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(54) **ELECTRICAL ASSEMBLY AND RELATED METHODS**

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(52) **U.S. Cl.**
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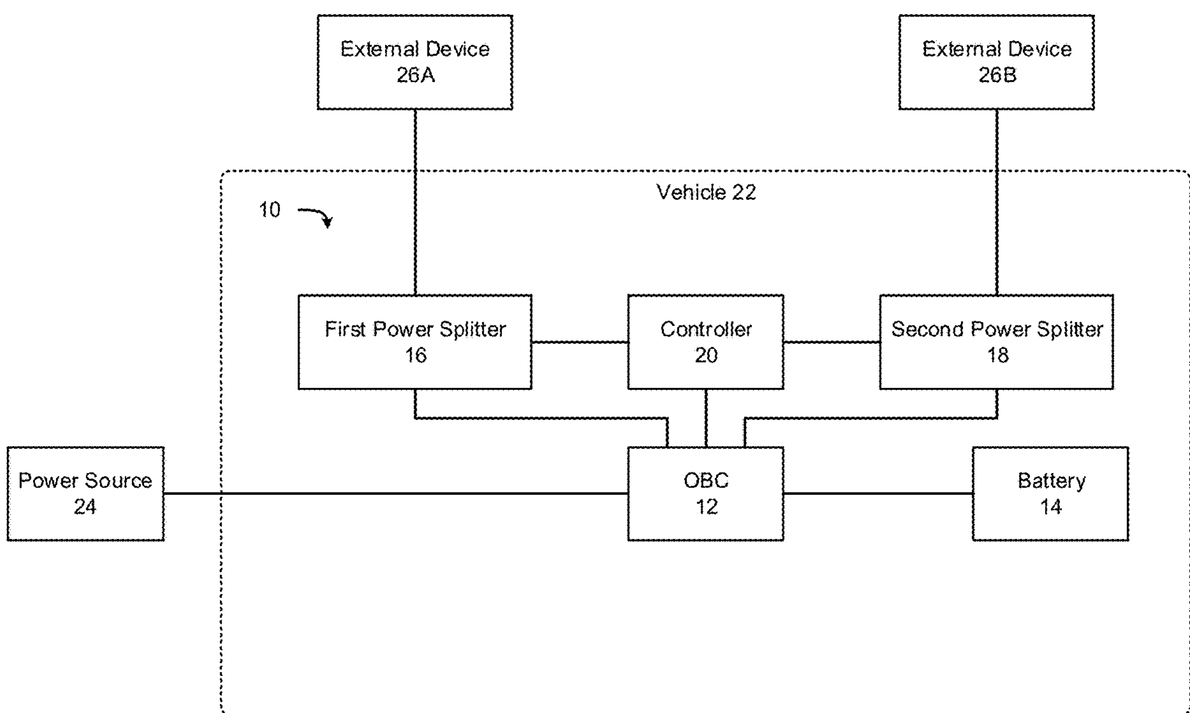
(57) **ABSTRACT**

An electrical assembly includes an onboard charger (OBC) and a power splitter. The OBC is configured to receive alternating current from a power source. The power splitter is electrically connected with the OBC and is configured to provide an output voltage. The electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.



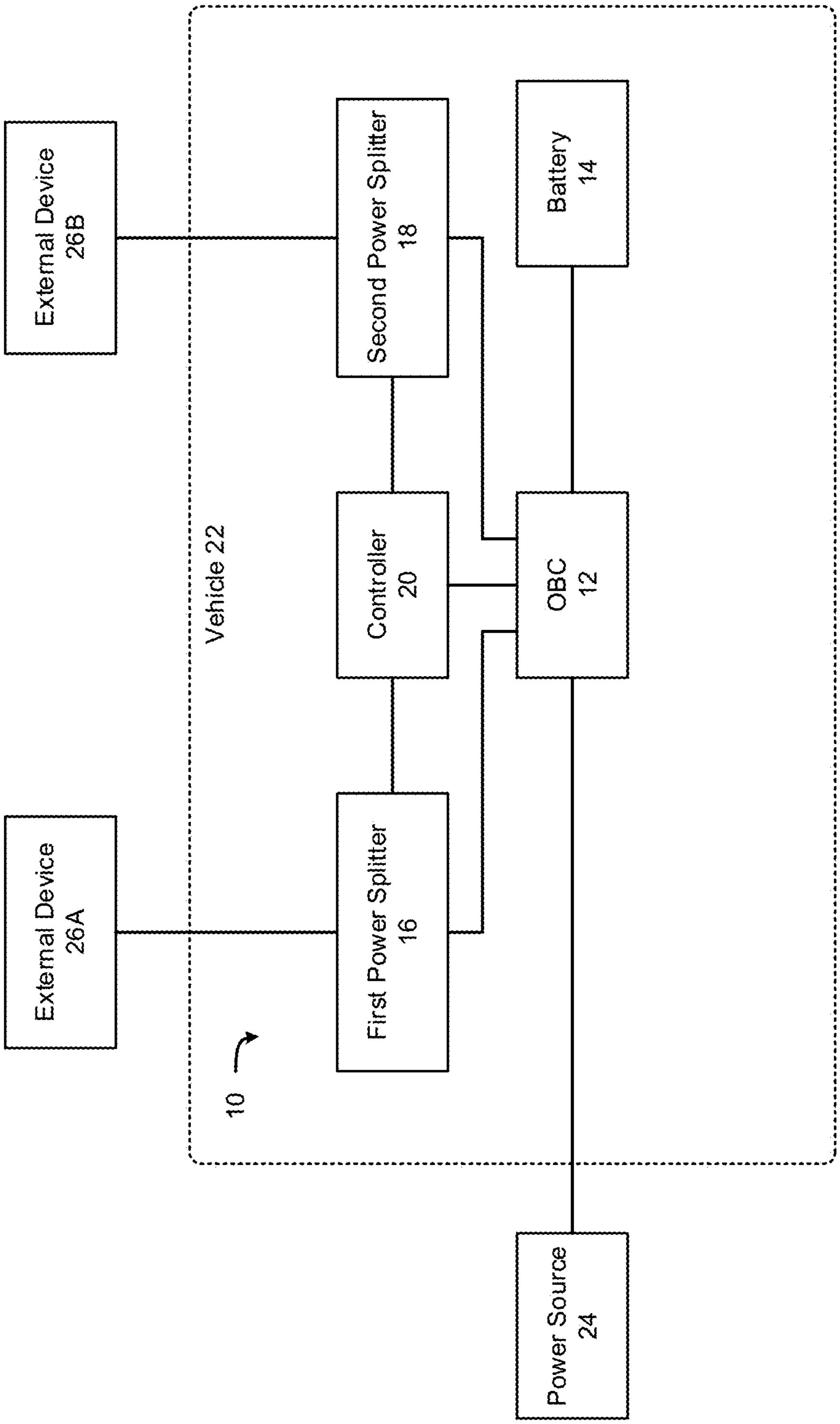

External Device 26B
External Device 26A
Second Power Splitter 18
First Power Splitter 16
Controller 20
Vehicle 22
Battery 14
OBC 12
Power Source 24
10

FIG. 1

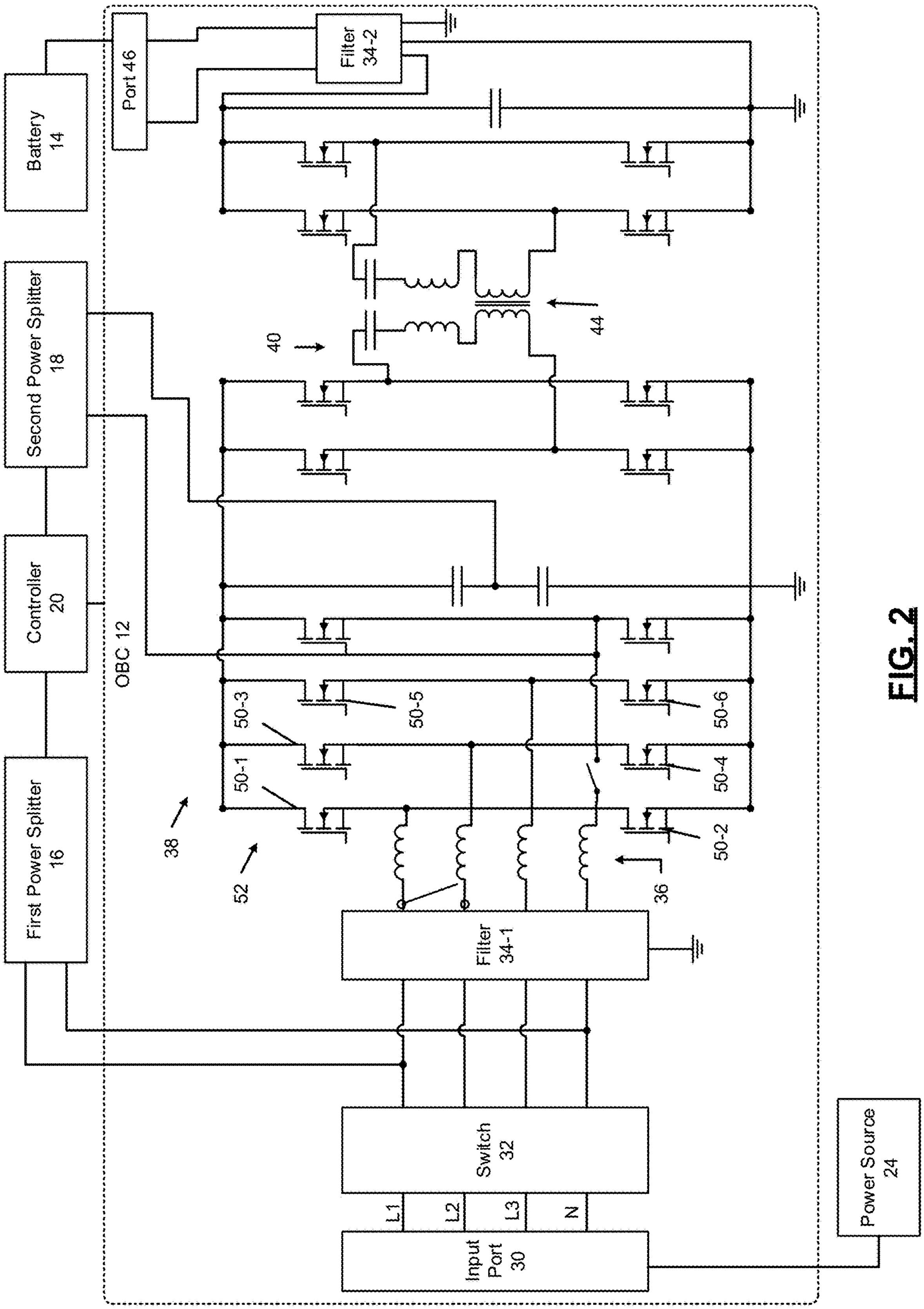

Battery
14
Port 46
Filter
34-2
Second Power Splitter
18
Controller
20
OBC 12
First Power Splitter
16
40
44
38
52
36
50-1
50-2
50-3
50-4
50-5
50-6
Filter
34-1
Switch
32
L1
L2
L3
N
Input
Port
30
Power Source
24

FIG. 2

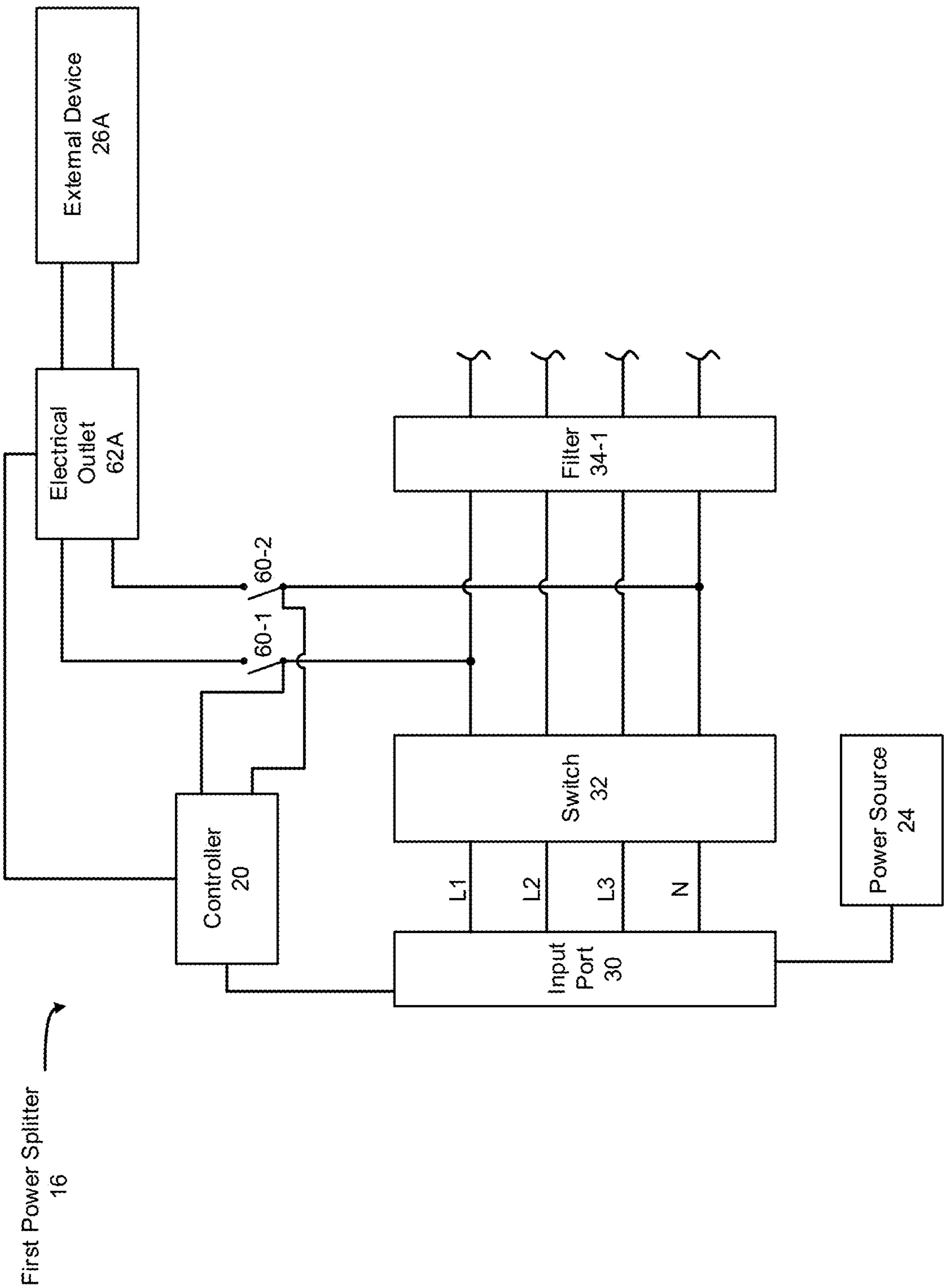

External Device
26A
Electrical
Outlet
62A
60-2
60-1
Filter
34-1
Controller
20
Switch
32
L1
L2
L3
N
Input
Port
30
Power Source
24
First Power Splitter
16

FIG. 3

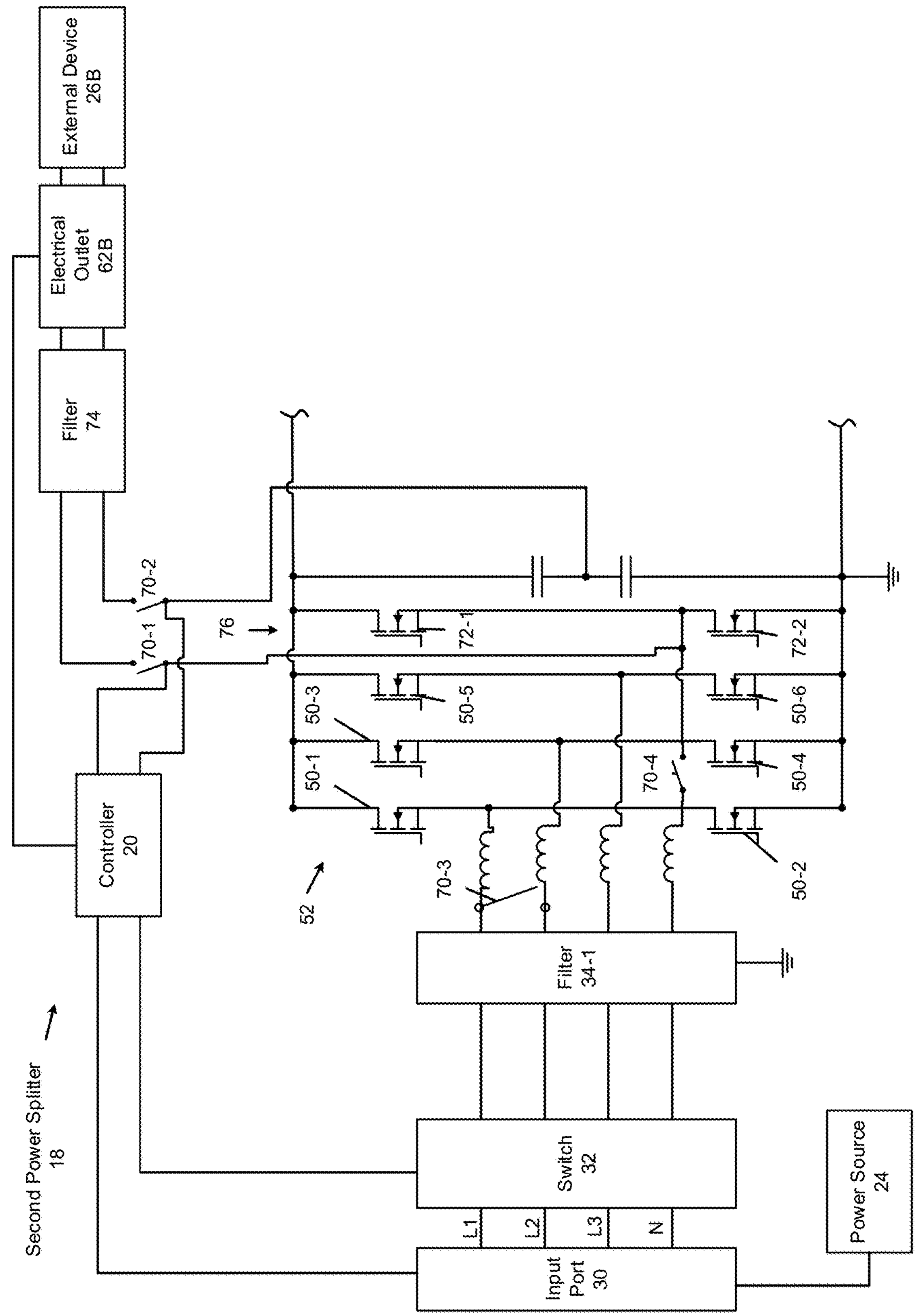

External Device
26B
Electrical
Outlet
62B
Filter
74
70-2
70-1
76
72-1
72-2
50-3
50-5
50-1
50-6
70-4
50-4
Controller
20
70-3
50-2
52
Filter
34-1
Second Power Splitter
18
Switch
32
L1
L2
L3
N
Input
Port
30
Power Source
24

FIG. 4

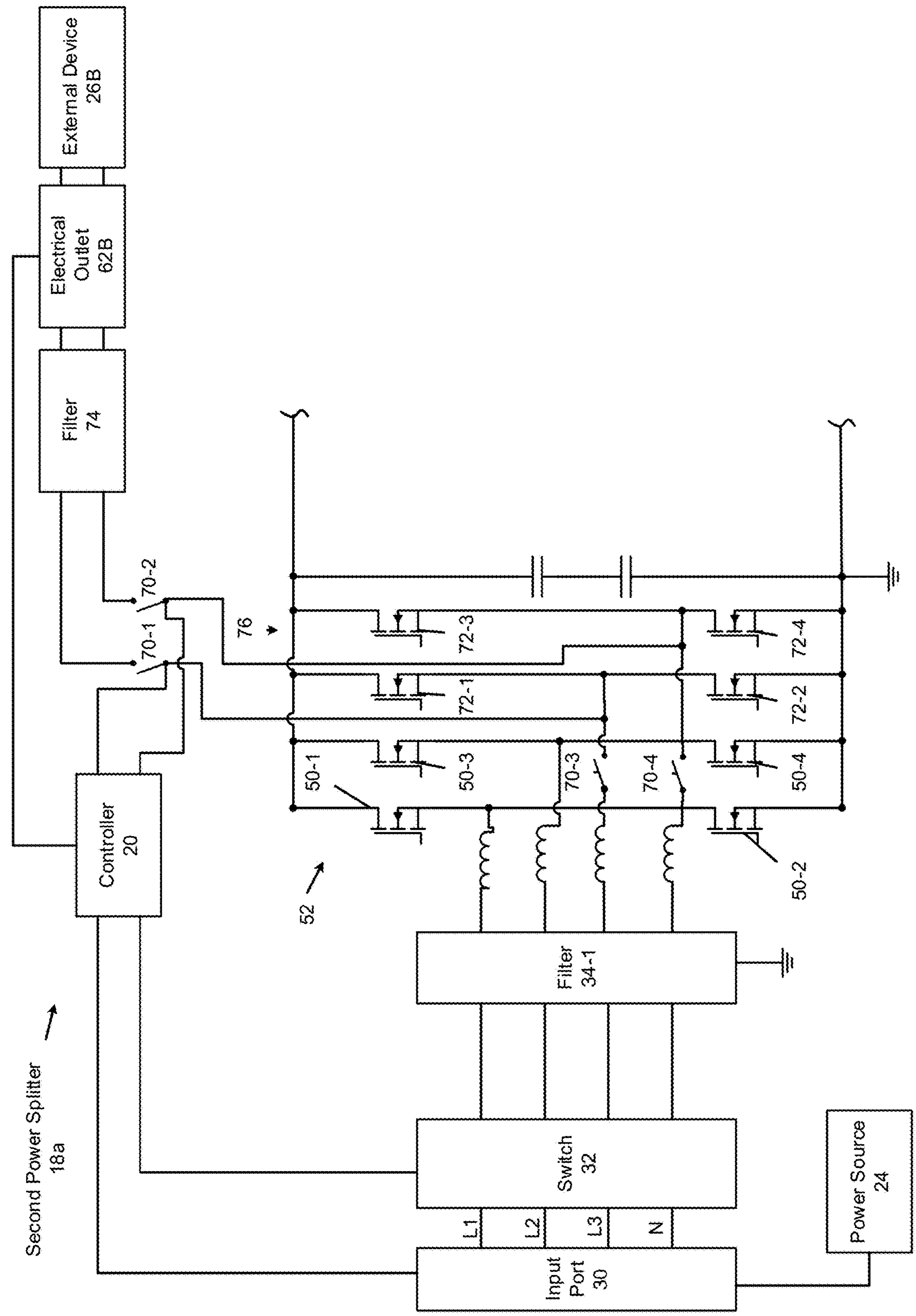

External Device
26B
Electrical
Outlet
62B
Filter
74
70-2
70-1
76
72-3
72-4
72-1
72-2
50-1
50-3
70-3
70-4
50-4
50-2
Controller
20
52
Second Power Splitter
18a
Filter
34-1
Switch
32
L1
L2
L3
N
Input
Port
30
Power Source
24

FIG. 5

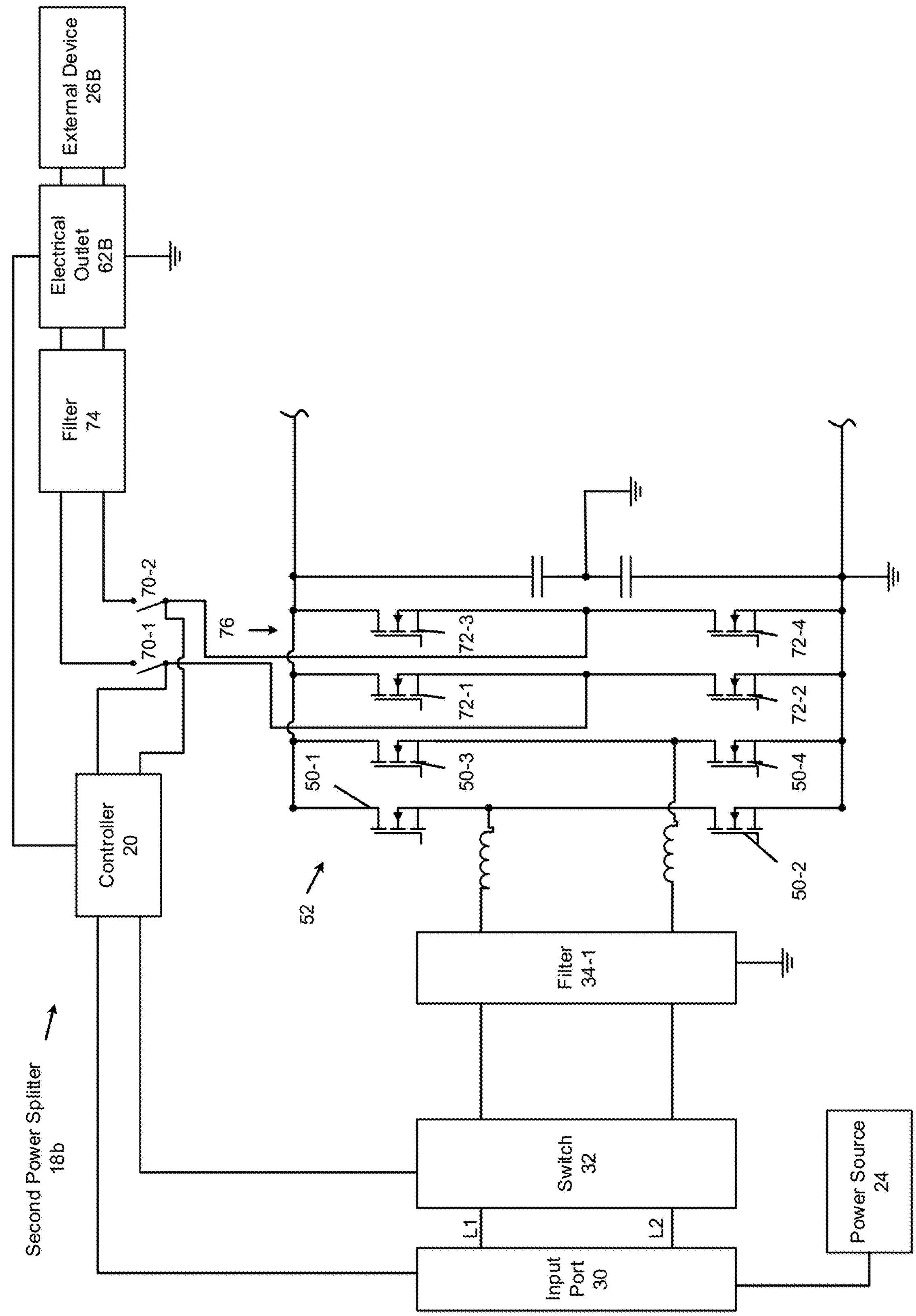

Second Power Splitter 18b
Controller 20
External Device 26B
Electrical Outlet 62B
Filter 74
70-1
70-2
76
72-1
72-2
72-3
72-4
50-1
50-2
50-3
50-4
52
Filter 34-1
Switch 32
L1
L2
Input Port 30
Power Source 24

FIG. 6

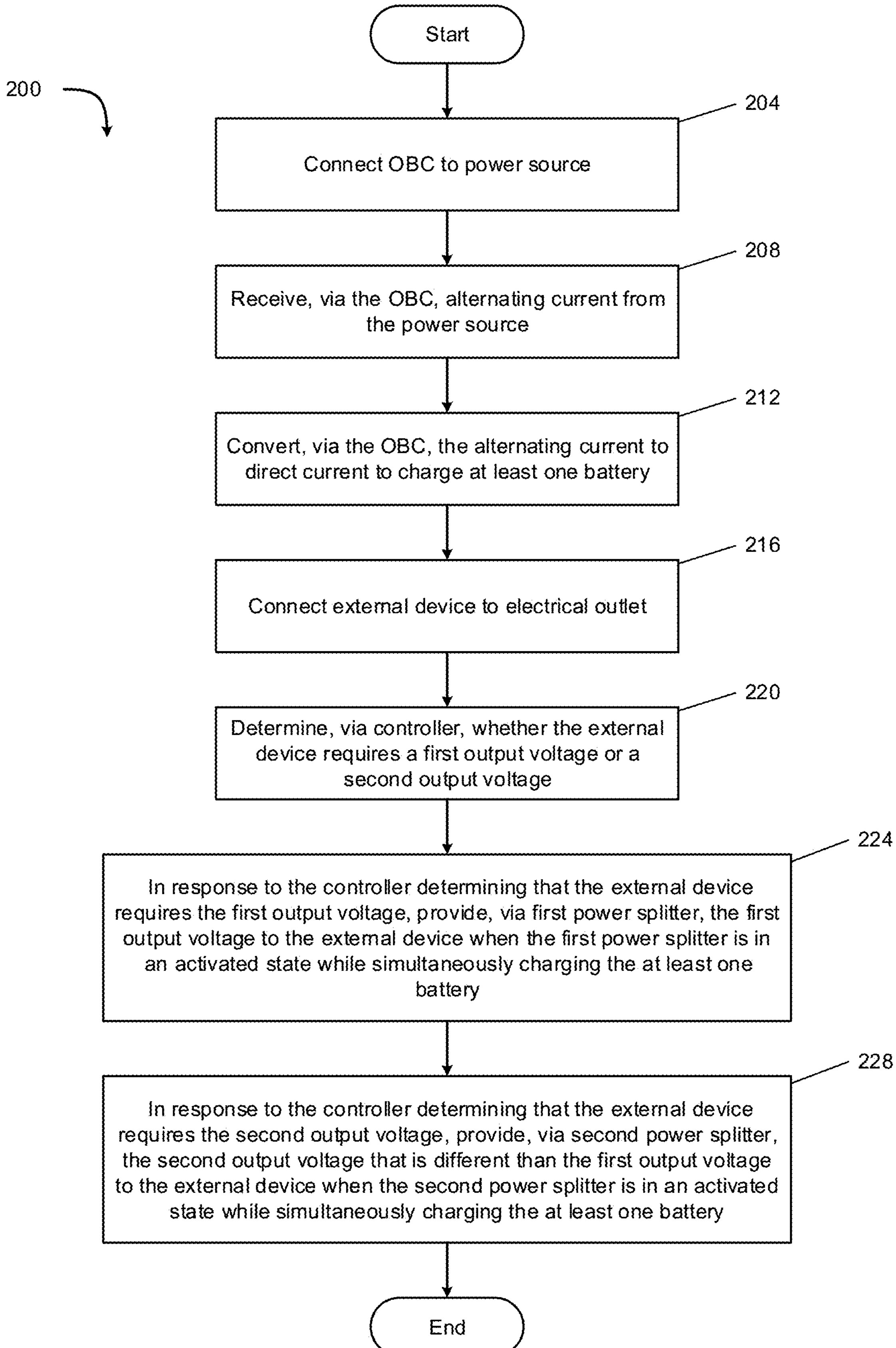

Start
200
204
Connect OBC to power source
208
Receive, via the OBC, alternating current from the power source
212
Convert, via the OBC, the alternating current to direct current to charge at least one battery
216
Connect external device to electrical outlet
220
Determine, via controller, whether the external device requires a first output voltage or a second output voltage
224
In response to the controller determining that the external device requires the first output voltage, provide, via first power splitter, the first output voltage to the external device when the first power splitter is in an activated state while simultaneously charging the at least one battery
228
In response to the controller determining that the external device requires the second output voltage, provide, via second power splitter, the second output voltage that is different than the first output voltage to the external device when the second power splitter is in an activated state while simultaneously charging the at least one battery
End

FIG. 7

ELECTRICAL ASSEMBLY AND RELATED METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/551,149 filed Feb. 8, 2024, the entire disclosure of which is incorporated by reference.

FIELD

[0002] The present disclosure relates to an electrical assembly and more particularly to an electrical assembly that is configured to simultaneously charge a vehicle rechargeable energy storage system (RESS) and provide vehicle-to-load (V2L) power flow.

BACKGROUND

[0003] Electric vehicles (EVs) are gaining popularity as environmentally friendly alternatives to traditional internal combustion engine vehicles. EVs are powered by rechargeable batteries, which require periodic charging to ensure continuous operation. Conventionally, EVs are equipped with on-board chargers that facilitate the charging of the vehicle's batteries by connecting to an external power source, such as a charging station or electrical outlet. Conventional on-board chargers are typically designed to focus solely on charging the vehicle's rechargeable energy storage system (RESS) and do not simultaneously charge a RESS and provide vehicle-to-load (V2L) power flow to power accessories or auxiliary devices such as onboard electronics, heating or cooling systems, or other auxiliary components connected to the vehicle. While known electrical assemblies, such as EV on-board chargers, have proven acceptable for their intended purpose, a continuous need for improvement remains in the pertinent art.

[0004] The background description provided here is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

[0005] One aspect of the disclosure provides an electrical assembly. The electrical assembly includes an onboard charger (OBC) and a power splitter. The OBC is configured to receive alternating current from a power source. The power splitter is electrically connected with the OBC and is configured to provide an output voltage. The electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

[0006] Another aspect of the disclosure provides an electrical assembly. The electrical assembly includes a power splitter configured to electrically connect to an onboard charger (OBC) and provide an output voltage. The OBC is configured to receive alternating current from a power source. The electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

[0007] Further areas of applicability of the present disclosure will become apparent from the detailed description, the claims, and the drawings. The detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure will become more fully understood from the detailed description and the accompanying drawings.

[0009] FIG. **1** is a high-level schematic view of an example electrical assembly in accordance with the principles of the present disclosure.

[0010] FIG. **2** is a schematic view of an example onboard charger of an electrical assembly in accordance with the principles of the present disclosure.

[0011] FIG. **3** is a schematic view of an example first power splitter of an electrical assembly in accordance with the principles of the present disclosure.

[0012] FIG. **4** is a schematic view of an example second power splitter of an electrical assembly in accordance with the principles of the present disclosure.

[0013] FIG. **5** is a schematic view of an example second power splitter of an electrical assembly in accordance with the principles of the present disclosure.

[0014] FIG. **6** is a schematic view of an example second power splitter of an electrical assembly in accordance with the principles of the present disclosure.

[0015] FIG. **7** is a flowchart depicting an example method for operating an electrical assembly in accordance with the principles of the present disclosure.

[0016] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

Introduction

[0017] With reference to FIG. **1**, an example electrical assembly **10** is shown. As will be explained in more detail below, the electrical assembly **10** may include an onboard charger (OBC) **12**, at least one battery **14**, a first power splitter **16**, a second power splitter **18**, and/or a controller **20**, among others. In some example configurations, the electrical assembly **10** may include the first power splitter **16** and not the second power splitter **18**. In some instances, the electrical assembly **10** may include the second power splitter **18** and not the first power splitter **16**.

[0018] In various implementations, the OBC **12** may be electrically connected with the battery **14**, the first power splitter **16**, and/or the second power splitter **18**. The controller **20** may be electrically connected with the OBC **12**, the first power splitter **16**, and/or the second power splitter **18**. The electrical assembly **10** may be installed in and/or may be used in connection with a vehicle **22** (e.g., an automobile).

[0019] In various implementations, the OBC **12** is detachably connected with a power source **24** and may receive alternating current from the power source **24**. In some examples, the OBC **12** may receive up to approximately 240 volts (V) alternating current (AC) (e.g., single phase or three phase) from the power source **24**.

[0020] In various implementations, for single phase examples, the OBC **12** may receive approximately 48 amperes (A) of electrical current and/or approximately 11 kilowatts (kW) of power from the power source **24**. In various implementations, the OBC **12** may receive more or less than 48 A of electrical current and/or 11 kW of power from the power source **24**.

[0021] In various implementations, for three phase examples, the OBC **12** may receive approximately 16 A of electrical current per phase and/or approximately 11 kW of power from the power source **24**. In various implementations, the OBC **12** may receive more or less than 16 A of electrical current per phase and/or approximately 11 kW of power from the power source **24**.

[0022] In various implementations, the first power splitter **16** is electrically connected with the OBC **12** and is configured to provide a first output voltage (e.g., approximately 220V AC). In various implementations, a first external electrical device **26**A (e.g., an electronic device such as a computer, laptop, phone, etc.) may be detachably connected with the first power splitter **16** and may receive the first output voltage from the first power splitter **16**.

[0023] In various implementations, the second power splitter **18** is electrically connected with OBC **12** and is configured to provide a second output voltage (e.g., approximately 120V AC) that is different than the first output voltage. In various implementations, a second external electrical device **26**B (e.g., an electronic device such as a computer, laptop, phone, etc.) may be detachably connected with the second power splitter **18** and may receive the second output voltage from the second power splitter **18**.

[0024] In various implementations, the electrical assembly **10** simultaneously charges the at least one battery **14** and provides the first output voltage to an external electrical device (e.g., the first device **26**A) or the second output voltage to an external electrical device (e.g., the second device **26**B). For example, the OBC **12** converts the input alternating current from the power source **24** to direct current to charge the at least one battery **14**. The first power splitter **16** may provide the first output voltage to an external electrical device (e.g., the first device **26**A) when the first power splitter **16** is in an activated state. The second power splitter **18** may provide the second output voltage to an external electrical device (e.g., the second device **26**B) when the second power splitter **18** is in an activated state.

Onboard Charger

[0025] With reference to FIG. **2**, an example OBC **12** is shown. In various implementations, the OBC **12** may be electrically connected with the at least one battery **14**, the first power splitter **16**, the second power splitter **18**, and/or the controller **20**, among others. The OBC **12** may be detachably coupled with the power source **24**.

[0026] In various implementations, the OBC **12** may include an input port **30**, at least one switch **32** (e.g., relay, etc.), a first filter **34-1** (e.g., an AC filter), a second filter **34-2** (e.g., a DC filter), a plurality of inductors **36**, a plurality of transistors **38**, a plurality of capacitors **40**, a plurality of resistors, a transformer **44**, and an output port **46**, among others. The controller **20** may be electrically connected with and may control operation of at least some of the electrical components of the OBC **12** (e.g., the switch **32**, the transistors **38**, etc.).

[0027] In various implementations, the input port **30** may be removably connected with the power source **24** and may receive alternating electrical current from the power source **24**. In various implementations, at least some transistors of the plurality of transistors **38** (e.g., transistors **50-1** to **50-6**) may operate as and/or may define a rectifier **52** (e.g., a power factor correction rectifier). In some example configurations, the rectifier **52** may be electrically connected with the input port **30**, the switch **32**, the first filter **34-1**, the second filter **34-2**, the inductors **36**, additional transistors of the plurality of transistors **38**, the capacitors **40**, the resistors, the transformer **44**, and/or the output port **46**, among others.

[0028] In various implementations, the rectifier **52** may convert the alternating current received from the power source **24** to direct current. The at least one battery **14** may be electrically connected with the output port **46** and may receive the direct current to charge. In some example configurations, the OBC **12** may provide approximately 7.2 kW of power to charge the at least one battery **14**. The OBC **12** may provide more or less than 7.2 kW of power to charge the at least one battery **14**.

Battery

[0029] In various implementations, a battery **14** may include one or more battery packs. A battery pack may include a plurality of battery cells. In various implementations, the at least one battery **14** may supply electricity to electric motors, electrical systems, electrical components, and/or onboard electronics of the vehicle **22**.

First Power Splitter

[0030] With reference to FIG. **3**, an example first power splitter **16** is shown. In various implementations, the first power splitter **16** may be associated with and/or may facilitate compliance with the Combined Charging System (CCS) standard. In some example configurations, the first power splitter **16** may be an optional feature of the electrical assembly **10**. The first power splitter **16** may be electrically connected with the input port **30** and the controller **20**, among others.

[0031] In various implementations, the first power splitter **16** may include various electrical components such as a first switch **60-1** (e.g., a relay, etc.), a second switch **60-2** (e.g., a relay, etc.), and an electrical outlet **62**A, among others. The first switch **60-1** and the second switch **60-2** may be electrically connected with the input port **30**, the controller **20**, and the electrical outlet **62**A, among others.

[0032] In various implementations, an external electrical device **26**A (e.g., a device that uses approximately 220 V AC to operate and/or charge) may be removably coupled with the electrical outlet **62**A. The first power splitter **16** provides the first output voltage to the device **26**A when the first power splitter **16** is in an activated state.

[0033] In various implementations, the controller **20** may control operation of the first power splitter **16** by selectively activating or deactivating the first power splitter **16**. For example, the controller **20** may turn off or may turn on the first switch **60-1** and/or the second switch **60-2**. The first switch **60-1** and the second switch **60-2** are in a closed configuration (e.g., turned on) when the first power splitter **16** is in an activated state. The first switch **60-1** and the second switch **60-2** are in an open configuration (e.g., turned off) when the second power splitter **18** is in an activated state.

[0034] In various implementations, during operation of the electrical assembly **10**, the input port **30** may receive electrical current (e.g., approximately 48 A), input voltage (e.g., approximately 220 V), and/or input power (e.g., approximately 11 kW) from the power source **24**. In accordance with an external electrical device (e.g., device **26**A) being connected to the electrical outlet **62**A and the first power splitter **16** being in an activated state, the first power splitter **16** may provide a first output voltage (e.g., approximately 220V AC), a first output current (e.g., approximately 15A AC), and/or a first output power (e.g., approximately 3.6 kW) to the external electrical device, while the OBC **12** simultaneously provides power (e.g., approximately 7.2 kW) to charge the at least one battery **14**.

Second Power Splitter

[0035] With reference to FIG. **4**, an example second power splitter **18** is shown. In various implementations, the second power splitter **18** may be associated with and/or may facilitate compliance with the North American Charging Standard (NACS). In some example configurations, the second power splitter **18** may be an optional feature of the electrical assembly **10**. The second power splitter **18** may be electrically connected with the input port **30**, the OBC **12** (e.g., the rectifier **52**), and the controller **20**, among others.

[0036] In various implementations, the second power splitter **18** may include various electrical components such as a first switch **70-1** (e.g., a relay, etc.), a second switch **70-2** (e.g., a relay, etc.), a third switch **70-3** (e.g., a relay, etc.), a fourth switch **70-4** (e.g., a relay, etc.), a first transistor **72-1**, a second transistor **72-2**, a third transistor **72-3**, a fourth transistor **72-4**, a filter **74**, and/or an electrical outlet **62**B, among others.

[0037] In some example configurations, the second power splitter **18** may include an inverter **76**. With continued reference to FIG. **4**, in various implementations, the first transistor **72-1** and the second transistor **72-2** may operate as and/or may define the inverter **76** (e.g., a half-bridge inverter).

[0038] With reference to FIGS. **5** and **6**, second power splitters **18***a* and **18***b*, respectively, are provided. In view of the substantial similarity in structure and function of the components associated with the second power splitter **18***a*, **18***b* relative to the second power splitter **18**, like reference numerals are used hereinafter and in the drawings to identify like components, and references to the second power splitter **18** will be understood to apply equally to the second power splitter **18***a* or **18***b* unless otherwise indicated. In various implementations, the first transistor **72-1**, the second transistor **72-2**, the third transistor **72-3**, and the fourth transistor **72-4** may operate as and/or define the inverter **76** (e.g., a full-bridge inverter). In various implementations, the inverter **76** may be electrically connected with the rectifier **52** and may convert direct current from the rectifier **52** to alternating current to produce the second output voltage (e.g., approximately 120 V AC).

[0039] In some example configurations, the first switch **70-1** and the second switch **70-2** may be electrically connected with the inverter **76** and the filter **74**. The electrical outlet **62**B may be electrically connected with the filter **74**, the first switch **70-1**, and the second switch **70-2**. In various implementations, the third switch **70-3** and/or the fourth switch **70-4** may be electrically connected with the input port **30**, the rectifier **52**, and/or the inverter **76** (see, e.g., FIGS. **4** and **5**).

[0040] In various implementations, each transistor (e.g., transistors **38**, **50-1** to **50-6**, and **72-1** to **72-4**, etc.) may include a field effect transistor (FET), a metal oxide semiconductor field effect transistor (MOSFET), such as n-channel or p-channel MOSFET, a bipolar junction transistor (BJT), a smart FET, and/or a silicon die (e.g., bare silicon die), among others. Each transistor may include a closed (e.g., activated) state that may permit electrical current to flow through the respective transistor. Each transistor may include an open (e.g., deactivated) state that may prevent electrical current from flowing through the respective transistor.

[0041] In various implementations, an external electrical device **26**B (e.g., a device that uses approximately 120 V AC to operate and/or charge) may be removably coupled with the electrical outlet **62**B. The second power splitter **18** provides the second output voltage to the device **26**B when the second power splitter **18** is in an activated state.

[0042] In various implementations, the controller **20** may control operation of the second power splitter **18** by selectively activating or deactivating the second power splitter **18**. For example, the controller **20** may turn off or may turn on the first switch **70-1**, the second switch **70-2**, the third switch **70-3**, and the fourth switch **70-4**. The controller **20** may selectively activate or deactivate the first transistor **72-1**, the second transistor **72-2**, the third transistor **72-3**, and the fourth transistor **72-4**. In various implementations, the first switch **70-1** and the second switch **70-2** are in a closed configuration (e.g., turned on) when the second power splitter **18** is in an activated state. The first switch **70-1** and the second switch **70-2** are in an open configuration (e.g., turned off) when the first power splitter **16** is in an activated state.

[0043] With reference to FIG. **4**, in various implementations, the third switch **70-3** may be electrically connected to a first leg L**1** and a second leg L**2** of the OBC **12** and/or the fourth switch **70-4** may be electrically connected with a neutral leg of the OBC **12**. The third switch **70** may be in a closed configuration and/or the fourth switch **70-4** may be in an open configuration when the second power splitter **18** is in an activated state.

[0044] With reference to FIG. **5**, in some example configurations, the third switch **70-3** may be electrically connected to a third leg L**3** of the OBC **12**. In various implementations, the third switch **70-3** may be in an open configuration when the second power splitter **18***a* is in an activated state.

[0045] In various implementations, during operation of the electrical assembly **10**, the input port **30** may receive electrical current (e.g., approximately 48 A), input voltage (e.g., approximately 220 V), and/or input power (e.g., approximately 11 kW) from the power source **24**. In accordance with an external electrical device (e.g., device **26**B) being connected to the electrical outlet **62**B and the second power splitter **18** being in an activated state, the second power splitter **18** may provide the second output voltage (e.g., approximately 120V AC), a second output current (e.g., approximately 30A AC), and/or a second output power (e.g., approximately 3.6 kW) to the external electrical device while the OBC **12** simultaneously provides power (e.g., approximately 7.2 kW) to charge the at least one battery **14**.

[0046] In various implementations, the electrical outlet **62**B of the second power splitter **18** may be the same or may be different than the electrical outlet **62**A of the first power splitter **16**. In other words, in some implementations, the first power splitter **16** and the second power splitter **18** may both utilize (e.g., electrically communicate through) the electrical outlet **62**A, and, in some implementations, the first power splitter **16** and the second power splitter **18** may both utilize (e.g., electrically communicate through) the electrical outlet **62**B.

[0047] In various implementations, the controller **20** may determine whether to provide the first output voltage or the second output voltage to an external device (e.g., external device **26**A, **26**B) connected to an electrical outlet (e.g., electrical outlet **62**A, **64**B). For example, the controller **20** may determine which output voltage (e.g., the first output voltage or the second output voltage) is required for an electrical device (e.g., external device **26**A, **26**B) connected to an electrical outlet (e.g., electrical outlet **62**A, **64**B) based on a plug of the electrical device being connected with the electrical outlet. In various implementations, an electrical device (e.g., electrical device **26**A) that requires the first output voltage (e.g., approximately 220 V AC) may use a European standard electrical plug. In various implementations, an electrical device (e.g., electrical device **26**B) that requires the second output voltage (e.g., approximately 120 V AC) may use a North American standard electrical plug. The controller **20** may identify which plug is connected with the electrical outlet.

Controller

[0048] In various implementations, the controller **20** includes an electronic controller and/or an electronic processor, such as a programmable microprocessor and/or microcontroller. The controller **20** may include an application specific integrated circuit (ASIC). The controller **20** may include a central processing unit (CPU), a memory (for example, a non-transitory computer-readable storage medium), and/or an input/output (I/O) interface. The controller **20** may perform various functions, including those described in greater detail herein, with appropriate programming instructions and/or code embodied in software, hardware, and/or other medium. The controller **20** may include a plurality of controllers. The controller **20** may be connected to a display, such as a touch screen.

Vehicle

[0049] With reference to FIG. **1**, the electrical assembly **10**, the at least one battery **14**, the first device **26**A, and/or the second device **26**B may be incorporated with and/or disposed in the vehicle **22**. The vehicle **22** may include one or more of a variety of configurations. For example, a vehicle **22** may include a land vehicle, a passenger car, a van, a sport utility vehicle (SUV), a crossover, a truck (e.g., a pickup truck, a commercial truck, etc.), a bus, a watercraft, an aircraft (e.g., a plane, a helicopter, etc.), and/or a combination thereof (e.g., a vehicle for land and water, a vehicle for air and water, etc.), among others.

Power Source

[0050] In various implementations, the power source **24** may be associated with the power grid, a solar panel, a power converter, and/or an outlet, among others. In various implementations, residential, commercial, and/or public charging infrastructure may be used to connect the vehicle **22** (e.g., the input port **30**) with the power source **24**. In some examples, the charging infrastructure may include a charging station, a charging cable, and/or a charging connector, among others.

External Electrical Devices

[0051] In various implementations, an external electrical device (e.g., external electrical device **26**A, **26**B) includes one or more of a variety of configurations. For example, an external electrical device may include an electrical device, an electronics device, a cell phone, a tablet, a computer, a laptop, a video game system, a television, an e-bike, a power tool battery, a power tool, and/or a household appliance, among others.

Flowchart

[0052] FIG. **7** is a flowchart of an example method **200** for operating an electrical assembly **10**. In various implementations, the electrical assembly **10** may include an onboard charger (OBC) **12**, at least one battery **14** electrically connected with the OBC **12**, a first power splitter **16** electrically connected with the OBC **12**, a second power splitter **18** electrically connected with the OBC **12**, an electrical outlet (e.g., electrical outlet **62**A, **62**B) electrically connected with the first power splitter **16** and the second power splitter **18**, and a controller **20** electrically connected with the OBC **12**, the first power splitter **16**, the second power splitter **18**, and the electrical outlet. The method **200** may begin at **204**. At **204**, a user may connect the OBC **12** to a power source **24**. The method **200** may proceed to **208**. At **208**, the OBC **12** may receive alternating current from the power source **24**. In some example configurations, the OBC **12** may receive an input voltage (e.g., approximately 220 V AC) from the power source. The method **200** may proceed to **212**.

[0053] At **212**, the OBC **12** may convert the alternating current to direct current to charge the at least one battery **14**. The method **200** may proceed to **216**. At **216**, a user may connect an external device (e.g., external device **26**A, **26**B) to the electrical outlet. The method **200** may proceed to **220**.

[0054] At **220**, the controller **20** may determine whether the external device requires a first output voltage (e.g., approximately 220 V AC) or a second output voltage (e.g., approximately 120 V AC). For example, the controller **20** may determine which output voltage (e.g., the first output voltage or the second output voltage) is required for an electrical device (e.g., external device **26**A, **26**B) connected to an electrical outlet (e.g., electrical outlet **62**A, **64**B) based on a plug of the electrical device being connected with the electrical outlet. The method **200** may proceed to **224**.

[0055] At **224**, in response to the controller **20** determining that the external device requires the first output voltage, the first power splitter **16** may provide the first output voltage to the external device when the first power splitter **16** is in an activated state while simultaneously charging the at least one battery **14**. The method **200** may proceed to **228**.

[0056] At **228**, in response to the controller **20** determining that the external device requires the second output voltage, the second power splitter **18** may provide the second output voltage that is different than the first output voltage to the external device when the second power splitter **18** is in an activated state while simultaneously charging the at least one battery **14**. Then the method **200** may end.

[0057] The foregoing description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims. In the written description and claims, one or more steps within a method may be executed in a different order (or concurrently) without altering the principles of the present disclosure. Similarly, one or more instructions stored in a non-transitory computer-readable medium may be executed in a different order (or concurrently) without altering the principles of the present disclosure. Unless indicated otherwise, numbering or other labeling of instructions or method steps is done for convenient reference, not to indicate a fixed order.

[0058] Further, although each of the embodiments is described above as having certain features, any one or more of those features described with respect to any embodiment of the disclosure can be implemented in and/or combined with features of any of the other embodiments, even if that combination is not explicitly described. In other words, the described embodiments are not mutually exclusive, and permutations of one or more embodiments with one another remain within the scope of this disclosure.

[0059] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various terms, including "connected," "engaged," "coupled," "adjacent," "next to," "on top of," "above," "below," and "disposed." Unless explicitly described as being "direct," when a relationship between first and second elements is described in the above disclosure, that relationship encompasses a direct relationship where no other intervening elements are present between the first and second elements as well as an indirect relationship where one or more intervening elements are present between the first and second elements.

[0060] As noted below, the term "set" generally means a grouping of one or more elements. However, in various implementations a "set" may, in certain circumstances, be the empty set (in other words, the set has zero elements in those circumstances). As an example, a set of search results resulting from a query may, depending on the query, be the empty set. In contexts where it is not otherwise clear, the term "non-empty set" can be used to explicitly denote exclusion of the empty set—that is, a non-empty set will always have one or more elements.

[0061] A "subset" of a first set generally includes some of the elements of the first set. In various implementations, a subset of the first set is not necessarily a proper subset: in certain circumstances, the subset may be coextensive with (equal to) the first set (in other words, the subset may include the same elements as the first set). In contexts where it is not otherwise clear, the term "proper subset" can be used to explicitly denote that a subset of the first set must exclude at least one of the elements of the first set. Further, in various implementations, the term "subset" does not necessarily exclude the empty set. As an example, consider a set of candidates that was selected based on first criteria and a subset of the set of candidates that was selected based on second criteria; if no elements of the set of candidates met the second criteria, the subset may be the empty set. In contexts where it is not otherwise clear, the term "non-empty subset" can be used to explicitly denote exclusion of the empty set.

[0062] In the figures, the direction of an arrow, as indicated by the arrowhead, generally demonstrates the flow of information (such as data or instructions) that is of interest to the illustration. For example, when element A and element B exchange a variety of information but information transmitted from element A to element B is relevant to the illustration, the arrow may point from element A to element B. This unidirectional arrow does not imply that no other information is transmitted from element B to element A. Further, for information sent from element A to element B, element B may send requests for, or receipt acknowledgements of, the information to element A.

[0063] In this application, including the definitions below, the term "module" can be replaced with the term "controller" or the term "circuit." In this application, the term "controller" can be replaced with the term "module." The term "module" may refer to, be part of, or include: an Application Specific Integrated Circuit (ASIC); a digital, analog, or mixed analog/digital discrete circuit; a digital, analog, or mixed analog/digital integrated circuit; a combinational logic circuit; a field programmable gate array (FPGA); processor hardware (shared, dedicated, or group) that executes code; memory hardware (shared, dedicated, or group) that is coupled with the processor hardware and stores code executed by the processor hardware; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip.

[0064] The module may include one or more interface circuits. In some examples, the interface circuit(s) may implement wired or wireless interfaces that connect to a local area network (LAN) or a wireless personal area network (WPAN). Examples of a LAN are Institute of Electrical and Electronics Engineers (IEEE) Standard 802.11-2020 (also known as the WIFI wireless networking standard) and IEEE Standard 802.3-2018 (also known as the ETHERNET wired networking standard). Examples of a WPAN are IEEE Standard 802.15.4 (including the ZIGBEE standard from the ZigBee Alliance) and, from the Bluetooth Special Interest Group (SIG), the BLUETOOTH wireless networking standard (including Core Specification versions 3.0, 4.0, 4.1, 4.2, 5.0, and 5.1 from the Bluetooth SIG).

[0065] The module may communicate with other modules using the interface circuit(s). Although the module may be depicted in the present disclosure as logically communicating directly with other modules, in various implementations the module may actually communicate via a communications system. The communications system includes physical and/or virtual networking equipment such as hubs, switches, routers, and gateways. In some implementations, the communications system connects to or traverses a wide area network (WAN) such as the Internet. For example, the communications system may include multiple LANs connected to each other over the Internet or point-to-point leased lines using technologies including Multiprotocol Label Switching (MPLS) and virtual private networks (VPNs).

[0066] In various implementations, the functionality of the module may be distributed among multiple modules that are connected via the communications system. For example, multiple modules may implement the same functionality distributed by a load balancing system. In a further example, the functionality of the module may be split between a server (also known as remote, or cloud) module and a client (or, user) module. For example, the client module may include a native or web application executing on a client device and in network communication with the server module.

[0067] Some or all hardware features of a module may be defined using a language for hardware description, such as IEEE Standard 1364-2005 (commonly called "Verilog") and IEEE Standard 1076-2008 (commonly called "VHDL"). The hardware description language may be used to manufacture and/or program a hardware circuit. In some implementations, some or all features of a module may be defined by a language, such as IEEE 1666-2005 (commonly called "SystemC"), that encompasses both code, as described below, and hardware description.

[0068] The term code, as used above, may include software, firmware, and/or microcode, and may refer to programs, routines, functions, classes, data structures, and/or objects. Shared processor hardware encompasses a single microprocessor that executes some or all code from multiple modules. Group processor hardware encompasses a microprocessor that, in combination with additional microprocessors, executes some or all code from one or more modules. References to multiple microprocessors encompass multiple microprocessors on discrete dies, multiple microprocessors on a single die, multiple cores of a single microprocessor, multiple threads of a single microprocessor, or a combination of the above.

[0069] The memory hardware may also store data together with or separate from the code. Shared memory hardware encompasses a single memory device that stores some or all code from multiple modules. One example of shared memory hardware may be level 1 cache on or near a microprocessor die, which may store code from multiple modules. Another example of shared memory hardware may be persistent storage, such as a solid state drive (SSD) or magnetic hard disk drive (HDD), which may store code from multiple modules. Group memory hardware encompasses a memory device that, in combination with other memory devices, stores some or all code from one or more modules. One example of group memory hardware is a storage area network (SAN), which may store code of a particular module across multiple physical devices. Another example of group memory hardware is random access memory of each of a set of servers that, in combination, store code of a particular module. The term memory hardware is a subset of the term computer-readable medium.

[0070] The apparatuses and methods described in this application may be partially or fully implemented by a special-purpose computer created by configuring a general-purpose computer to execute one or more particular functions embodied in computer programs. Such apparatuses and methods may be described as computerized or computer-implemented apparatuses and methods. The functional blocks and flowchart elements described above serve as software specifications, which can be translated into the computer programs by the routine work of a skilled technician or programmer.

[0071] The computer programs include processor-executable instructions that are stored on at least one non-transitory computer-readable medium. The computer programs may also include or rely on stored data. The computer programs may encompass a basic input/output system (BIOS) that interacts with hardware of the special-purpose computer, device drivers that interact with particular devices of the special-purpose computer, one or more operating systems, user applications, background services, background applications, etc.

[0072] The computer programs may include: (i) descriptive text to be parsed, such as HTML (hypertext markup language), XML (extensible markup language), or JSON (JavaScript Object Notation), (ii) assembly code, (iii) object code generated from source code by a compiler, (iv) source code for execution by an interpreter, (v) source code for compilation and execution by a just-in-time compiler, etc. As examples only, source code may be written using syntax from languages including C, C++, C#, Objective C, Swift, Haskell, Go, SQL, R, Lisp, Java®, Fortran, Perl, Pascal, Curl, OCaml, JavaScript®, HTML5 (Hypertext Markup Language 5th revision), Ada, ASP (Active Server Pages), PHP (PHP: Hypertext Preprocessor), Scala, Eiffel, Smalltalk, Erlang, Ruby, Flash®, Visual Basic®, Lua, MATLAB, SIMULINK, and Python®.

[0073] The term non-transitory computer-readable medium does not encompass transitory electrical or electromagnetic signals propagating through a medium (such as on a carrier wave). Non-limiting examples of a non-transitory computer-readable medium are nonvolatile memory circuits (such as a flash memory circuit, an erasable programmable read-only memory circuit, or a mask read-only memory circuit), volatile memory circuits (such as a static random access memory circuit or a dynamic random access memory circuit), magnetic storage media (such as an analog or digital magnetic tape or a hard disk drive), and optical storage media (such as a CD, a DVD, or a Blu-ray Disc).

[0074] The term "set" generally means a grouping of one or more elements. The elements of a set do not necessarily need to have any characteristics in common or otherwise belong together. The phrase "at least one of A, B, and C" should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean "at least one of A, at least one of B, and at least one of C." The phrase "at least one of A, B, or C" should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR.

[0075] The following Clauses provide an exemplary configuration for an electrical assembly and related methods, as described above.

[0076] Clause 1: An electrical assembly comprising: an onboard charger (OBC) configured to receive alternating current from a power source; and a power splitter electrically connected with the OBC and configured to provide an output voltage, wherein the electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

[0077] Clause 2: The electrical assembly of clause 1, wherein: the OBC is configured to receive an input voltage from the power source; and the output voltage is less than the input voltage.

[0078] Clause 3: The electrical assembly of clause 1 or 2, wherein: the OBC is configured to receive up to 240V AC from the power source; and the output voltage is approximately 120V AC.

[0079] Clause 4: The electrical assembly of any of clauses 1 through 3, wherein: the OBC includes: an input port; and a rectifier electrically connected with the input port; the power splitter includes an inverter that is electrically connected with the rectifier; and the input port is removably coupled with the power source.

[0080] Clause 5: The electrical assembly of clause 4, wherein: the rectifier is configured to convert the alternating current received from the power source to direct current to charge the at least one battery; and the inverter is configured to convert the direct current from the rectifier to alternating current to produce the output voltage.

[0081] Clause 6: The electrical assembly of clause 4, wherein the power splitter includes: a first switch and a second switch electrically connected with the inverter; and an electrical outlet electrically connected with the first switch and the second switch.

[0082] Clause 7: The electrical assembly of clause 6, wherein the first switch and the second switch are in a closed configuration when the power splitter is in an activated state.

[0083] Clause 8: The electrical assembly of clause 6, wherein: an external device is removably coupled with the electrical outlet; and the power splitter is configured to provide the output voltage to the external device when the power splitter is in an activated state.

[0084] Clause 9: The electrical assembly of any of clauses 1 through 8, wherein the OBC is configured to electrically connect to an additional power splitter operable to provide an additional output voltage that is different than the output voltage.

[0085] Clause 10: The electrical assembly of clause 9, wherein: the OBC is configured to receive up to 240V AC from the power source; and the additional output voltage is approximately 220V AC.

[0086] Clause 11: The electrical assembly of clause 9, wherein: the OBC includes an input port; the input port is removably coupled with the power source; and the additional power splitter is electrically connected with the input port.

[0087] Clause 12: The electrical assembly of clause 11, wherein: the additional power splitter includes: a first switch and a second switch electrically connected with the input port; and an electrical outlet electrically connected with the first switch and the second switch; and the first switch and the second switch are in a closed configuration when the additional power splitter is in an activated state.

[0088] Clause 13: The electrical assembly of clause 12, wherein: an external device is removably coupled with the electrical outlet; and the additional power splitter is configured to provide the additional output voltage to the external device when the additional power splitter is in an activated state.

[0089] Clause 14: A vehicle comprising: the electrical assembly of any of clauses 1 through 13.

[0090] Clause 15: An electrical assembly comprising: a power splitter configured to electrically connect to an onboard charger (OBC) and provide an output voltage, wherein: the OBC is configured to receive alternating current from a power source, and the electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

[0091] Clause 16: The electrical assembly of clause 15, wherein: the OBC includes: an input port; and a rectifier electrically connected with the input port; the power splitter includes an inverter that is electrically connected with the rectifier; and the input port is removably coupled with the power source.

[0092] Clause 17: The electrical assembly of clause 16, wherein: the rectifier is configured to convert the alternating current received from the power source to direct current to charge the at least one battery; and the inverter is configured to convert the direct current from the rectifier to alternating current to produce the output voltage.

[0093] Clause 18: The electrical assembly of clause 16, wherein: the power splitter includes: a first switch and a second switch electrically connected with the inverter; and an electrical outlet electrically connected with the first switch and the second switch; and the first switch and the second switch are in a closed configuration when the power splitter is in an activated state.

[0094] Clause 19: The electrical assembly of any of clauses 15 through 18, wherein the OBC is configured to electrically connect to an additional power splitter operable to provide an additional output voltage that is different than the output voltage.

[0095] Clause 20: The electrical assembly of clause 19, wherein: the additional power splitter includes: a first switch and a second switch electrically connected with an input port of the OBC; and an electrical outlet electrically connected with the first switch and the second switch; and the first switch and the second switch are in a closed configuration when the additional power splitter is in an activated state.

What is claimed is:

1. An electrical assembly comprising:

an onboard charger (OBC) configured to receive alternating current from a power source; and

a power splitter electrically connected with the OBC and configured to provide an output voltage,

wherein the electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

2. The electrical assembly of claim **1** wherein:

the OBC is configured to receive an input voltage from the power source; and

the output voltage is less than the input voltage.

3. The electrical assembly of claim **1** wherein:

the OBC is configured to receive up to 240V AC from the power source; and

the output voltage is approximately 120V AC.

4. The electrical assembly of claim **1** wherein:

the OBC includes:

an input port; and

a rectifier electrically connected with the input port;

the power splitter includes an inverter that is electrically connected with the rectifier; and

the input port is removably coupled with the power source.

5. The electrical assembly of claim **4** wherein:

the rectifier is configured to convert the alternating current received from the power source to direct current to charge the at least one battery; and

the inverter is configured to convert the direct current from the rectifier to alternating current to produce the output voltage.

6. The electrical assembly of claim **4** wherein the power splitter includes:

a first switch and a second switch electrically connected with the inverter; and

an electrical outlet electrically connected with the first switch and the second switch.

7. The electrical assembly of claim **6** wherein the first switch and the second switch are in a closed configuration when the power splitter is in an activated state.

8. The electrical assembly of claim **6** wherein:
an external device is removably coupled with the electrical outlet; and
the power splitter is configured to provide the output voltage to the external device when the power splitter is in an activated state.

9. The electrical assembly of claim **1** wherein the OBC is configured to electrically connect to an additional power splitter operable to provide an additional output voltage that is different than the output voltage.

10. The electrical assembly of claim **9** wherein:
the OBC is configured to receive up to 240V AC from the power source; and
the additional output voltage is approximately 220V AC.

11. The electrical assembly of claim **9** wherein:
the OBC includes an input port;
the input port is removably coupled with the power source; and
the additional power splitter is electrically connected with the input port.

12. The electrical assembly of claim **11** wherein:
the additional power splitter includes:
a first switch and a second switch electrically connected with the input port; and
an electrical outlet electrically connected with the first switch and the second switch; and
the first switch and the second switch are in a closed configuration when the additional power splitter is in an activated state.

13. The electrical assembly of claim **12** wherein:
an external device is removably coupled with the electrical outlet; and
the additional power splitter is configured to provide the additional output voltage to the external device when the additional power splitter is in an activated state.

14. A vehicle comprising:
the electrical assembly of claim **1**.

15. An electrical assembly comprising:
a power splitter configured to electrically connect to an onboard charger (OBC) and provide an output voltage, wherein:
the OBC is configured to receive alternating current from a power source, and
the electrical assembly is configured to simultaneously charge at least one battery and provide the output voltage.

16. The electrical assembly of claim **15** wherein:
the OBC includes:
an input port; and
a rectifier electrically connected with the input port;
the power splitter includes an inverter that is electrically connected with the rectifier; and
the input port is removably coupled with the power source.

17. The electrical assembly of claim **16** wherein:
the rectifier is configured to convert the alternating current received from the power source to direct current to charge the at least one battery; and
the inverter is configured to convert the direct current from the rectifier to alternating current to produce the output voltage.

18. The electrical assembly of claim **16** wherein:
the power splitter includes:
a first switch and a second switch electrically connected with the inverter; and
an electrical outlet electrically connected with the first switch and the second switch; and
the first switch and the second switch are in a closed configuration when the power splitter is in an activated state.

19. The electrical assembly of claim **15** wherein the OBC is configured to electrically connect to an additional power splitter operable to provide an additional output voltage that is different than the output voltage.

20. The electrical assembly of claim **19** wherein:
the additional power splitter includes:
a first switch and a second switch electrically connected with an input port of the OBC; and
an electrical outlet electrically connected with the first switch and the second switch; and
the first switch and the second switch are in a closed configuration when the additional power splitter is in an activated state.

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