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Inventor(s)	OHMORI; CHIKARA

POWER SUPPLY SYSTEM, ELECTRIC MOVING BODY, CHARGER, AND ENERGIZATION CONFIRMATION METHOD

Abstract

A switch in one power storage pack is turned ON and when all of a plurality of voltages respectively measured by voltage measurement units in all power storage packs including the switch that has been turned ON indicate energization, it is determined that the current state is normal, and when a voltage indicating energization is measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit in a power storage pack other than the one power storage pack including the switch that has been turned ON, it is determined that there is an anomaly in a power line for a power storage pack included in a plurality of power storage packs.

Inventors:	**OHMORI; CHIKARA (Osaka, JP)**
Applicant:	**Panasonic Intellectual Property Management Co., Ltd.** (Osaka, JP)
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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a power supply system including a plurality of power storage packs connected in parallel, an electric moving body, a charger, and an energization confirmation method.

BACKGROUND ART

[0002] In recent years, electric motorcycles (electric scooters), electric bicycles, and the like have become popular. Generally, portable battery packs that are attachable/detachable are used in the electric motorcycles, the electric bicycles, and the like. In order to increase the capacity of power systems, there has been an increasing need for connecting battery packs in parallel. Meanwhile, battery swap type EVs have also been developed. For battery swap type ultra-compact EVs, portable battery packs for use in electric motorcycles, electric bicycles, and the like can be used, and battery packs used by EVs can also be reused for power storage systems.

[0003] In a power supply system in which portable battery packs are mounted on a mounting slot at a vehicle and connected in parallel, there are cases, depending on how the portable battery packs are mounted, where a loose connection of a power line occurs while a signal line is properly connected. In this case, the vehicle determines that all the battery packs are properly connected because the signal line is properly connected, and determines an allowable current value on the basis of the number of connected battery packs including a battery pack loosely connected to the power line. This may cause an electric current exceeding the allowable current value of a battery pack unit to flow to the battery pack unit and cause damage to the battery pack.

[0004] Conceivable methods for detecting whether a battery pack is connected to a system body includes a method in which voltages inside and outside a relay (a relay for switching a power line between energization and de-energization) in a battery pack are measured and when the difference between these voltages is greater than or equal to a predetermined voltage value, it is determined that there is a loose connection (for example, refer to Patent Literature (PTL) 1).

CITATION LIST

Patent Literature

[0005] PTL 1: Unexamined Japanese Patent Publication No. 2017-005939

SUMMARY OF INVENTION

[0006] However, in the aforementioned method, if battery packs with substantially the same voltage differences are connected in parallel, the occurrence of a loose connection does not result in a significant voltage difference between these, meaning that the accuracy of detecting a loose connection of a battery pack is not necessarily high. Furthermore, when there are significant voltage variations between battery packs connected in parallel and an electric current (cross current) flows from a battery pack to another, it requires time to finalize the measured voltage, which may lead to increased detection time.

[0007] Other conceivable methods include a method for physically detecting a battery pack being mounted by referring to opening or closing of a lid and a method for magnetically detecting a battery pack and a mounting slot approaching each other. None of these methods offers reliable energization confirmation of a power line; thus, there remains a risk of erroneous determination.

[0008] The present disclosure is conceived in view of this situation and has an object to provide a technique to accurately confirm the energization state of a power line for each power storage pack in a system in which a plurality of power storage packs are connected in parallel.
[0009] In order to solve the above problem, a power supply system according to one aspect of the present disclosure includes a plurality of power storage packs connected in parallel with respect to a load. Each of the power storage packs includes: a power storage module; a switch that turns ON and OFF energization between the power storage module and the load; a voltage measurement unit that measures a voltage across both ends of the switch and the power storage module connected in series; and a control unit that obtains the voltage measured by the voltage measurement unit and is configured to control the switch. A plurality of control units respectively included in the plurality of power storage packs are connected by a signal line, the switch in one power storage pack is turned ON when a plurality of switches respectively included in the plurality of power storage packs are OFF, when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all of the plurality of power storage packs including the switch that has been turned ON indicate energization, it is determined that a current state is normal, and when a voltage indicating energization is measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit in a power storage pack other than the one power storage pack including the switch that has been turned ON, it is determined that there is an anomaly in a power line for a power storage pack included in the plurality of power storage packs.
[0010] Note that an arbitrary combination of the structural elements described above and those obtained by converting the expressions described in the present disclosure into devices, systems, methods, computer programs, and the like are also effective as embodiments of the present disclosure.
[0011] According to the present disclosure, in a system in which a plurality of power storage packs are connected in parallel, the energization state of a power line for each power storage pack can be accurately confirmed.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0012] FIG. **1** is an example configuration of an electric motor vehicle according to an exemplary embodiment.
[0013] FIG. **2** is a diagram for describing one example of an energization confirmation sequence for battery packs.
[0014] FIG. **3** is a diagram illustrating a table compiling the results of determination of an energization confirmation sequence for battery packs.
[0015] FIG. **4**A is a diagram for describing another specific example of an energization confirmation sequence for battery packs.
[0016] FIG. **4**B is a diagram for describing another specific example of an energization confirmation sequence for battery packs.
[0017] FIG. **5** is an example configuration of a charger according to an exemplary embodiment.
DESCRIPTION OF EMBODIMENTS
[0018] FIG. **1** is an example configuration of electric motor vehicle **1** according to an exemplary embodiment. Hereinafter, the exemplary embodiment assumes that electric motor vehicle **1** is an electric motorcycle. Electric motor vehicle **1** includes power supply system **2**, motor **3**, inverter **4**, vehicle control unit **5**, and notification unit **6** as main structural elements. Power supply system **2** includes a mounting slot in which a plurality of (in FIG. **1**, four) battery packs **10** are mounted. Note that in an application in which there is a demand for increased capacity such as compact EVs,

five or more parallel mounting slots may be provided. In an application in which there is a demand for lighter weight such as electric bicycles, two or three parallel mounting slots may be provided.

[0019] Inverter **4** converts direct-current power supplied from power supply system **2** into alternating-current power and supplies the alternating-current power to motor **3** during power running. During regeneration, the alternating-current power supplied from motor **3** is converted into direct-current power and supplied to power supply system **2**. Motor **3**, which is a three-phase alternating-current motor, rotates according to the alternating-current power supplied from inverter **4** during power running. During regeneration, rotational energy generated as a result of a reduction in speed is converted into alternating-current power and supplied to inverter **4**.

[0020] The direct-current end of inverter **4** is connected to power supply system **2** by power line Lp. On power line Lp, main switch Sm is connected between inverter **4** and merging points of the plurality of battery packs **10**. A relay, a semiconductor switch (for example, a metal oxide semiconductor field effect transistor (MOSFET), or the like can be used as main switch Sm. Vehicle control unit **5** is a vehicle electronic control unit (ECU) that controls entire electric motor vehicle **1**. Vehicle control unit **5** can be configured from a microcontroller and non-volatile memory (for example, electrically erasable programmable read-only memory (EEPROM) or flash memory), for example. Notification unit **6**, which is a user interface, includes at least one of a light-emitting diode (LED) lamp, a meter panel, a display, a speaker, and the like, for example.

[0021] Battery pack **10**, which is portable/swappable battery pack **10** that is attachable/detachable, includes battery module **11**, switch unit **12**, voltage measurement unit **13**, battery control unit **14**, and connector **15**. A user or a maintenance worker mounts battery pack **10** on power supply system **2** by fitting connector **15** of battery pack **10** into the mounting slot of power supply system **2**. In the example illustrated in FIG. **1**, connector **15** includes a positive power supply terminal, a negative power supply terminal, and a signal terminal.

[0022] Battery module **11** includes a plurality of cells E**1** to En connected in series. Note that battery module **11** may be configured by connecting, in series, a plurality of parallel cell blocks including a plurality of cells connected in parallel. As the cells, lithium-ion battery cells, nickel-hydrogen battery cells, lead battery cells, or the like can be used. The following example herein assumes that lithium-ion battery cells (with a nominal voltage of 3.6 V to 3.7 V) are used. The number of cells connected in series is determined according to a drive voltage for motor **3**.

[0023] First switch S**1** is connected between a positive end power supply terminal of connector **15** and a positive end terminal of battery module **11**, and second switch S**2** is connected between a negative end power supply terminal of connector **15** and a negative end terminal of battery module **11**. A precharge circuit is connected in parallel with first switch S**1**. The precharge circuit includes resistor R**1** and third switch S**3** connected in series. The precharge circuit is provided in order to limit an inrush current with resistor R**1** at the start of energization. Relays, semiconductor switches, and the like can be used as first switch S**1** to third switch S**3**. First switch S**1** to third switch S**3** and resistor R**1** are collectively referred to herein as switch unit **12**. Switch unit **12** functions as a switch that turns ON and OFF the energization between battery module **11** and a load (that is inverter **4** and motor **3** in FIG. **1**). Voltage measurement unit **13** measures a voltage across both ends of switch unit **12** and battery module **11** connected in series **12**, and outputs the voltage to battery control unit **14**. Voltage measurement unit **13** includes a voltage-dividing resistor, a differential amplifier, and an A/D converter, for example.

[0024] Battery control unit **14** controls entire battery pack **10**. Battery control unit **14** can be configured from a microcontroller and non-volatile memory, for example. The plurality of battery control units **14** respectively included in the plurality of battery packs **10** and vehicle control unit **5** are connected by signal line Ls. The plurality of battery control units **14** and vehicle control unit **5** can perform serial communication with each other by using a controller area network (CAN) protocol, for example.

[0025] Battery control unit **14** obtains a voltage of battery module **11** including switch unit **12** that has been measured by voltage measurement unit **13**. Battery control unit **14** controls switch unit **12**. Upon powering on electric motor vehicle **1**, for example, battery control unit **14** turns ON third switch S**3** first while controlling first switch S**1** and second switch S**2** to the OFF state. In this state, an electric current flows from battery module **11** toward the vehicle via resistor R**1**. When a predetermined time has passed since battery control unit **14** turned ON third switch S**3**, battery control unit **14** turns ON first switch S**1** and second switch S**2** and turns OFF third switch S**3**. This enables a soft start.

[0026] FIG. **2** is a diagram for describing one example of an energization confirmation sequence for battery packs **10**. The energization confirmation sequence may be performed every time electric motor vehicle **1** is powered on or may be performed when battery pack **10** is mounted in one of the mounting slots of power supply system **2**.

[0027] In the state where the plurality of switch units **12** respectively included in the plurality of battery packs **10** are OFF, battery control unit **14** in one battery pack **10** turns ON switch unit **12** included in said battery pack **10**. FIG. **2** illustrates an example where first battery control unit **14***a* in first battery pack **10***a* turns ON first switch unit **12***a*.

[0028] When a user of electric motor vehicle **1** performs an operation to power on electric motor vehicle **1**, vehicle control unit **5** transmits an energization confirmation mode signal including a turn-on instruction for first switch unit **12***a* to first battery control unit **14***a* in first battery pack **10***a* via signal line Ls, and transmits energization confirmation mode signals including turn-off instructions for second switch unit **12***b* to fourth switch unit **12***d* to second battery control unit **14***b* to fourth battery control unit **14***d* in second battery pack **10***b* to fourth battery pack **10***d*. A channel for battery pack **10** to which vehicle control unit **5** transmits the turn-on signal may be always the same or may be regularly changed.

[0029] Furthermore, as triggered by battery pack **10** being detected to have been mounted in the mounting slot of power supply system **2**, vehicle control unit **5** may transmit the energization confirmation mode signal including the turn-on instruction to first battery control unit **14***a* in first battery pack **10***a*, and transmit the energization confirmation mode signals including the turn-off instructions to second battery control unit **14***b* to fourth battery control unit **14***d* in second battery pack **10***b* to fourth battery pack **10***d*.

[0030] When battery pack **10** is removed and mounted during activation of electric motor vehicle **1**, vehicle control unit **5** can detect, from disconnection and energization of signal line Ls, whether battery pack **10** has been removed and mounted. When battery pack **10** is removed and mounted during shut-down of electric motor vehicle **1**, vehicle control unit **5** can detect, on the basis of the battery pack ID and the state of charge (SOC) received from battery pack **10** mounted, whether battery pack **10** has been removed and mounted during shut-down. For example, when the battery pack ID before shut-down and the battery pack ID after the shut-down are different, vehicle control unit **5** determines that battery pack **10** has been replaced with another one. Furthermore, for example, when the battery pack ID is the same and the SOC before shut-down is greater than the SOC after the shut-down, vehicle control unit **5** determines that battery pack **10** has been removed once for charging and then mounted.

[0031] At the time when a user or a maintenance worker attaches connector **15** of battery pack **10** to the mounting slot, there are cases where the signal terminal inside connector **15** is properly connected to the signal terminal of the mounting slot, but at least one of the positive and negative power supply terminals inside connector **15** is loosely connected to the corresponding power terminal of the mounting slot. A loose connection of power line Lp occurs when a user or a maintenance worker fails to mount battery pack **10** at the exact fitting position on the mounting slot. The loose connection also occurs due to breakage, corrosion, wear, etc., of the power supply terminal.

[0032] When receiving the energization confirmation mode signal including the turn-on instruction from vehicle control unit **5**, first battery control unit **14***a* in first battery pack **10***a* turns ON first switch unit **12***a* and after first switch unit **12***a* is turned ON, obtains a voltage from first voltage measurement unit **13***a*. First battery control unit **14***a* transmits the obtained voltage to vehicle control unit **5** via signal line Ls.

[0033] When receiving the energization confirmation mode signal including the turn-off instruction from vehicle control unit **5**, second battery control unit **14***b* to fourth battery control unit **14***d* in second battery pack **10***b* to fourth battery pack **10***d* confirm that second switch unit **12***b* to fourth switch unit **12***d* are OFF and after the confirmation, obtain voltages from second voltage measurement unit **13***b* to fourth voltage measurement unit **13***d*. Second battery control unit **14***b* to fourth battery control unit **14***d* transmit the obtained voltages to vehicle control unit **5** via signal line Ls.

[0034] FIG. **3** is a diagram illustrating a table compiling the results of determination of the energization confirmation sequence for battery packs **10**. When one of first switch unit **12***a* to fourth switch unit **12***d* in a predetermined battery pack among first battery pack **10***a* to fourth battery pack **10***d* is turned ON and all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* in first battery pack **10***a* to fourth battery pack **10***d* indicate energization, vehicle control unit **5** determines that the energization of all battery packs **10***a* to **10***d* is normal (pattern 1).

[0035] When all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* in first battery pack **10***a* to fourth battery pack **10***d* indicate de-energization (0 V), vehicle control unit **5** determines that there is an energization anomaly in first battery pack **10***a* (pattern 2). In this case, it is considered that there is an anomaly such as disconnection of power line Lp in first battery pack **10***a* or an open-circuit fault of first switch unit **12***a*.

[0036] Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of first battery pack **10***a*. Vehicle control unit **5** turns ON an LED lamp for remounting notifications, for example. For example, a plurality of LED lamps corresponding to the number and positions of mounting slots for battery packs may be provided so that vehicle control unit **5** turns ON an LED lamp corresponding to a mounting slot in which remounting of the battery pack is required. Vehicle control unit **5** may, for example, cause the display to show a text message that reads “please remount the battery pack at the far left end.” Vehicle control unit **5** may, for example, cause the speaker to output a voice message that reads “please remount the battery pack at the far left end,” or output an alert sound. Other possible means of notifications for users includes the flashing cycle, etc., of an LED and a display on each battery pack **10** that shows an error code.

[0037] When a user or a maintenance worker remounts first battery pack **10***a* in the mounting slot, vehicle control unit **5** performs the above-described energization confirmation sequence again. When the voltages measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* do not change (when pattern 2 remains unchanged), the determination of anomalous energization in first battery pack **10***a* is finalized. Vehicle control unit **5** provides, from notification unit **6**, a message that prompts repair or replacement of first battery pack **10***a*. Furthermore, vehicle control unit **5** reduces the upper limit value of an electric current that is output from inverter **4** to motor **3** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*. In the example illustrated in FIG. **2**, vehicle control unit **5** changes the upper limit value of the electric current that is output from inverter **4** to motor **3** to three-fourths of the upper limit value applied when the energization of all four battery packs **10** in parallel is normal. Moreover, vehicle control unit **5** also reduces the upper limit value of an electric current that is regenerated from motor **3** to inverter **4** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*.

[0038] When the voltage measured by first voltage measurement unit **13***a* in first battery pack **10***a* indicates energization and the plurality of voltages measured by second voltage measurement unit **13***b* to fourth voltage measurement unit **13***d* in second battery pack **10***b* to fourth battery pack **10***d* indicate de-energization, vehicle control unit **5** determines that there is a loose connection between first battery pack **10***a* and power supply system **2** (pattern 3). In this case, it is considered that at least one of the positive and negative power supply terminals inside connector **15** of first battery pack **10***a* is loosely connected to the corresponding power supply terminal of the mounting slot of power supply system **2**. The loose connection between battery pack **10** and power supply system **2** and the energization anomaly in battery pack **10** are collectively referred to herein as an anomaly in power line Lp for battery pack **10**.

[0039] Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of first battery pack **10***a*. When a user or a maintenance worker remounts first battery pack **10***a* in the mounting slot, vehicle control unit **5** performs the above-described energization confirmation sequence again. When the cause is misaligned fitting of connector **15** and as a result of remounting, the misaligned fitting is solved so that an energizing path is properly formed, all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* change to energization (pattern 1).

[0040] When there is irreversible damage such as breakage of a power supply terminal, the voltages measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* do not change and pattern 3 remains unchanged. When the voltages measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* do not change (when pattern 2 remains unchanged), vehicle control unit **5** determines that there is an irreversible loose connection of first battery pack **10***a*. Vehicle control unit **5** provides, from notification unit **6**, a message that prompts repair or replacement of first battery pack **10***a*. Furthermore, vehicle control unit **5** reduces the upper limit value of an electric current that is output from inverter **4** to motor **3** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*. Moreover, vehicle control unit **5** also reduces the upper limit value of an electric current that is regenerated from motor **3** to inverter **4** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*.

[0041] When the voltages respectively measured by first voltage measurement unit **13***a*, third voltage measurement unit **13***c*, and fourth voltage measurement unit **13***d* in first battery pack **10***a*, third battery pack **10***c*, and fourth battery pack **10***d* indicate energization and the voltage measured by second voltage measurement unit **13***b* in second battery pack **10***b* indicates de-energization, vehicle control unit **5** determines that there is an anomaly in power line Lp for second battery pack **10***b* (pattern 4). Whether the disconnected area is inside second battery pack **10***b* or at the connector part cannot be identified at this stage.

[0042] Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of second battery pack **10***b*. When a user or a maintenance worker remounts second battery pack **10***b* in the mounting slot, vehicle control unit **5** performs the above-described energization confirmation sequence again. When the cause is misaligned fitting of connector **15** and as a result of remounting, the misaligned fitting is solved, all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* change to energization (pattern 1).

[0043] When the cause is another irreversible anomaly in power line Lp, the voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* do not change and pattern 4 remains unchanged. When the voltages measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* do not change (when pattern 4 remains unchanged), vehicle control unit **5** finalizes the determination of anomaly occurrence in power line Lp for second battery pack **10***b*. Vehicle control unit **5** provides, from notification unit **6**, a message that prompts repair or replacement of second battery pack **10***b*. Furthermore, vehicle control unit **5** reduces the upper limit value of an electric current that is output from inverter **4** to motor **3** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*. Moreover, vehicle control unit **5** also reduces the upper limit value of an electric current that is regenerated from motor **3** to inverter **4** to an upper limit value corresponding to the number of battery packs in parallel, excluding first battery pack **10***a*.

[0044] Note that vehicle control unit **5** may transmit the energization confirmation mode signal including the turn-on instruction to second battery control unit **14***b* in second battery pack **10***b*, transmit the energization confirmation mode signals including the turn-off instructions to first battery control unit **14***a*, third battery control unit **14***c*, and fourth battery control unit **14***d* in first battery pack **10***a*, third battery pack **10***c*, and fourth battery pack **10***d*, and perform the energization confirmation sequence again. When the voltage measured by second voltage measurement unit **13***b* indicates energization, vehicle control unit **5** determines that there is an irreversible loose connection between second battery pack **10***b* and power supply system **2**, and when the voltage measured by second voltage measurement unit **13***b* indicates de-energization, vehicle control unit **5** determines that there is an energization anomaly in second battery pack **10***b*.

[0045] When the voltages respectively measured by first voltage measurement unit **13***a*, second voltage measurement unit **13***b*, and fourth voltage measurement unit **13***d* in first battery pack **10***a*, second battery pack **10***b*, and fourth battery pack **10***d* indicate energization and the voltage measured by third voltage measurement unit **13***c* in third battery pack **10***c* indicates de-energization, vehicle control unit **5** determines that there is an anomaly in power line Lp for third battery pack **10***c* (pattern 5). The subsequent processes are substantially the same as the processes in pattern 4 with second battery pack **10***b* replaced by third battery pack **10***c*.

[0046] When the voltages respectively measured by first voltage measurement unit **13***a* to third voltage measurement unit **13***c* in first battery pack **10***a* to third battery pack **10***c* indicate energization and the voltage measured by fourth voltage measurement unit **13***c* in fourth battery pack **10***d* indicates de-energization, vehicle control unit **5** determines that there is an anomaly in power line Lp for fourth battery pack **10***d* (pattern 6). The subsequent processes are substantially the same as the processes in pattern 4 with second battery pack **10***b* replaced by fourth battery pack **10***d*.

[0047] The example illustrated in FIG. **2** shows a situation where there is an irreversible loose connection between first battery pack **10***a* and power supply system **2**; when a user or a maintenance worker remounts first battery pack **10***a* in the mounting slot, the loose connection between first battery pack **10***a* and power supply system **2** is solved.

[0048] The example illustrated in FIG. **2**, which explains about power supply system **2** for four battery packs **10** in parallel, is adaptable for three or more battery packs **10** in parallel. When there are two battery packs **10** in parallel, namely, first battery pack **10***a* and second battery pack **10***b*, turning ON switch unit **12** in one of battery packs **10** does not enable finalization of the determination of pattern 3 and pattern 4 indicated in FIG. **3**. Therefore, vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of first battery pack **10***a* and second battery pack **10***b*.

[0049] In a situation where the determination of pattern 3 and pattern 4 cannot be finalized, similar to the example illustrated in FIG. **2**, when a user or a maintenance worker remounts first battery pack **10***a* and second battery pack **10***b* in the mounting slots, vehicle control unit **5** performs the energization confirmation sequence again and when the remounting solves the misaligned fitting of first battery pack **10***a* and second battery pack **10***b* so that energizing paths are formed, all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* and second voltage measurement unit **13***b* change to energization (pattern 1), and both first battery pack **10***a* and second battery pack **10***b* are determined as being normal.

[0050] In a situation where the determination of pattern 3 and pattern 4 cannot be finalized, switch **12***b* in second battery pack **10***b*, which is the other of the battery packs that is different from first power storage pack **10***a* which is one of the battery packs that includes switch **12***a* that has been turned ON, switches to ON and voltage measurement unit **13***b* in second power storage pack **10***b* measures a voltage and when the voltage measured by voltage measurement unit **13***b* in second power storage pack **10***b* indicates energization, it may be determined that there is an anomaly in power line Lp for first power storage pack **10***a*, and when the voltage measured by voltage measurement unit **13***b* in second power storage pack **10***b* indicates de-energization, it may be determined that there is an anomaly in power line Lp for second power storage pack **10***b*.

[0051] FIGS. **4**A, **4**B are diagrams for describing other specific examples of the energization confirmation sequence for battery packs **10**. The example illustrated in FIG. **4**A shows a situation where there are irreversible loose connections at two locations that are between first battery pack **10***a* and power supply system **2** and between second battery pack **10***b* and power supply system **2**.

[0052] Vehicle control unit **5** transmits the energization confirmation mode signal including the turn-on instruction to first battery control unit **14***a* in first battery pack **10***a*, transmits the energization confirmation mode signals including the turn-off instructions to second battery control unit **14***a* to fourth battery control unit **14***d* in second battery pack **10***b* to fourth battery pack **10***d*, and performs the energization confirmation sequence. In the state illustrated in FIG. **4**A, the result is as follows: the voltage measured by first voltage measurement unit **13***a* in first battery pack **10***a* indicates energization and the plurality of voltages respectively measured by second voltage measurement unit **13***b* to fourth voltage measurement unit **13***d* in second battery pack **10***b* to fourth battery pack **10***d* indicate de-energization, and vehicle control unit **5** determines that there is a loose connection between first battery pack **10***a* and power supply system **2** (pattern 3).

[0053] Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of first battery pack **10***a*. When a user or a maintenance worker remounts first battery pack **10***a* in the mounting slot, the loose connection between first battery pack **10***a* and power supply system **2** is solved, as illustrated in FIG. **4**B.

[0054] Vehicle control unit **5** performs the above-described energization confirmation sequence again. The result is as follows: the voltages respectively measured by first voltage measurement unit **13***a*, third voltage measurement unit **13***c*, and fourth voltage measurement unit **13***d* in first battery pack **10***a*, third battery pack **10***c*, and fourth battery pack **10***d* indicate energization and the voltage measured by second voltage measurement unit **13***b* in second battery pack **10***b* indicates de-energization, and vehicle control unit **5** determines that there is an anomaly in power line Lp for second battery pack **10***b* (pattern 4).

[0055] Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of second battery pack **10***b*. When a user or a maintenance worker remounts second battery pack **10***b* in the mounting slot, the loose connection between second battery pack **10***b* and power supply system **2** is solved.

[0056] Vehicle control unit **5** performs the above-described energization confirmation sequence again. The result is as follows: all of the plurality of voltages respectively measured by first voltage measurement unit **13***a* to fourth voltage measurement unit **13***d* in first battery pack **10***a* to fourth battery pack **10***d* indicate energization, and vehicle control unit **5** determines that the energization of all battery packs **10***a* to **10***d* is normal (pattern 1).

[0057] Note that at the stage at which pattern 3 described above is detected, vehicle control unit **5** may skip issuing a message that prompts remounting and perform the energization confirmation sequence in which another switch unit **12** is turned ON. By performing more than one time the energization confirmation sequence in which different switch unit **12** is turned ON, vehicle control unit **5** can identify all battery packs **10** with an anomaly in power line Lp among the plurality of battery packs **10** mounted on power supply system **2**. Vehicle control unit **5** provides, from notification unit **6**, a message that prompts remounting of all battery packs **10** with an anomaly in power line Lp.

[0058] The foregoing has described an example where vehicle control unit **5** transmits the energization confirmation mode signals to first battery control unit **14***a* to fourth battery control unit **14***d* in first battery pack **10***a* to fourth battery pack **10***d*. In this regard, when a user or a maintenance worker mounts battery pack **10** in the mounting slot of power supply system **2**, battery control unit **14** in said battery pack **10** (hereinafter referred to as mounted battery pack **10**) may turn ON switch unit **12** in mounted battery pack **10** and transmit the energization confirmation mode signals including the turn-off instructions to battery control units **14** in other battery packs **10** connected by signal line Ls.

[0059] When receiving the energization confirmation mode signals including the turn-off instructions from battery control unit **14** in mounted battery pack **10**, battery control units **14** in other battery packs **10** confirm that switch units **12** are OFF and after the confirmation, obtain voltages from voltage measurement units **13**. Battery control units **14** in other battery packs **10** transmit the obtained voltages to battery control unit **14** in mounted battery pack **10** via signal line Ls.

[0060] On the basis of the plurality of voltages respectively measured by voltage measurement units **13** in the plurality of battery packs **10** connected to power supply system **2**, battery control unit **14** in mounted battery pack **10** determines which one of patterns 1 to 3 described above corresponds to the current situation. When pattern 2 or 3 described above corresponds to the current situation, battery control unit **14** in mounted battery pack **10** transmits, to vehicle control unit **5**, a request signal for requesting notification unit **6** to provide a message that prompts remounting of mounted battery pack **10**. Note that when mounted battery pack **10** itself is equipped with an indicator lamp for remounting notifications, battery control unit **14** in mounted battery pack **10** may turn ON said indicator lamp.

[0061] Note that power supply system **2** may include a fixed master battery control unit that is physically independent of battery pack **10**. The master battery control unit manages, via signal line Ls, battery pack **10** mounted in the mounting slot. The master battery control unit can perform the above-described energization confirmation sequence.

[0062] The above-described energization confirmation sequence can be applied to a charger capable of charging the plurality of battery packs **10** in parallel. FIG. **5** is an example configuration of charger **1***a* according to an exemplary embodiment. Charger **1***a* includes charging stand **2***a*, inverter **4**, charging control unit **5***a*, and notification unit **6**. Charging stand **2***a* includes a plurality of slots in which the plurality of battery packs **10** can be stored in the state of being connected in parallel.

[0063] The alternating-current end of inverter **4** is connected to commercial power system **7**; inverter **4** can convert, into direct-current power, alternating-current power supplied from commercial power system **7**, to charge at least one battery pack **10** mounted on charging stand **2***a*. Inverter **4** may be configured to include a full-wave rectifier, a filter, and a DC/DC converter.

[0064] When detecting that battery pack **10** has been mounted in one of charging slots of charging stand **2***a*, charging control unit **5***a* transmits an energization confirmation mode signal including a turn-on instruction for first switch unit **12***a* to first battery control unit **14***a* in first battery pack **10***a* via signal line Ls, and transmits energization confirmation mode signals including turn-off instructions for second switch unit **12***b* to fourth switch unit **12***d* to second battery control unit **14***b* to fourth battery control unit **14***d* in second battery pack **10***b* to fourth battery pack **10***d*. The subsequent processes are substantially the same as those performed for electric motor vehicle **1** described above.

[0065] As described above, the energization state of power line Lp for each battery pack **10** mounted on power supply system **2** or charging stand **2***a* can be accurately confirmed according to the present exemplary embodiment. In the present exemplary embodiment, energization and de-energization are determined according to whether there is a voltage, and thus this detection method is reliable as compared to when a physical or magnetic sensor is used. Furthermore, in the present exemplary embodiment, even when there are voltage variations between the plurality of battery packs **10** connected in parallel, the number of switch units **12** to turn ON is one and therefore, no cross current is generated. Consequently, unnecessary power consumption due to a cross current is eliminated. Furthermore, there is no need to wait until the cross current ends in order to finalize the measured voltage value, meaning that the energization state can always be confirmed in the same measurement time. The present disclosure has been described thus far based on the exemplary embodiment. The exemplary embodiment is merely an example; a person having ordinary skill in the art will readily appreciate that various variations are possible as a combination of these structural elements and these processes and that these variations are also included in the scope of the present disclosure.

[0066] The above exemplary embodiment has described an example in which battery pack **10** incorporating battery module **11** is used. In this regard, a capacitor pack incorporating a capacitor that includes an electric double layer capacitor cell, a lithium ion capacitor cell, or the like may be used. The battery pack and the capacitor pack are collectively referred herein to as a power storage pack.

[0067] The above exemplary embodiment assumes that the power storage pack is a portable/swappable power storage pack that is attachable/detachable. In this regard, the energization confirmation method according to the present disclosure can be applied to a power storage pack (to be charged with a charging cable) fixed to electric motor vehicle **1**. For example, every time a user performs an operation to power ON electric motor vehicle **1**, vehicle control unit **5** performs the above-described energization confirmation sequence. Vehicle control unit **5** can detect an anomaly in power line Lp for one of the plurality of power storage packs connected in parallel. In this example, when an anomaly is detected, vehicle control unit **5** does not provide a message that prompts remounting, but provides a message that prompts repair or replacement.

[0068] Power supply system **2** according to the exemplary embodiment that includes a plurality of power storage packs connected in parallel can also be used for an electric moving body different from electric motor vehicle **1**. Examples of the electric moving body include electric boats or ships. For example, power supply system **2** according to the exemplary embodiment can be mounted on a water bus, a water taxi, or the like. Other examples of the electric moving body include electric trains. For example, instead of diesel multiple units used on non-electrified routes, an electric train incorporating power supply system **2** according to the exemplary embodiment can be used. Examples of the electric moving body also include electric aerial vehicles. Electric aerial vehicles include a multirotor (a drone). The multirotor also includes what is called a flying car. Furthermore, the plurality of power storage packs according to the exemplary embodiment that are connected in parallel can also constitute a stationary power storage system.

[0069] Note that the exemplary embodiment may be specified according to the following items.

[Item 1]

[0070] A power supply system (**2**) including: [0071] a plurality of power storage packs (**10**) connected in parallel with respect to a load (**3**, **4**), wherein each of the plurality of power storage packs (**10**) includes: [0072] a power storage module (**11**); [0073] a switch (**12**) that turns ON and OFF energization between the power storage module (**11**) and the load (**3**, **4**); [0074] a voltage measurement unit (**13**) that measures a voltage across both ends of the switch (**12**) and the power storage module (**11**) connected in series; and [0075] a control unit (**14**) that obtains the voltage measured by the voltage measurement unit (**13**) and is configured to control the switch (**12**), [0076] a plurality of control units (**14**) respectively included in the plurality of power storage packs (**10**) are connected by a signal line (Ls), [0077] the switch (**12**) in one power storage pack (**10**) is turned ON when a plurality of switches (**12**) respectively included in the plurality of power storage packs (**10**) are OFF, [0078] when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units (**13**) in all of the plurality of power storage packs (**10**) including the switch (**12**) that has been turned ON indicate energization, it is determined that a current state is normal, and [0079] when a voltage indicating energization is measured by the voltage measurement unit (**13**) in the one power storage pack (**10**) including the switch (**12**) that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit (**13**) in a power storage pack (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has

been turned ON, it is determined that there is an anomaly in a power line (Lp) for a power storage pack (**10**) included in the plurality of power storage packs (**10**).
[0080] Thus, the energization state of the power line (Lp) for each power storage pack (**10**) connected to the power supply system (**2**) can be accurately confirmed.
[Item 2]
[0081] The power supply system (**2**) according to item 1, wherein [0082] when the plurality of power storage packs (**10**) are three or more power storage packs, [0083] when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units (**13**) in all power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicate de-energization, it is determined that there is an anomaly in a power line (Lp) for the one power storage pack (**10**) including the switch (**12**) that has been turned ON, [0084] when a voltage indicating de-energization is included in the plurality of voltages respectively measured by the plurality of voltage measurement units (**13**) in all the power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON, it is determined that there is an anomaly in a power line (Lp) for a power storage pack (**10**) in which the voltage indicating the de-energization has been measured, and [0085] when the plurality of power storage packs (**10**) are two power storage packs (**10**), [0086] it is determined that there is an anomaly in a power line (Lp) for at least one of the two power storage packs (**10**).
[0087] Thus, the energization state of the power line (Lp) for each power storage pack (**10**) connected to the power supply system (**2**) can be accurately confirmed.
[Item 3]
[0088] The power supply system (**2**) according to item 1, wherein [0089] each of the plurality of power storage packs (**10**) is attachable to and detachable from the power supply system (**2**), and [0090] when the voltage measured by the voltage measurement unit (**13**) in the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicates energization and all of a plurality of voltages respectively measured by a plurality of the voltage measurement units (**13**) in all power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicate de-energization, it is determined that there is a loose connection between the one power storage pack (**10**) including the switch (**12**) that has been turned ON and the power supply system (**2**).
[0091] Thus, the energization state of the power line (Lp) for each power storage pack (**10**) mounted on the power supply system (**2**) can be accurately confirmed.
[Item 4]
[0092] The power supply system (**2**) according to item 1 or 3, wherein [0093] a user interface provides a message that prompts remounting of the power storage pack (**10**) determined to include the anomaly in the power line (Lp).
[0094] Thus, it is possible to provide an opportunity to solve the loose connection by remounting.
[Item 5]
[0095] The power supply system (**2**) according to item 4, wherein [0096] after the power storage pack (**10**) determined to include the anomaly in the power line (Lp) is remounted, the switch (**12**) in the one power storage pack (**10**) is turned ON.
[0097] Thus, it is possible to distinguish whether the anomaly is a temporary loose connection or an irreversible anomaly in the power line (Lp).
[Item 6]
[0098] An electric moving body (**1**) including: [0099] a motor (**3**); [0100] a drive circuit (**4**) that drives the motor (**3**); and [0101] the power supply system (**2**) according to any one of items 1 to 5 that includes a plurality of power storage packs (**10**) connected in parallel with respect to the drive circuit (**4**).
[0102] Thus, it is possible to implement the electric moving body (**1**) that includes the function of enabling accurate confirmation of the energization state of the power line (Lp) for each power

storage pack (**10**) connected to the power supply system (**2**).
[Item 7]
[0103] A charger (**1***a*) including: [0104] a charging stand (**2***a*) configured to charge a plurality of power storage packs (**1**) connected in parallel, each of the plurality of power storage packs (**10**) being attachable to and detachable from the charging stand (**2***a*), wherein [0105] each of the plurality of power storage packs (**10**) includes: [0106] a power storage module (**11**); [0107] a switch (**12**) that turns ON and OFF energization between the power storage module (**11**) and the charger (**11**); [0108] a voltage measurement unit (**13**) that measures a voltage across both ends of the switch (**12**) and the power storage module (**11**) connected in series; and [0109] a control unit (**14**) that obtains the voltage measured by the voltage measurement unit (**13**) and is configured to control the switch (**12**), [0110] a plurality of control units (**14**) respectively included in the plurality of power storage packs (**10**) are connected by a signal line (Ls), [0111] the switch (**12**) in one power storage pack (**10**) is turned ON when a plurality of switches (**12**) respectively included in the plurality of power storage packs (**10**) are OFF, [0112] when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units (**13**) in all of the plurality of power storage packs (**10**) including the switch (**12**) that has been turned ON indicate energization, it is determined that a current state is normal, [0113] when the voltage measured by the voltage measurement unit (**13**) in the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicates de-energization and all of a plurality of voltages respectively measured by a plurality of the voltage measurement units (**13**) in all power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicate de-energization, it is determined that there is an energization anomaly in the one power storage pack (**10**) including the switch (**12**) that has been turned ON, [0114] when the voltage measured by the voltage measurement unit (**13**) in the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicates energization and all of the plurality of voltages respectively measured by the plurality of voltage measurement units (**13**) in all the power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON indicate de-energization, it is determined that there is a loose connection between the one power storage pack (**10**) including the switch (**12**) that has been turned ON and the charger, and [0115] when a voltage indicating de-energization is included in the plurality of voltages respectively measured by the plurality of voltage measurement units (**13**) in all the power storage packs (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON, it is determined that there is an anomaly in a power line (Lp) for a power storage pack (**10**) in which the voltage indicating the de-energization has been measured.
[0116] Thus, it is possible to implement the charger (**2***a*) that includes the function of enabling accurate confirmation of the energization state of the power line (Lp) for each power storage pack (**10**) mounted on the charging stand (**2***a*).
[Item 8]
[0117] An energization confirmation method to be performed on a plurality of power storage packs (**10**) connected in parallel with respect to a load (**3**, **4**), wherein [0118] each of the plurality of power storage packs (**10**) includes: [0119] a power storage module (**11**); [0120] a switch (**12**) that turns ON and OFF energization between the power storage module (**11**) and the load (**3**, **4**); [0121] a voltage measurement unit (**13**) that measures a voltage across both ends of the switch (**12**) and the power storage module (**11**) connected in series; and [0122] a control unit (**14**) that obtains the voltage measured by the voltage measurement unit (**13**) and is configured to control the switch (**12**), [0123] a plurality of control units (**14**) respectively included in the plurality of power storage packs (**10**) are connected by a signal line (Ls), and [0124] the energization confirmation method includes: [0125] turning ON the switch (**12**) in one power storage pack (**10**) when a plurality of switches (**12**) respectively included in the plurality of power storage packs (**10**) are OFF; [0126] when all of a plurality of voltages respectively measured by a plurality of the voltage measurement

units (**13**) in all of the plurality of power storage packs (**10**) including the switch (**12**) that has been turned ON indicate energization, determining that a current state is normal; and [0127] when a voltage indicating energization is measured by the voltage measurement unit (**13**) in the one power storage pack (**10**) including the switch (**12**) that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit (**13**) in a power storage pack (**10**) other than the one power storage pack (**10**) including the switch (**12**) that has been turned ON, determining that there is an anomaly in a power line (Lp) for a power storage pack (**10**) included in the plurality of power storage packs (**10**).
[0128] Thus, the energization state of the power line (Lp) for each power storage pack (**10**) connected in parallel can be accurately confirmed.
REFERENCE SIGNS LIST
[0129] **1** electric motor vehicle [0130] **1***a* charger [0131] **2** power supply system [0132] **2***a* charging stand [0133] **3** motor [0134] **4** inverter [0135] **5** vehicle control unit [0136] **5***a* charging control unit [0137] **6** notification unit [0138] **7** commercial power system [0139] **10** battery pack [0140] **11** battery module [0141] **12** switch unit [0142] **13** voltage measurement unit [0143] **14** battery control unit [0144] **15** connector [0145] S**1**-S**3** switch [0146] Sm main switch [0147] E**1**-En cell [0148] R**1** resistor [0149] Lp power line [0150] Ls signal line

Claims

1. A power supply system comprising: a plurality of power storage packs connected in parallel with respect to a load, wherein each of the plurality of power storage packs includes: a power storage module; the power storage module and the load are connected by a power line; a switch that turns ON and OFF energization between the power storage module and the load; a voltage measurement unit that measures a voltage across both ends of the switch and the power storage module connected in series; and a control unit that obtains the voltage measured by the voltage measurement unit and is configured to control the switch, a plurality of control units respectively included in the plurality of power storage packs are connected by a signal line, the switch in one power storage pack is turned ON when a plurality of switches respectively included in the plurality of power storage packs are OFF, when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all of the plurality of power storage packs including the switch that has been turned ON indicate energization, the control unit determines that an energization state is normal a power line, and when a voltage indicating energization is measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit in a power storage pack other than the one power storage pack including the switch that has been turned ON, the control unit determines that there is an anomaly in the power line for a power storage pack included in the plurality of power storage packs.
2. The power supply system according to claim 1, wherein when the plurality of power storage packs are three or more power storage packs, when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all power storage packs other than the one power storage pack including the switch that has been turned ON indicate de-energization, the control unit determines that there is an anomaly in the power line for the one power storage pack including the switch that has been turned ON, when a voltage indicating de-energization is included in the plurality of voltages respectively measured by the plurality of voltage measurement units in all the power storage packs other than the one power storage pack including the switch that has been turned ON, the control unit determines that there is an anomaly in the power line for a power storage pack in which the voltage indicating the de-energization has been measured, and when the plurality of power storage packs are two power storage packs, the control unit determines that there is an anomaly in the power line for at least one of the two power storage packs.

3. The power supply system according to claim 1, wherein each of the plurality of power storage packs is attachable to and detachable from the power supply system, and when the voltage measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON indicates energization and all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all power storage packs other than the one power storage pack including the switch that has been turned ON indicate de-energization, the control unit determines that there is a loose connection between the one power storage pack including the switch that has been turned ON and the power supply system.
4. The power supply system according to claim 1-3, wherein a user interface provides a message that prompts remounting of the power storage pack determined to include the anomaly in the power line.
5. The power supply system according to claim 4, wherein after the power storage pack determined to include the anomaly in the power line is remounted, the switch in the one power storage pack is turned ON.
6. An electric moving body comprising: a motor; a drive circuit that drives the motor; and the power supply system according to claim 1 that includes a plurality of power storage packs connected in parallel with respect to the drive circuit.
7. A charger comprising: a charging stand configured to charge a plurality of power storage packs connected in parallel, each of the plurality of power storage packs being attachable to and detachable from the charging stand, wherein each of the plurality of power storage packs includes: a power storage module; the power storage module and the load are connected by a power line; a switch that turns ON and OFF energization between the power storage module and the charger; a voltage measurement unit that measures a voltage across both ends of the switch and the power storage module connected in series; and a control unit that obtains the voltage measured by the voltage measurement unit and is configured to control the switch, a plurality of control units respectively included in the plurality of power storage packs are connected by a signal line, the switch in one power storage pack is turned ON when a plurality of switches respectively included in the plurality of power storage packs are OFF, when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all of the plurality of power storage packs including the switch that has been turned ON indicate energization, the control unit determines that an energization state is normal in a power line, when the voltage measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON indicates de-energization and all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all power storage packs other than the one power storage pack including the switch that has been turned ON indicate de-energization, the control unit determines that there is an energization anomaly in the one power storage pack including the switch that has been turned ON, when the voltage measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON indicates energization and all of the plurality of voltages respectively measured by the plurality of voltage measurement units in all the power storage packs other than the one power storage pack including the switch that has been turned ON indicate de-energization, the control unit determines that there is a loose connection between the one power storage pack including the switch that has been turned ON and the charger, and when a voltage indicating de-energization is included in the plurality of voltages respectively measured by the plurality of voltage measurement units in all the power storage packs other than the one power storage pack including the switch that has been turned ON, the control unit determines that there is an anomaly in the power line for a power storage pack in which the voltage indicating the de-energization has been measured.
8. An energization confirmation method to be performed on a plurality of power storage packs connected in parallel with respect to a load, wherein each of the plurality of power storage packs includes: a power storage module; a switch that turns ON and OFF energization between the power

storage module and the load; a voltage measurement unit that measures a voltage across both ends of the switch and the power storage module connected in series; and a control unit that obtains the voltage measured by the voltage measurement unit and is configured to control the switch, a plurality of control units respectively included in the plurality of power storage packs are connected by a signal line, and the energization confirmation method comprises: turning ON the switch in one power storage pack when a plurality of switches respectively included in the plurality of power storage packs are OFF; when all of a plurality of voltages respectively measured by a plurality of the voltage measurement units in all of the plurality of power storage packs including the switch that has been turned ON indicate energization, the control unit determines that an energization state is normal in a power line; and when a voltage indicating energization is measured by the voltage measurement unit in the one power storage pack including the switch that has been turned ON and a voltage indicating de-energization is measured by the voltage measurement unit in a power storage pack other than the one power storage pack including the switch that has been turned ON, determining that there is an anomaly in a power line for a power storage pack included in the plurality of power storage packs.