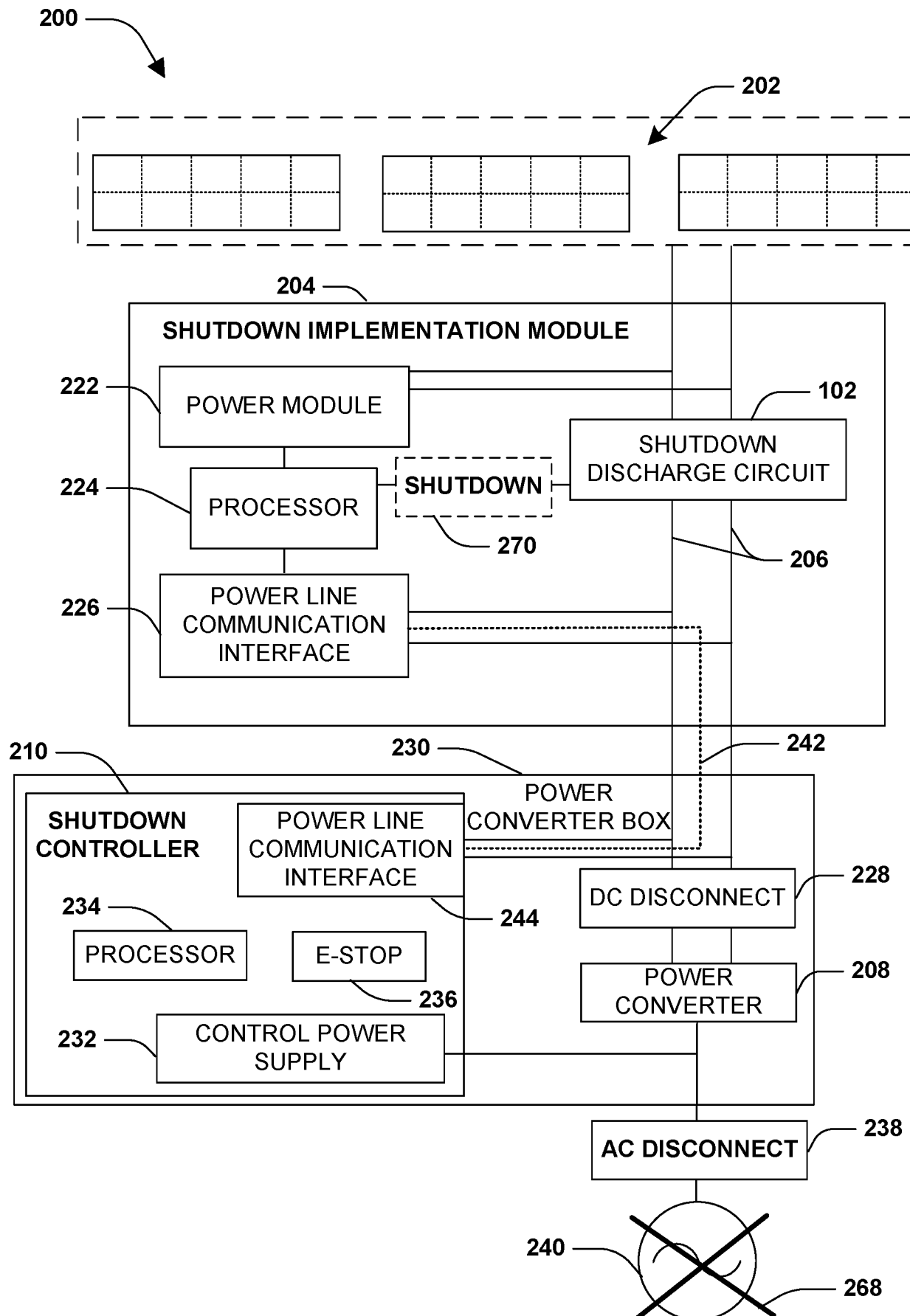


FIG. 2F

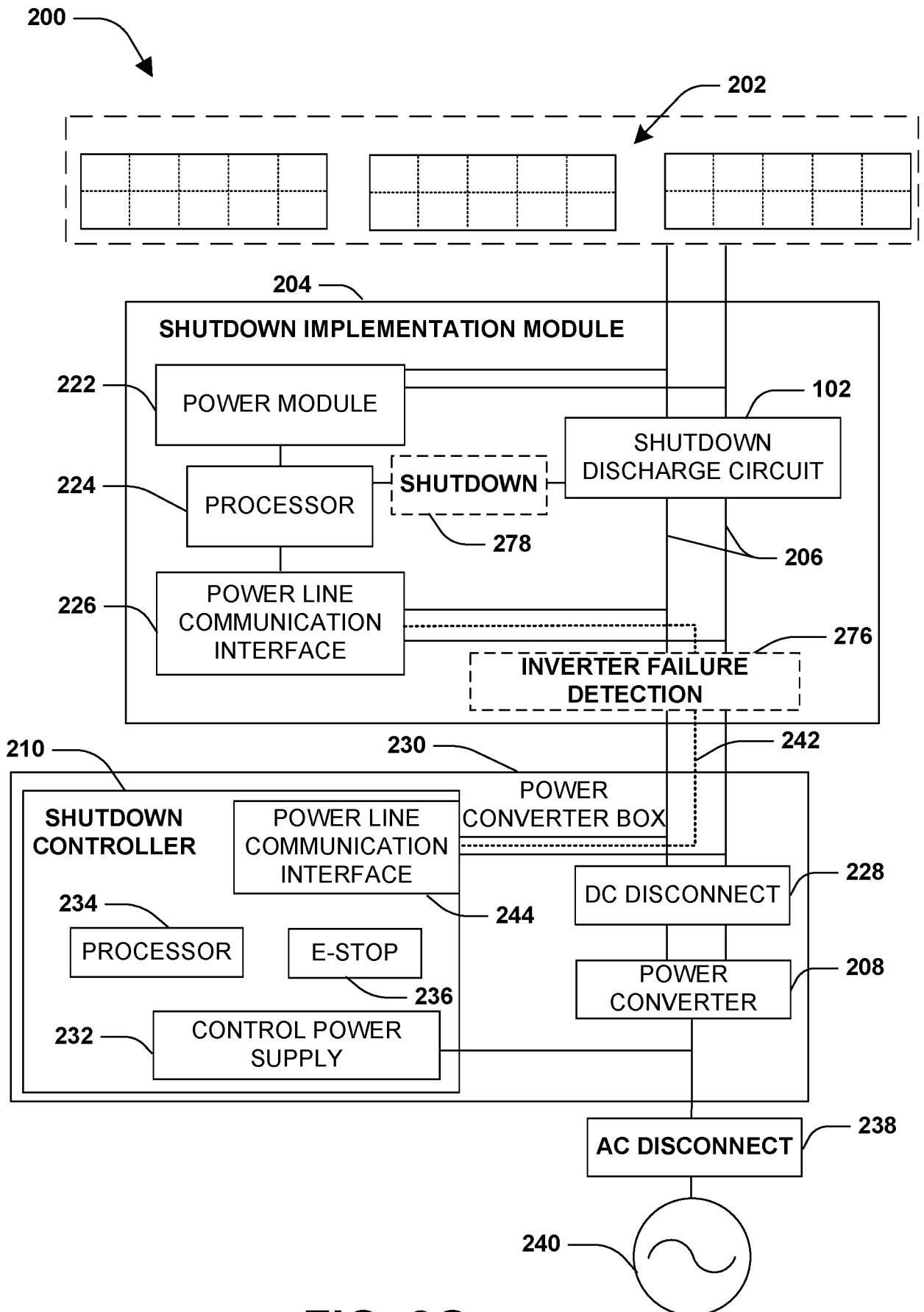


FIG. 2G

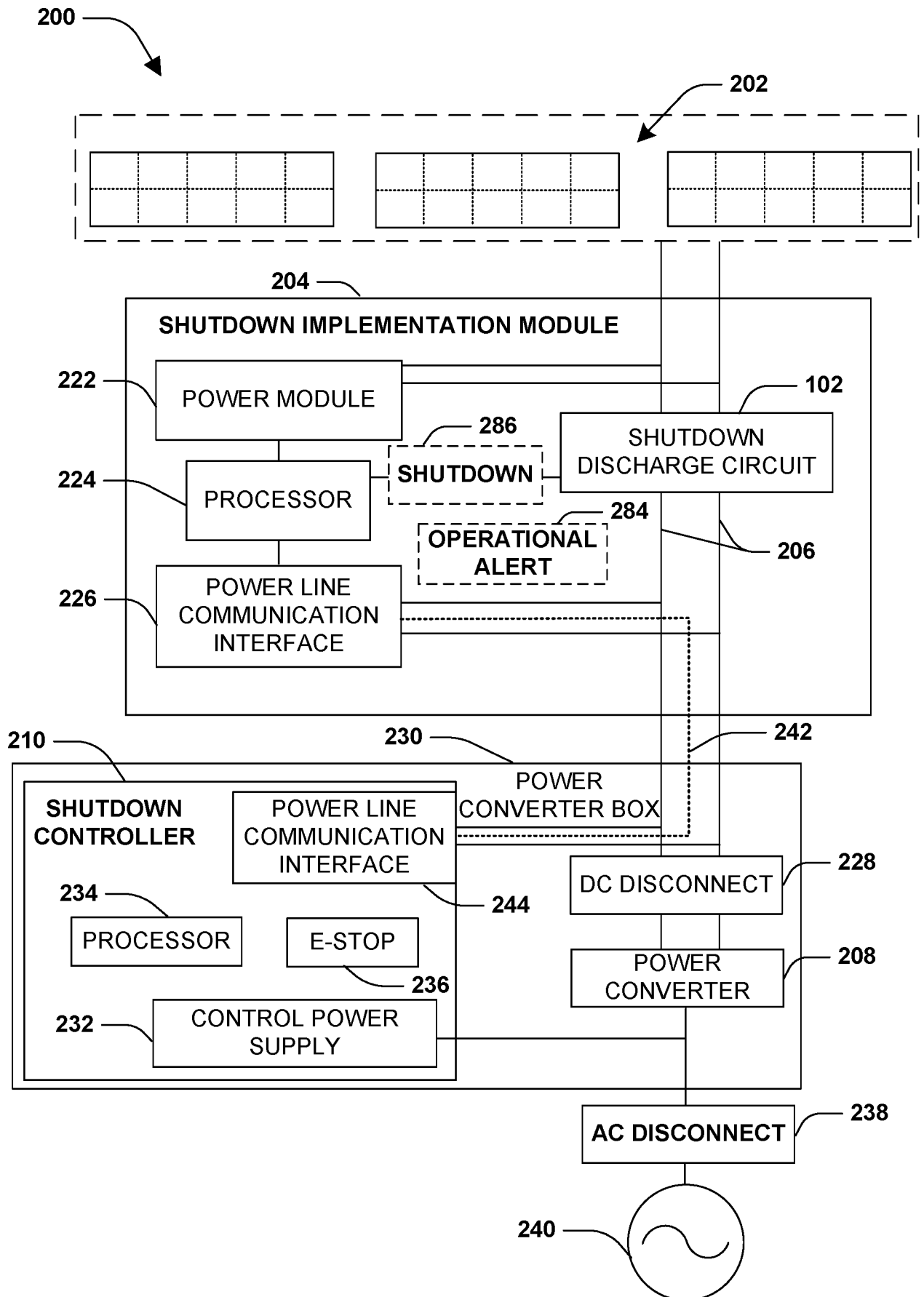
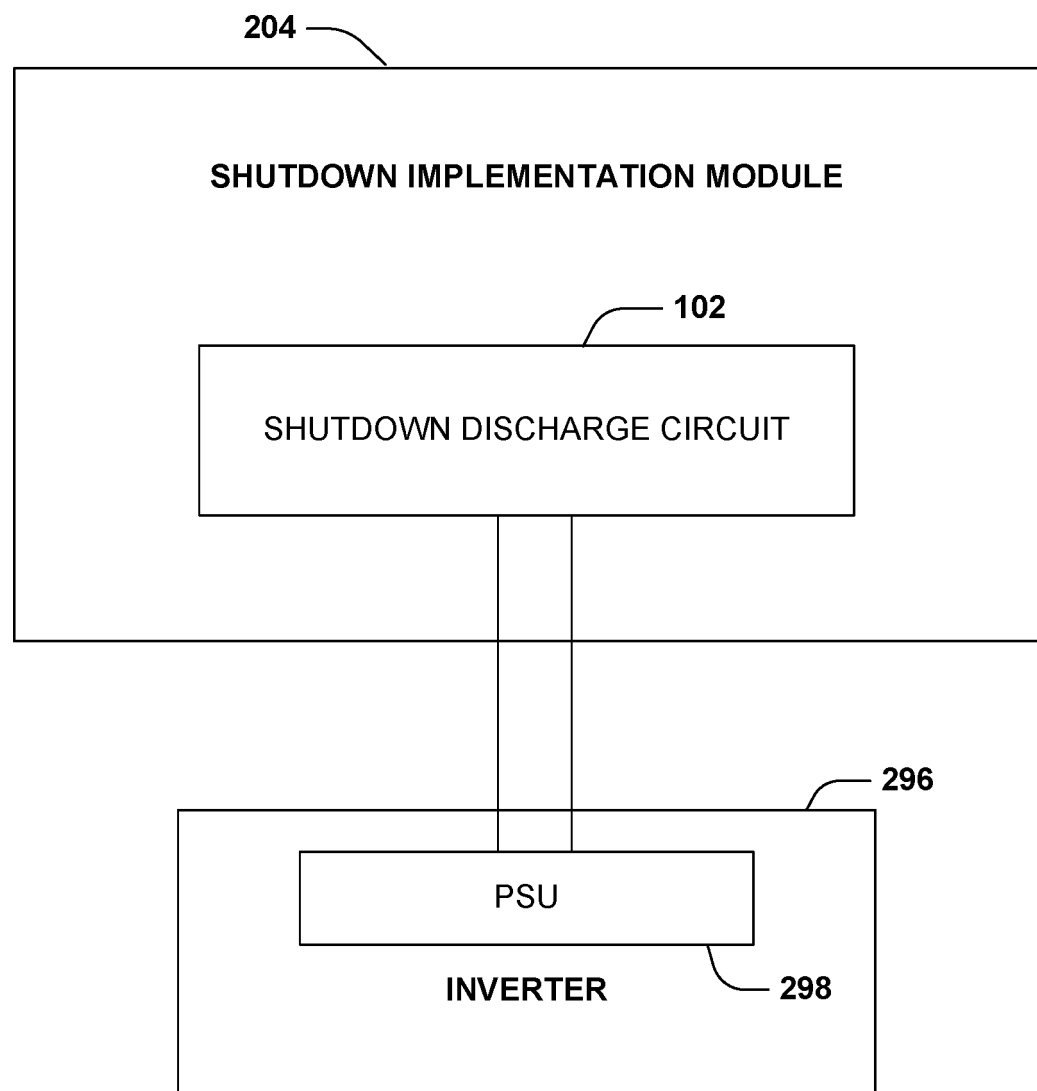
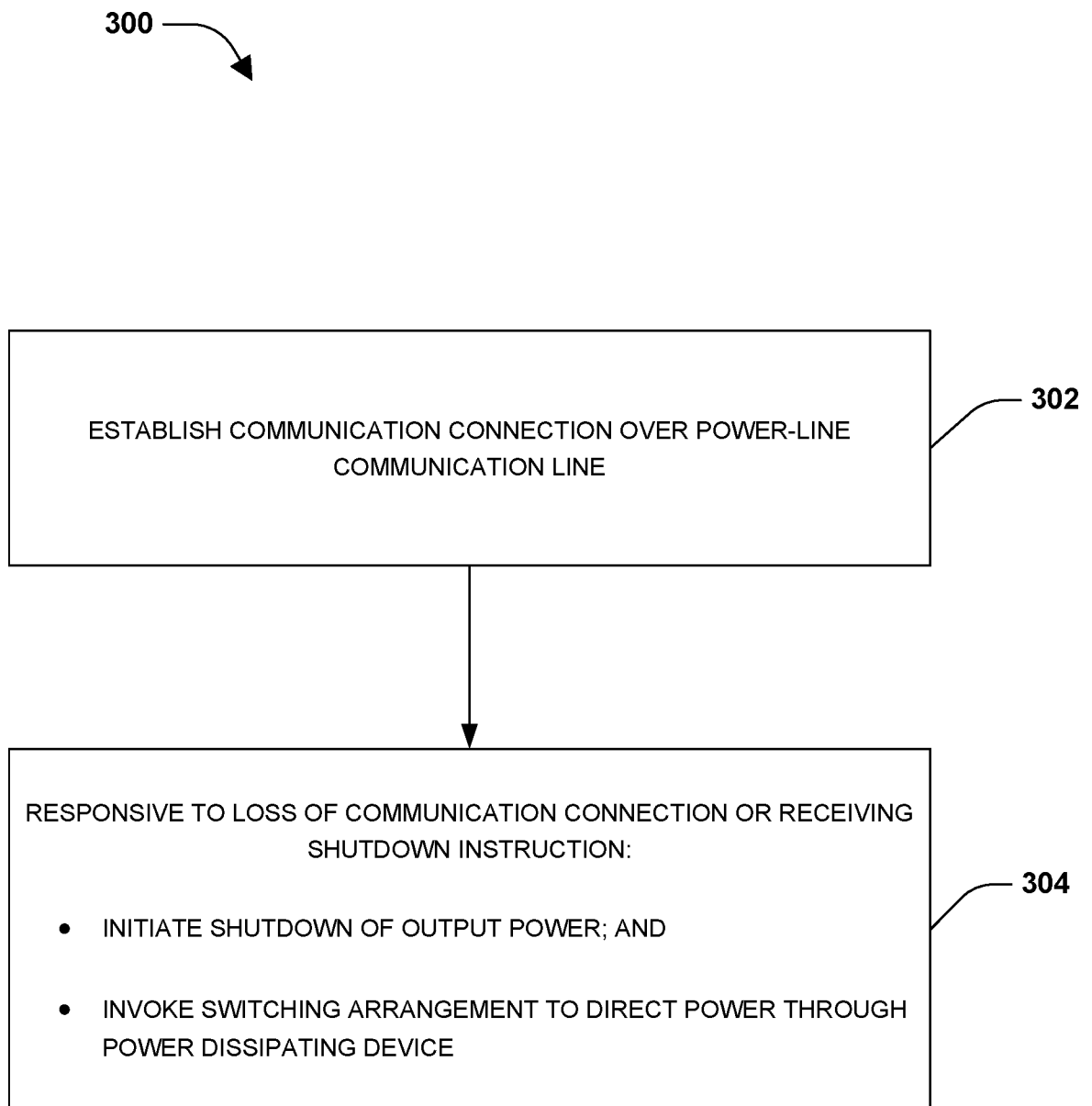
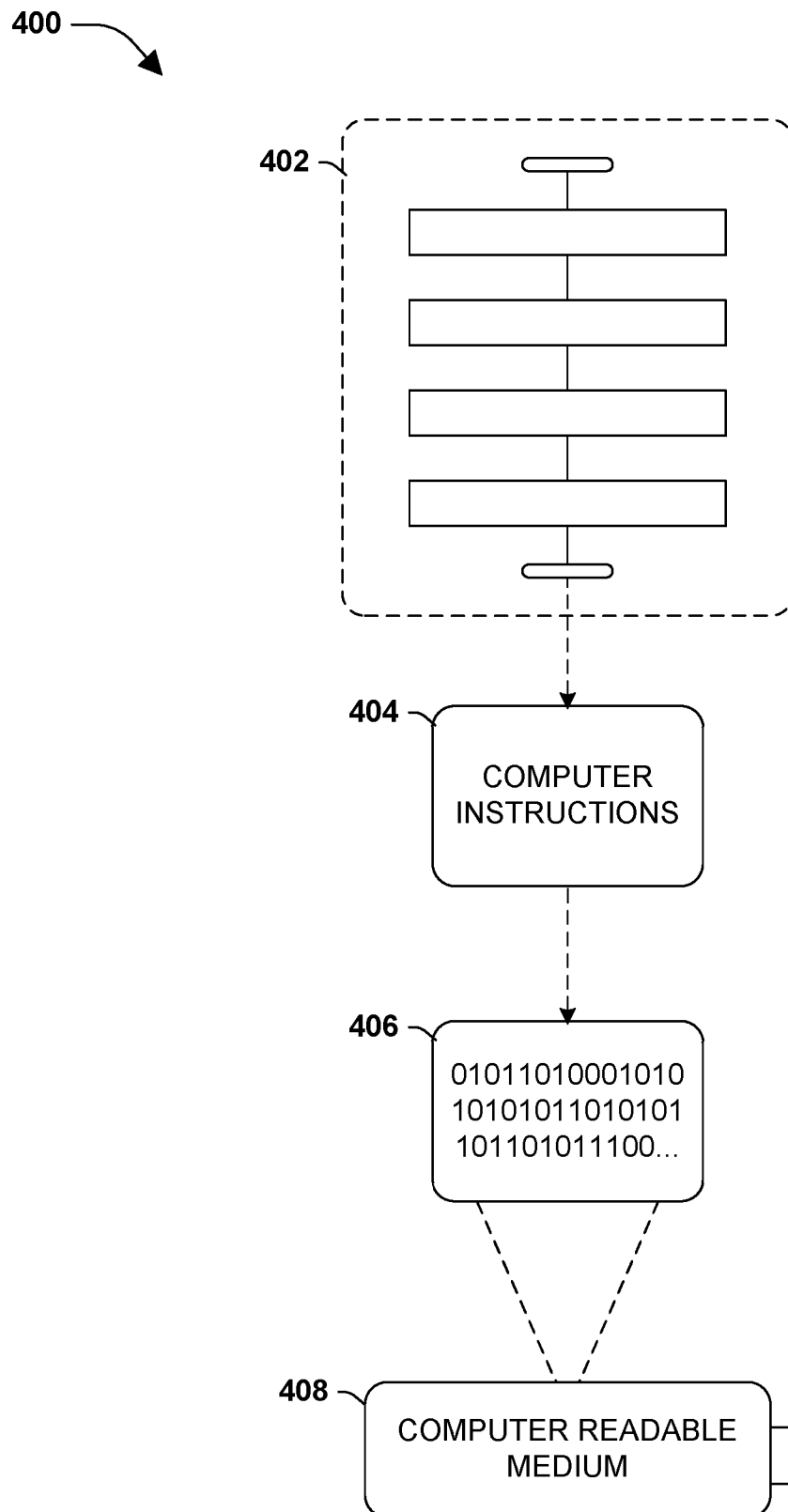
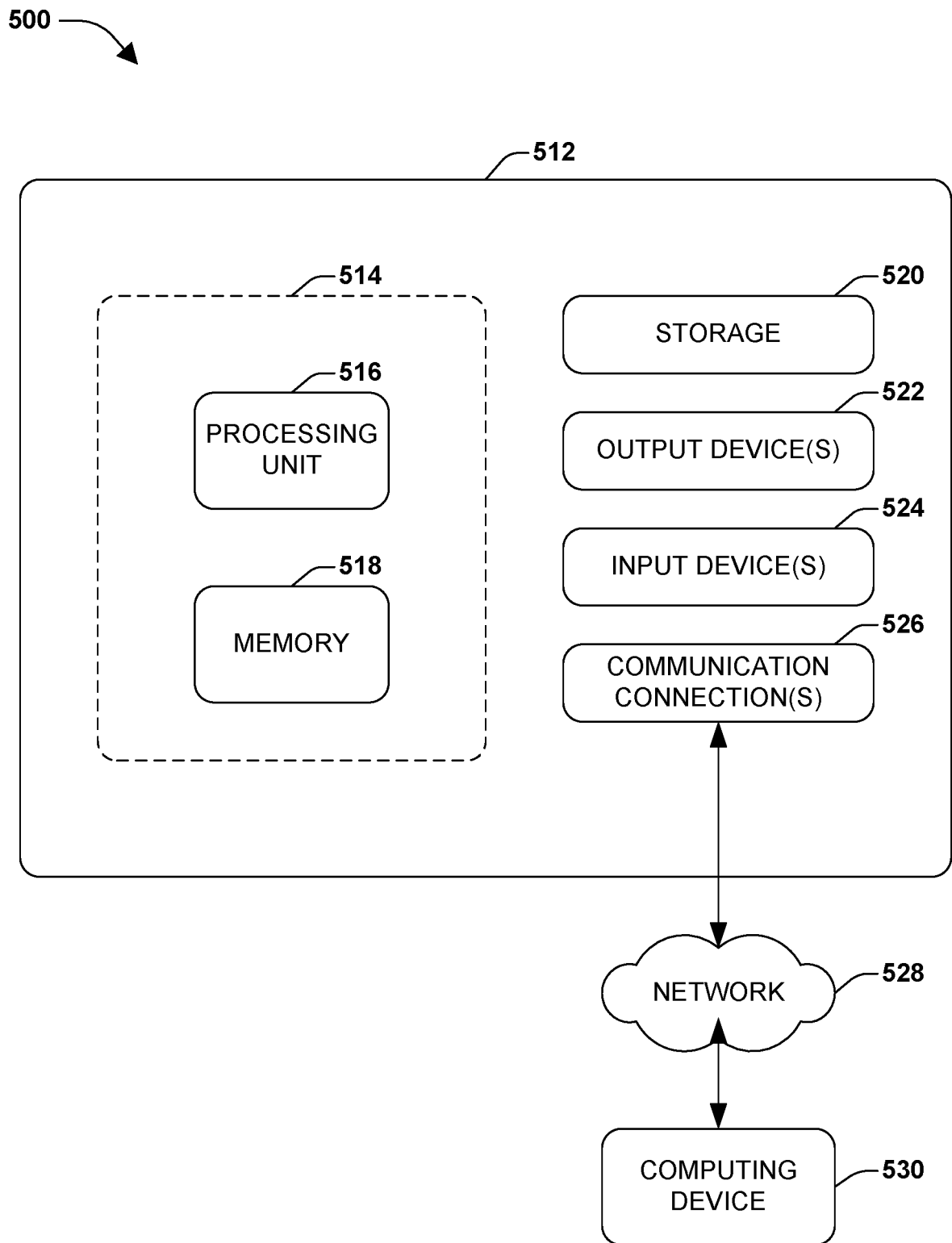


FIG. 2H

**FIG. 2I**

**FIG. 3**

**FIG. 4**

**FIG. 5**