

POWER SUPPLY DEVICE AND POWER SUPPLY CONTROL METHOD

Specification

Title of Invention

Power supply device and power control method

Technical Field

【0001】

The present invention relates to a power supply device and a power control method, and more particularly, to a power supply device and a power control method for supplying power by switching plural secondary batteries.

Background Art

【0002】

Conventionally, there has been proposed a power supply device for enabling an electric apparatus to be used even in the outdoors or in emergency situations. Typically, the conventional power supply device drives a power unit of an internal combustion engine using gasoline or gas as fuel and converts kinetic energy of the power unit into electric energy. However, the power supply device using such an internal combustion engine exhibited a problem of being unusable in an indoor space or a sealed atmosphere due to the oxygen consumed by combustion of fuel. Therefore, in recent years, a power supply device that supplies electric power from a secondary battery that stores electric power is also becoming popular.

【0003】

With the power supply device using the secondary battery, the amount of electric power that can be supplied depends on the charging capacity of the secondary battery. Therefore, the size of the secondary

battery would need to be large for continuously supplying a large amount of electric power. This results in problems such increase in weight and cost. To avoid such problems, there has been proposed a power supply device in which plural secondary batteries are detachably mounted and the power supply from the plural secondary batteries is switched (see, for example, Patent Document 1).

Related Art Documents

[Patent documents]

【0004】

[Patent Document 1] Japanese Laid-Open Patent Publication No.
2006-296109

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

【0005】

With the conventional power supply device, in a case of a decrease in the remaining charge amount of a secondary battery connected to a load or a case of removing a secondary battery, the connection of the secondary battery is disconnected, and then another secondary battery is selected and connected to the load. FIG. 10 is a graph showing voltage fluctuations at the time of switching batteries with the conventional power supply device.

【0006】

In FIG. 10, the horizontal axis represents time, and the vertical axis represents voltage. In FIG. 10, the voltage at the input position of a DC-AC inverter is thickly plotted with a small amplitude. In FIG. 10, the voltage at the output position of the DC-AC inverter is narrowly

plotted with a large amplitude. Further, the left half of FIG. 10 shows a state in which the secondary battery having a small remaining charge amount and a small output voltage is connected to the load, and the right half of FIG. 10 shows a state in which the secondary battery having a large remaining charge amount and a large output voltage is connected to the load. The vicinity of the center of FIG. 10 shows a state in which two secondary batteries are disconnected from the load.

【0007】

It can be understood that the voltage at the input position of the DC-AC inverter changes before and after switching the connection of the secondary battery, and there is a period in which no electric power is supplied from the secondary battery at the moment of the switching. Thereby, voltage rapidly decreases at such moment. Further, it can be understood that the voltage at the output position of the DC-AC inverter does not change at the stage where the output is stabilized before and after switching the connection of the secondary batteries. However, voltage fluctuation does occur for a short time after the moment of switching the connection of the secondary battery.

【0008】

As shown in FIG. 10, in the case of switching the connection of the secondary battery with the conventional power supply device, an instantaneous interruption occurs upon which no electric power is supplied. Thus, it becomes difficult to continuously supply electric power to the load. Particularly, with a power supply device that converts a direct current supplied from a secondary battery into an alternating current with a DC-AC inverter, the voltage fluctuation of the output alternating current increases. This leads to a possibility of causing a precision device, an information device, or the like to malfunction.

Further, an inverter power supply circuit having a high responsiveness would be required to suppress the fluctuation of the output voltage. This leads to a problem of increasing the size and cost of the power supply device.

【0009】

The present invention has been made in view of the above-described problems, and an object of the present invention is to provide a power supply device and a power supply control method capable of continuously supplying stable power by suppressing fluctuations of the output voltage while preventing instantaneous interruption even when the connection of plural secondary batteries are switched with respect to a load.

Means of Solving the problem

【0010】

In order to solve the above problems, a power supply device according to an embodiment of the present invention includes a first battery and a second battery configured to charge and discharge, a first switch having one end connected in series to an output part of the first battery, a second switch having one end connected in series to an output part of the second battery, a parallel connection part to which another end of the first switch and another end of the second switch are connected, and a switch control unit configured to control the opening and closing of the first switch and the second switch, wherein the switch control unit has an overlap period during which the first switch and the second switch are simultaneously closed when the first switch is changed from a closed state to an open state and the second switch is changed from an open state to a closed state, wherein the parallel connection part is connected

to a DC-AC inverter, and wherein the overlap period ranges from 0.5 cycles to 5 cycles of an output waveform from the DC-AC inverter.

Further, in order to solve the above problems, a power supply device according an embodiment of the present invention includes a first battery and a second battery configured to charge and discharge, a first switch having one end connected in series to an output part of the first battery, a second switch having one end connected in series to an output part of the second battery, a parallel connection part to which another end of the first switch and another end of the second switch are connected, and a switch control unit configured to control the opening and closing of the first switch and the second switch, wherein the switch control unit has an overlap period during which the first switch and the second switch are simultaneously closed when the first switch is changed from a closed state to an open state and the second switch is changed from an open state to a closed state, wherein the output part of the first battery is a first potential, wherein the output part of the second battery is a second potential, wherein a potential of the parallel connection part is an intermediate potential between the first potential and the second potential during the overlap period.

【0011】

With the power supply device according to an embodiment of the present invention, the fluctuation amount of output voltage is suppressed while preventing instantaneous interruption even when switching the connection of plural secondary batteries to the load owing to the providing of the overlap period in which the first switch and the second switch are simultaneously closed when switching the connection from the first battery to the second battery. Thereby, stable supplying of power can be continued.

【0012】

Further, according to one aspect of the present invention, the overlap period ranges from 5 milliseconds or more to 60 milliseconds or less.

【0013】

Further, according to one aspect of the present invention, a peak fluctuation of the output waveform during the overlap period is 10% or less.

【0014】

To solve the above problems, an embodiment of the present invention provides a power supply control method for switching a connection between a parallel connection part and first and second batteries that perform charging and discharging. The power supply control method includes connecting an output part of the first battery to the parallel connection part and disconnecting an output part of the second battery from the parallel connection part during a first connection period, disconnecting an output part of the first battery from the parallel connection part and connecting the output part of the second battery to the parallel connection part during a second connection period, and providing an overlap period between the first connection period and the second connection period for connecting the output part of the first battery and the output part of the second battery to the parallel connection part, wherein the parallel connection part is connected to a DC-AC inverter, and wherein the overlap period ranges from 0.5 cycles to 5 cycles of an output waveform from the DC-AC inverter.

Further, to solve the above problems, an embodiment of the present invention provides a power supply control method for switching a connection between a parallel connection part and first and second

batteries that perform charging and discharging. The power supply control method includes connecting an output part of the first battery to the parallel connection part and disconnecting an output part of the second battery from the parallel connection part during a first connection period, disconnecting the output part of the first battery from the parallel connection part and connecting the output part of the second battery to the parallel connection part during a second connection period, and providing an overlap period between the first connection period and the second connection period for connecting the output part of the first battery and the output part of the second battery to the parallel connection part, wherein the output part of the first battery is a first potential, wherein the output part of the second battery is a second potential, and wherein a potential of the parallel connection part is an intermediate potential between the first potential and the second potential during the overlap period.

Effects of the Invention

【0015】

According to an embodiment of the present invention, it is possible to provide a power supply device and a power supply control method capable of suppressing fluctuation of an output voltage while preventing an instantaneous interruption and continuing stable supply of power even the connection of plural secondary batteries are switched with respect to a load.

Brief Description of the Drawings

【0016】

FIG. 1 is a block diagram showing an exemplary configuration of a power supply device 10 according to a first embodiment of the present invention.

FIG. 2 is a diagram showing the switching of connection in the power supply device 10, in which FIG. 2(a) shows a first connection period, FIG. 2(b) shows an overlap period, and FIG. 2(c) shows a second connection period.

FIG.3 is a timing chart showing the switching of the connection in the power supply device 10, FIG. 3 (a) shows a signal of a first switch SW1, FIG. 3 (b) shows a signal of a second switch SW2, FIG. 3 (c) shows the voltage at the input position of a DC-AC inverter 13, and FIG. 3 (d) shows the voltage at the output position of the DC-AC inverter 13.

FIG. 4 is a graph showing voltage fluctuations of Comparative Examples 1 and 2 that are provided without an overlap period in which FIG. 4(a) shows the switching from a high voltage to a low voltage, and FIG. 4(b) shows the switching from a low voltage to a high voltage.

FIG.5 is a graph showing an intermediate potential in a case where an overlap period is provided.

FIG. 6 is a graph showing the switching from a low voltage to a high voltage in a case where an overlap period is provided in which FIG. 6(a) shows Example 1, FIG. 6(b) shows Example 2, FIG. 6(c) shows Example 3, and FIG. 6(d) shows Example 4.

FIG. 7 is a graph showing the switching from a high voltage to a low voltage in a case where an overlap period is provided in which FIG. 7(a) shows Example 5, FIG. 7(b) shows Example 6, FIG. 7(c) shows Example 7, and FIG. 7(d) shows Example 8.

FIG. 8 is a graph showing the output fluctuation from the DC-AC inverter 13 in which FIG. 8 (a) shows the switching from high voltage to

low voltage in Comparative Example 1 and Example 5 and 6, FIG. 8 (b) shows the switching from low voltage to high voltage in Comparative Example 2 and Example 1 and 2, and FIG. 8 (c) shows Examples 7 and 8.

FIG.9 is a graph showing the output fluctuation of the DC-AC inverter 13 in Comparative Examples 1 and 2 that are provided with no overlap period.

FIG.10 is a graph showing the voltage fluctuation at the time of switching batteries with a conventional power supply device.

Mode for Carrying Out the Invention

【0017】

(First Embodiment)

Hereinafter, embodiments of the present invention are described in detail with reference to the drawings. The same or equivalent components, members, and processes shown in the drawings are denoted by the same reference numerals, and redundant descriptions thereof will be omitted as appropriate. FIG. 1 is a block diagram showing an exemplary configuration of a power supply device 10 according to a first embodiment of the present invention. As illustrated in FIG. 1, the power supply device 10 includes a switch control unit 11, a first battery 12a, a second battery 12b, a first switch SW1, a second switch SW2, a DC-AC inverter 13, and a load 14.

【0018】

The switch control unit 11 controls the opening and closing operations of the first switch SW1 and the second switch SW2. Although the specific configuration of the switch control unit 11 is not limited in particular, it may include, for example, a memory, an external storage device, a Central Processing Unit (CPU), and an information

communication device (not illustrated) and perform information processing to control the first switch SW1 and the second switch SW2 in accordance with a predetermined program. Further, the switch control unit 11 may monitor the state of each unit of the power supply device 10 and control the opening and closing operations of the first switch SW1 and the second switch SW2 based on the state of each unit of the power supply device 10 and in accordance with a predetermined program.

【0019】

The first battery 12a and the second battery 12b are secondary batteries capable of charging and discharging electric power. Like known secondary batteries, the first battery 12a and the second battery 12b include, for example, a terminal used for charging and discharging and a BMS (Battery Management System) for controlling the charging and discharging. An output part of the first battery 12a is connected to one end of the first switch SW1, and an output part of the second battery 12b is connected to the second switch SW2. The voltage at the output part of the first battery 12a is a VBA1 and the voltage at the output part of the second battery 12b is a VBA2.

【0020】

The specific configuration of the first battery 12a and the second battery 12b is not limited. For example, a known lithium-ion battery, a nickel-hydrogen battery, or an all-solid-state battery may be used. Further, the battery cells included in the secondary batteries used in electric vehicles, hybrid vehicles, and the like may be reused to be used as the first battery 12a and the second battery 12b. Although it may be assumed that reused battery cells each have different deterioration degrees and different chargeable capacities and output voltages, the

power supply device 10 of the present embodiment can be used without any substantive issues.

【0021】

The first battery 12a and the second battery 12b preferably have an inner impedance of 10 mΩ or more. When the internal impedance is less than 10 mΩ, an unintended charging operation may occur in a below-described overlap period during a switching operation and may be difficult to secure a sufficient overlap period.

【0022】

Each of the first switch SW1 and the second switch SW2 has one end connected to the output part of the first battery 12a and the second battery 12b, respectively. The first switch SW1 and the second switch SW2 are units that perform connection and disconnection between the first battery 12a and the second battery 12b and the load 14 by way of opening and closing operations. As shown in FIG. 1, the other ends of the first switch SW1 and the second switch SW2 are connected to the parallel connection part. Thereby, the series connection of the first battery 12a and the first switch SW1 and the series connection of the second battery 12b and the second switch SW2 are connected in parallel to each other. The voltage of the parallel connection part is DCAC_IN.

【0023】

The specific configuration of the first switch SW1 and the second switch SW2 is not limited in particular. For example, a known semiconductor switch or a mechanical switch may be used. As will be described below, since the opening and closing operations of the first switch SW1 and the second switch SW2 are performed at millisecond levels, it is preferable to use a semiconductor switch such as a

Field-Effect Transistor (FET) capable of performing a high-speed switching operation.

【0024】

The DC-AC inverter 13 is provided between the parallel connection part and the load 14. The DC-AC inverter 13 is a part that converts direct-current DCAC_IN input from the parallel connection part into alternating current AC_OUT and outputs the AC_OUT to the load 14. The specific configuration of the DC-AC inverter 13 is not limited, and known configurations may be used. However, the configuration of the DC-AC inverter 13 is preferred to output a sinusoidal wave for widening the range of objects that are to be operated as the load 14. Although the AC_OUT output from the DC-AC inverter 13 is not limited in particular, it is preferred to have a voltage range of a 100V-220V used as a commercial power source in each country and have a frequency range of 50 Hz-60 Hz.

【0025】

The load 14 is an electronic device connected to the output of the DC-AC inverter 13 and driven by the alternating current output from the DC-AC inverter 13. Although the load 14 is not limited, the load 14 may be, for example, a computer device, a network device, an electronic medical device, or an ultra-low temperature freezer. In the power supply device 10 of the present embodiment, even when plural secondary batteries are switched, instantaneous interruption does not occur, and fluctuations in the output voltage can be suppressed. Thereby, the load 14 that is required to supply stable power can be connected and continuously used.

【0026】

Although FIG. 1 shows an example in which two batteries and two switches are used, the number of batteries and switches is not limited.

For example, three or more batteries and switches may be used. Even in a case of selectively switching three or more batteries, the batteries connected in the first connection period before the switching and the batteries connected in the second connection period after the switching operate as a pair. Therefore, even in the case where three or more batteries are provided in the power supply device 10, the operation and the control of the connection switching are the same as those in the case where two batteries are used.

【0027】

FIG. 2 is a diagram showing the switching of connection in the power supply device 10, in which FIG. 2(a) shows a first connection period, FIG. 2(b) shows an overlap period, and FIG. 2(c) shows a second connection period. The switch control unit 11 is not illustrated in FIG. 2 for the sake of simplification. However, the first switch SW1 and the second switch SW2 are controlled to be opened and closed by a control signal sent from the switch control unit 11. Further, the arrows shown in the drawing schematically represent an example of the direction of electric current.

【0028】

In the first connection period illustrated in FIG. 2(a), the first switch SW1 is in a closed state (ON) and the second switch SW2 is in an open state (OFF). Therefore, DC current is supplied from the first battery 12a to the first switching SW1 and the parallel connection part, converted into AC_OUT by the DC-AC inverter 13, and supplied to the load 14. In the power supply device 10, a transition is made to an overlap period when an instruction to stop the discharge from the first battery 12a and switch to the discharge from the second battery 12b is sent.

【0029】

Here, the case where the discharge from the first battery 12a is stopped may be a case where the remaining charge level of the first battery 12a decreases to a point where the discharge target is switched to a charge target. This case may also apply when a detachment action is performed on the first battery 12a to cause a locking device (not illustrated) to be released. This case may also apply when a user inputs an instruction to exclude the first battery 12a from the discharge target. This case may also apply when the temperature of the first battery 12a increases to a point where a control unit provided in the power supply device 10 sends a protection instruction for stopping the discharge.

【0030】

In the overlap period illustrated in FIG. 2(b), the first switch SW1 is in a closed state (ON) and the second switch SW2 is in a closed state (ON). In this overlap period, DC current is supplied from the side where the voltage of the first battery 12a and the second battery 12b are higher to the parallel connection part, converted into AC_OUT by the DC-AC inverter 13, and supplied to the load 14. The example illustrated in FIG. 2(b) is an example where the first battery 12a is higher than the second battery 12b and the electric current is supplied from the first battery 12a to the second battery 12b. However, in a case where the second battery 12b is higher than the first battery 12a, the flow of electric current flow is reversed. After the overlap period set to a predetermined length has elapsed, a transition to the second connection period is made.

【0031】

In the second connection period illustrated in FIG. 2(c), the first switch SW1 is in an open state (OFF) and the second switch SW2 is in a closed state (ON). Therefore, DC current is supplied from the second battery 12b to the second switching SW2 and the parallel connection part,

converted into AC_OUT by the DC-AC inverter 13, and supplied to the load 14. Thereafter, the load 14 is continuously operated by the electric power supplied from the second battery 12b.

【0032】

In the above-described power supply device 10 of the present embodiment, the switch control unit 11 includes an overlap period in which the first switch SW1 and the second switch SW2 are simultaneously closed when the first switch SW1 is changed from the closed state to the open state and the second switch SW2 is changed from the open state to the closed state. Therefore, the first battery 12a or the second battery 12b is connected to the parallel connection part, so that instantaneous interruption at the time of switching does not occur during the first connection period, the overlap period, and the second connection period.

【0033】

Further, during the overlap period, the first battery 12a, which is on the side where the voltage is high, discharges and causes the electric current oriented in the charge direction to flow through the second battery 12b, which is on the side where the voltage is low. If the electric current oriented in the direction in which the second battery 12b is charged is large during the overlap period, the second battery 12b cannot be perform charging and discharging due to the activation of the protective circuit of the BMS included in the second battery 12b. Therefore, the length of the overlap period is desired to be set to a short period, so that the electric current oriented in the charging direction is prevented from excessively flowing in the second battery 12b. The length of the overlap period will be described below.

【0034】

FIG.3 is a timing chart showing the switching of the connection in the power supply device 10 in which FIG. 3 (a) shows a signal of a first switch SW1, FIG. 3 (b) shows a signal of a second switch SW2, FIG. 3 (c) shows the voltage at the input position of a DC-AC inverter 13, and FIG. 3 (d) shows the voltage at the output position of the DC-AC inverter 13. In the figures, the horizontal axis represents time t , and the vertical axis represents voltage. Further, the first connection period is illustrated up to time t_1 , the overlap period is illustrated from time t_1 to time t_2 , and the second connection period is illustrated after time t_2 .

【0035】

As shown in FIG. 3(a), an ON signal is applied to the first switch SW1 in the first connection period and the overlap period, and an OFF signal is applied to the first switch SW1 in the second connection period. As shown in FIG. 3(b), an OFF signal is applied to the second switch SW2 in the first connection period, and an ON signal is applied in the overlap period and the first connection period.

【0036】

As shown in FIG. 3(c), the voltage at the input position of the DC-AC inverter 13 (parallel connection part) is substantially equal to the voltage VBA1 (corresponding to a first potential) at the output part of the first battery 12a in the first connection period and is substantially equal to the voltage VBA2 (corresponding to a second potential) at the output part of the second battery 12b in the second connection period. In the overlap period, the voltage at the input position of the DC-AC inverter 13 (parallel connection part) is at an intermediate potential which is a potential between the voltage VBA1 and the voltage VBA2.

【0037】

Although FIG.3(c) illustrates an example where the intermediate potential is in the vicinity of the average value of the voltage VBA1 and the voltage VBA2, the intermediate potential does not necessarily need to be the average value as long as it is between the voltage VBA1 and the voltage VBA2. Further, although FIG. 3(c) illustrates an example where the value of intermediate potential is constant throughout the overlap period, the potential may be changed between the voltage VBA1 and the voltage VBA2.

【0038】

As shown in FIG. 3(d), the voltage AC_OUT at the output position of the DC-AC inverter 13 is output as a sinusoidal alternating current. In FIG. 3(d), the waveforms of AC_OUT after the time t_1 are indicated with circled numbers. Each of the numbers indicates the order of half cycles of the output waveform because the waveform is one cycle at the peak and the bottom. In the first connection period, the peak voltage of AC_OUT is stable. However, upon entering the overlap period in the time t_1 , the peak voltage fluctuates after DCAC_IN changes from the voltage VBA1 to the intermediate potential. Further, even upon entering the second connection period from the overlap period at the time t_2 , the peak-voltage fluctuates after DCAC_IN changes from the intermediate potential to the voltage VBA2.

【0039】

The fluctuation of the peak-voltage of AC_OUT increases at the time t_1 when entering the overlap period and at the time t_2 when entering the second connection period, and attenuates as the period of the sinusoidal wave passes. This is because even if the input voltage to the DC-AC inverter 13 changes, the output voltage is converted to a target output voltage according to the performance and time-constant of the

DC-AC inverter 13. However, the load 14 may not operate normally if the fluctuation of the peak voltage of the output voltage AC_OUT is large and the time until it's attenuation and stabilization is long.

【0040】

Therefore, with the power supply device 10 of the present embodiment, it is preferable that the overlap period be set to range from 5 milliseconds (ms) or more to 60 milliseconds (ms) or less. More preferably, the overlap period is to range from 5 milliseconds (ms) or more to 20 milliseconds (ms) or less. Alternatively, it is preferable for the overlap period to range from 0.5 cycles to 5 cycles of the output waveform from the DC-AC inverter 13. More preferably, the overlap period is to range from 0.5 cycles to 2 cycles of the output waveform from the DC-AC inverter 13. Further, it is preferable that the DC-AC inverter 13 have a peak-to-peak fluctuation of 10% or less.

【0041】

(Comparative Example)

FIG. 4 is a graph showing the voltage fluctuations of Comparative Examples 1 and 2 that are provided without an overlap period in which FIG. 4(a) shows the switching from a high voltage to a low voltage, and FIG. 4(b) shows the switching from a low voltage to a high voltage. Further, in FIG. 4, the voltage DCAC_IN at the input position of the DC-AC inverter 13 (parallel connection part) is thickly plotted with a small amplitude. In FIG. 4, the voltage AC_OUT at the output position of DC-AC inverter 13 is thinly plotted with a large amplitude. Further, FIG. 4 shows a first connection period in which the first battery 12a is connected, and the right half of FIG.4 shows a second connection period in which the second battery 12b is connected. The output of DC-AC inverter 13 is a sinusoidal wave of an AC 100 V, 50 Hz and the load 14 is 1 kW. Further, the output

voltage VBA1 of the first battery 12a is 27 V (high voltage side), and the output voltage VBA2 of the second battery 12b is 23 V (low voltage side).

【0042】

As shown in FIG. 4(a), the peak fluctuation of AC_OUT was -8.7% after switching from the first battery 12a on the high voltage side to the second battery 12b on the low voltage side. Further, as shown in FIG. 4(b), the peak fluctuation of AC_OUT was +12.5% after switching from the second battery 12b on the low voltage side to the first battery 12a on the high voltage side. Here, the switching from the low voltage to the high voltage is referred to as Comparative Example 1, and the switching from the high voltage to the low voltage is referred to as Comparative Example 2.

【0043】

(Examples)

Examples 1 to 4 illustrate the switching from the second battery 12b on the low-voltage side to the first battery 12a on the high-voltage side in which the overlap period is set to 10 milliseconds (ms), 20 milliseconds (ms), 40 milliseconds (ms), and 60 milliseconds (ms). Examples 5 to 8 illustrate the switching from the first battery 12a on the high-voltage side to the second battery 12b on the low-voltage side in which the overlap period is set to 10 milliseconds (ms), 20 milliseconds (ms), 40 milliseconds (ms), and 60 milliseconds (ms). Like the comparative examples, the output of the DC-AC inverter 13 is a sinusoidal wave of an AC 100 V, 50 Hz, and the load 14 is 1 kW in Examples 1 to 8. Further, the output voltage VBA1 of the first battery 12a is 28.36 V (high voltage side), and the output voltage VBA2 of the second battery 12b is 24.72 V (low voltage side).

【0044】

FIG. 5 is a graph showing an intermediate potential in a case where an overlap period is provided. In the example illustrated in FIG. 5, the effect of the fluctuation in DCAC_IN caused by the voltage-conversion in the DC-AC inverter 13 is eliminated by setting the load 14 to 0 kW based on the settings of Example 8. In the overlap period, which is between the first connection period and the second connection period, the voltage DCAC_IN of the parallel connection part is an intermediate potential of 26.49 V and is between the output voltage 28.36 V of the first battery 12a and the output voltage 24.72 V of the second battery 12b.

【0045】

FIG. 6 is a graph showing the switching from a low voltage to a high voltage in a case where an overlap period is provided in which FIG. 6(a) shows Example 1, FIG. 6(b) shows Example 2, FIG. 6(c) shows Example 3, and FIG. 6(d) shows Example 4. FIG. 7 is a graph showing the switching from a high voltage to a low voltage in a case where an overlap period is provided in which FIG. 7(a) shows Example 5, FIG. 7(b) shows Example 6, FIG. 7(c) shows Example 7, and FIG. 7(d) shows Example 8.

【0046】

Based on the graphs shown in FIGS. 6 and 7, FIG.8 illustrates a graph of the results of measuring the peak fluctuation amount per half cycle of AC_OUT for Comparative Examples 1 and 2 and Examples 1 to 8. FIG. 8 is a graph showing the output fluctuation from the DC-AC inverter 13 in which FIG. 8 (a) shows the switching from high voltage to low voltage in Comparative Example 1 and Example 5 and 6, FIG. 8 (b) shows the switching from low voltage to high voltage in Comparative Example 2 and Example 1 and 2, and FIG. 8 (c) shows Examples 7 and 8. The

horizontal axis of FIG. 8 indicates the order of peaks for each half cycle of the output waveform of AC_OUT after entering the overlap period at the time t_1 . A half cycle is equivalent to 10 milliseconds (ms) because the output of the DC-AC inverter 13 is 50 Hz in any one of the examples. The vertical axis in FIG. 8 indicates the amount of fluctuation of the output waveform of the DC-AC inverter 13 with respect to the peak voltage during the first connection period.

【0047】

As shown in FIG. 8 (a) and FIG.8(b), Comparative Example 1, that is provided with no overlap period (0 ms), is plotted with peaks 1 and 2 that have fluctuation amounts greater than those of Examples 1 to 8. Particularly, with Comparative Example 1 that switches from the low voltage side to the high voltage side, the fluctuation amounts of the peaks 1 and 2 are more than 10% and may thereby adversely affect the operation of the load 14. With Comparative Example 2, which switches from the high voltage side to the low voltage side, the fluctuation amounts of the peaks 1 and 2 are slightly less than 9%. However, with the power supply device 10, the peak fluctuation amount exceeds 10% during the period of using the load 14 because the switching from the low voltage side to the high voltage side and the switching from the high voltage side to the low voltage side frequently occur.

【0048】

With Example 5 (10 ms) and Example 6 (20 ms) that switch from the low voltage side to the high voltage side shown in FIG. 8A, the fluctuation amounts of the peaks 1 and 2 are smaller than those of Comparative Example 1 and are suppressed to 10% or less. Further, in both Examples 5 and Example 6, the fluctuation amounts decrease after the peaks 1 and 2 and converge to the output setting of the DC-AC

inverter 13. The fluctuation amounts of Example 5 and Example 6 are plotted until reaching peaks 4 and 6, respectively. The convergence of the fluctuation amount of Example 5 and Example 6 can be confirmed by plotting the fluctuation amount until a time longer than the overlap period.

【0049】

With Example 1 (10 ms) and Example 2 (20 ms) that switch from the high voltage side to the low voltage side shown in FIG. 8 (b), the maximum peak position is different from that of Comparative Example 2. However, the maximum peak fluctuations of Examples 1 and 2 are suppressed to 8% or less, which are smaller than those of Comparative Example 2. In both Examples 1 and 2, the fluctuation amounts decrease after the largest peak and converge to the output setting of the DC-AC inverter 13. The fluctuation amounts of Example 1 and Example 2 are plotted until reaching peaks 7 and 8, respectively. The convergence tendency of the fluctuation amounts of Example 1 and Example 2 can be confirmed from the positions of the maximum peak of the fluctuation amounts.

【0050】

With Example 7 (40ms) and Example 8 (60ms) that switch from the low voltage side to the high voltage side shown in FIG. 8(c), the fluctuation amounts of the peaks 1 and 2 are smaller than those of Comparative Example 1 and are suppressed to 10% or less. Further, with both Example 7 and Example 8, after the fluctuation amounts decrease after the peaks 1 and 2, there is a second increase in the peak fluctuation amount. However, it does not exceed the peaks 1 and 2 and thereafter converge to the output setting of the DC-AC inverter 13. In Example 7 and Example 8, the peaks 10 and 11 are plotted, respectively,

and the convergence tendency can be confirmed from the position of the second increase of the peak fluctuation amount.

【0051】

As shown in FIG. 8(c), with Example 8, the peak fluctuation is sustained up to the vicinity of the peak 11. If the overlap period continues longer than this, the time until the convergence would be prolonged. Therefore, it is preferable that the overlap period ranges from 5 milliseconds (ms) or more to 60 milliseconds (ms) or less. Further, in Examples 7 and Example 8, the second increase in the peak fluctuation amount occurs at the stage where the overlap period has ended and enters the second connection period. However, in Examples 5 and 6, the second increase in the peak fluctuation amount does not occur. Therefore, it is more preferable that the overlap period ranges from 5 milliseconds (ms) or more to 20 milliseconds (ms) or less.

【0052】

FIG. 9 is a graph showing the output fluctuation of the DC-AC inverter 13 in Comparative Examples 1 and 2 that are provided with no overlap period. In FIG. 9, Comparative Example 1 is plotted with a solid line, Comparative Example 2 is plotted with a dashed line, and the accumulation of a normalized fluctuation amount is plotted with a dashed-dotted line. As shown in FIG. 9, with Comparative Examples 1 and 2 where the overlap period is not provided, the peak fluctuation amount is substantially converged, and the output waveform of AC_OUT is stabilized up to the peaks 3 to 4. Therefore, the response time of the DC-AC inverter 13 can be regarded as 30 milliseconds (ms) to 40 milliseconds (ms). Further, the accumulation of the fluctuation amounts up to peak 2 reaches 63% (-2 dB), and the time-constant of the DC-AC inverter 13 becomes 20 milliseconds (ms).

【0053】

By setting the overlap period within the response time of the DC-AC inverter 13, the time t_2 at the end of the overlap period is set within the response time of DC-AC inverter 13, so that the second increase in the peak fluctuation amount can be suppressed. Therefore, the overlap period is preferred to range from 0.5 cycles to 5 cycles of the waveform of AC_OUT output from the DC-AC inverter 13.

【0054】

Further, by setting the overlap period within the time constant of the DC-AC inverter 13, the time t_2 at the end of the overlap period can be set within the time constant of DC-AC inverter 13, so that the second increase in peak fluctuation can be suppressed. Therefore, it is more preferable that the overlap period is a period ranging from 0.5 cycles to 2 cycles of the waveform of AC_OUT output from the DC-AC inverter 13.

【0055】

With the above-described power supply device 10 of the present embodiment, the fluctuation amount of output voltage is suppressed while preventing instantaneous interruption even when switching the connection of plural secondary batteries to the load 14 owing to the providing of the overlap period in which the first switch SW1 and the second switch SW2 are simultaneously closed when switching the connection from the first battery 12a to the second battery 12b. Thereby, stable supplying of power can be continued.

【0056】

(Second Embodiment)

Next, a second embodiment of the present invention will be described. Details that overlap with those of the first embodiment will not be described. In the first embodiment, the DC-AC inverter 13 is provided

between the parallel connection part of the first switch SW1 and the second switch SW2 and the load 14 to convert a direct current into an alternating current. Alternatively, a DC-DC converter may be provided instead of the DC-AC inverter 13. In the case of using the DC-DC converter, the load 14 is an electronic device driven by a direct current.

【0057】

Even in the case of using the DC-DC converters, the other ends of the first switch SW1 and the second switch SW2 are connected to the parallel connection part, and the connection is switched in the order of the first connection period, the overlap period, and the second connection period. As a result, no instantaneous interruption occurs in the voltage DCAC_IN input to the DC-DC converter, and the voltage DCAC_IN becomes an intermediate potential during the overlap period.

【0058】

Even with the power supply device 10 of the present embodiment, the fluctuation amount of output voltage is suppressed while preventing instantaneous interruption even when switching the connection of plural secondary batteries to the load 14 owing to the providing of the overlap period in which the first switch SW1 and the second switch SW2 are simultaneously closed when switching the connection from the first battery 12a to the second battery 12b. Thereby, stable supplying of power can be continued.

【0059】

The present invention is not limited to the above-described embodiments, and various modifications can be made within the scope of the claims, and embodiments obtained by appropriately combining the technical means disclosed in the different embodiments are also included in the technical scope of the present invention.

[Description of Reference Numerals]

【0060】

10... Power supply device

11... Switch control unit

12a... First battery

12b... Second battery

13... DC-AC inverter

14... Load

SW1... first switch

SW2... second switch

[Document Name]

Claims

[Claim 1]

A power supply device comprising:

a first battery and a second battery configured to charge and discharge;

a first switch having one end connected in series to an output part of the first battery;

a second switch having one end connected in series to an output part of the second battery;

a parallel connection part to which another end of the first switch and another end of the second switch are connected; and

a switch control unit configured to control the opening and closing of the first switch and the second switch;

wherein the switch control unit has an overlap period during which the first switch and the second switch are simultaneously closed when the first switch is changed from a closed state to an open state and the second switch is changed from an open state to a closed state,

wherein the parallel connection part is connected to a DC-AC inverter, and

wherein the overlap period ranges from 0.5 cycles to 5 cycles of an output waveform from the DC-AC inverter.

[Claim 2]

A power supply device comprising:

a first battery and a second battery configured to charge and discharge;

a first switch having one end connected in series to an output part of the first battery;

a second switch having one end connected in series to an output part of the second battery;

a parallel connection part to which another end of the first switch and another end of the second switch are connected; and

a switch control unit configured to control the opening and closing of the first switch and the second switch;

wherein the switch control unit has an overlap period during which the first switch and the second switch are simultaneously closed when the first switch is changed from a closed state to an open state and the second switch is changed from an open state to a closed state,

wherein the output part of the first battery is a first potential,
wherein the output part of the second battery is a second potential,

wherein a potential of the parallel connection part is an intermediate potential between the first potential and the second potential during the overlap period.

[Claim 3]

The power supply device according to claim 1,
wherein a peak fluctuation of the output waveform during the overlap period is 10% or less.

[Claim 4]

The power supply device according to any one of claims 1 to 3,
wherein the overlap period ranges from 5 milliseconds or more to 60 milliseconds or less.

[Claim 5]

A power supply control method for switching a connection between a parallel connection part and first and second batteries that perform charging and discharging; the power supply control method comprising:

connecting an output part of the first battery to the parallel connection part and disconnecting an output part of the second battery from the parallel connection part during a first connection period;

disconnecting an output part of the first battery from the parallel connection part and connecting the output part of the second battery to the parallel connection part during a second connection period; and

providing an overlap period between the first connection period and the second connection period for connecting the output part of the first battery and the output part of the second battery to the parallel connection part;

wherein the parallel connection part is connected to a DC-AC inverter, and

wherein the overlap period ranges from 0.5 cycles to 5 cycles of an output waveform from the DC-AC inverter.

[Claim 6]

A power supply control method for switching a connection between a parallel connection part and first and second batteries that perform charging and discharging, the power supply control method comprising:

connecting an output part of the first battery to the parallel connection part and disconnecting an output part of the second battery from the parallel connection part during a first connection period;

disconnecting the output part of the first battery from the parallel connection part and connecting the output part of the second battery to the parallel connection part during a second connection period; and

providing an overlap period between the first connection period and the second connection period for connecting the output part of the first battery and the output part of the second battery to the parallel connection part;

wherein the output part of the first battery is a first potential,
wherein the output part of the second battery is a second potential,
and

wherein a potential of the parallel connection part is an intermediate potential between the first potential and the second potential during the overlap period.