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April 19, 2023

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The document is designated as:

- JP2011193653A (Onishi)

A handwritten signature in blue ink that reads "Dwaine Palmer".

Signature of Dwaine Palmer

(19) Japanese Patent Office (JP)

(12) Publication of Unexamined Patent
Application (A)

(11) Patent Application Disclosure

2011-193653

(P2011-193653)

(43) Publication Date: September 9, 2011

(51) Int. Cl.

H02J 7/00 (2006.01)**H01M 10/44 (2006.01)****H01M 10/48 (2006.01)**

FI

Theme code (ref.)

H02J 7/00 302A 5G503

H01M 10/44 P 5H030

H01M 10/48 P

Request for Examination: Not Requested Number of Claims: 3 OL Total pages: 7

(21) Application No.: 2010-58368 (P2010-58368)

(22) Application Date: March 15, 2010

Application in accordance with Article 30(1) of the Patent Act; Publisher: Executive Committee of Shikoku Section Joint Conference of The Institute of Electrical and Related Engineers; Title of Publication: Abstract of 2009 Shikoku Section Joint Conference of The Institutes of Electrical and Related Engineers; Publication date: September 15, 2009

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F term (reference) 5G503 BA01 BB01 BB04 CA01 CA11 DA13 GB04

5H030 AS08 BB21 FF44

(54) [TITLE OF INVENTION] ACTIVE CONTROL STORAGE BATTERY

(57) ABSTRACT

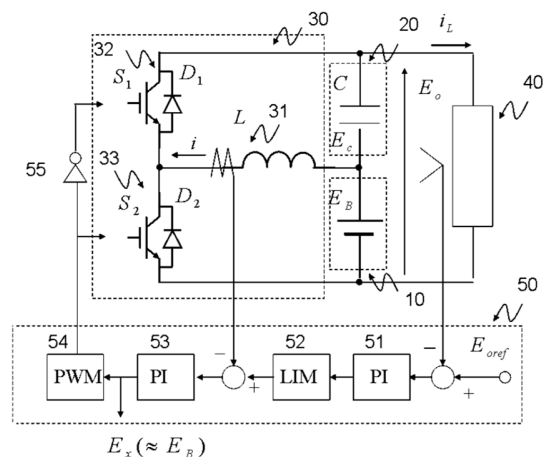
PROBLEM

An object is to easily configure a storage battery system capable of maintaining a constant terminal voltage until the remaining capacity is exhausted, even if the terminal voltage of the storage battery drops due to advancement of discharge of the storage battery, and which can be used until the final discharge voltage.

SOLUTION

The present invention connects a capacitor in series with a storage battery, transfers energy between the storage battery and the capacitor by switching control, compensates for voltage fluctuations of the storage battery by a capacitor terminal voltage, and performs control so as to maintain a constant direct current voltage of the storage battery and capacitor combination connected in series, and the remaining capacity of the storage battery is obtained from the switching control signal in order to simplify the control system.

[Selected Drawing] FIG. 1



What Is Claimed Is:

[Claim 1]

A storage battery system, comprising a storage battery and a capacitor connected in series, wherein charging and discharging are performed between the storage battery and the capacitor such that the direct current voltage of the entire storage battery system integrating the storage battery and the capacitor is kept constant.

[Claim 2]

A battery voltage monitoring system, wherein voltage information of a storage battery is read from a control calculated amount for generating a PWM control signal of a control circuit of the storage battery system.

[Claim 3]

An active storage battery system, wherein the direct current voltage of the storage battery control system is controlled based on the information of the battery voltage monitoring system based on the calculated amount from the control circuit.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL FIELD

[0001]

The present invention relates to an active storage battery system that monitors the terminal voltage of a storage battery and equivalently controls the voltage of the storage battery to be constant by switching control.

CONVENTIONAL TECHNOLOGY

[0002]

Lead storage batteries, nickel metal hydride storage batteries, lithium ion storage batteries, and the like, are used as secondary batteries that can be charged and discharged in many products including electric vehicles. As a storage battery is discharged, the terminal voltage drops, which affects the performance and function of the device that is used. Therefore, the storage battery is charged without being completely discharged, and the capacity of the storage battery cannot be fully utilized.

[0003]

On the other hand, primary batteries are rarely used while monitoring the voltage, and are replaced when the performance and function of the connected device begin to be affected, but often the battery is replaced with a new battery even though there is still some remaining capacity.

[0004]

The remaining capacity of the battery can be known to some extent from the degree of drop in the terminal voltage, and therefore the storage battery voltage is detected in order to monitor overcharging and overdischarging conditions that affect the life of the storage battery, but the terminal voltage changes depending on the charge/discharge current value, so it is desirable to detect the terminal voltage under load rather than under no-load in order to more accurately know the remaining capacity.

[0005]

When the remaining capacity of the storage battery is low, the terminal voltage drops and the performance of the connected device cannot be exhibited. Therefore, the remaining capacity of the storage battery cannot be sufficiently utilized.

PRIOR ART DOCUMENTS

Patent Documents

[0006]

Patent Document 1: Japanese Unexamined Patent Application H5-328533

Patent Document 2: Japanese Unexamined Patent Application H5-127787

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0007]

An object of the present invention is to provide a storage battery system that maintains a constant terminal voltage until the remaining capacity is exhausted, even if the terminal voltage of the storage battery drops due to advancement of discharge of the storage battery, and which can be used until the final discharge voltage.

[0008]

The storage battery control system of the present invention is an adapter device for making full use of the storage battery, and an issue is to obtain voltage information of the storage battery from a control calculated amount of the storage battery control system.

MEANS FOR SOLVING THE PROBLEM

[0009]

The present invention connects a capacitor in series with a storage battery, transfers energy between the storage battery and the capacitor by switching control, compensates for voltage fluctuations of the storage battery with a capacitor terminal voltage, and performs control so as to maintain a constant direct current voltage of the storage battery and capacitor combination connected in series, and the remaining capacity of the storage battery is obtained from the switching control signal.

[0010]

FIG. 1 shows a main circuit configuration and control system of the active control storage battery of the present invention. This figure illustrates the active storage battery system of the present invention that maintains a constant direct current output voltage applied to a load 40 by controlling the capacitor voltage by controlling a switching power converting device 30 that performs charging and discharging between the storage battery and the capacitor based on a switching signal from a control block 50 that has protected the output voltage as an overall storage battery system that connects in series a capacitor 20 a storage battery 10 that is subject to control and integrates the storage battery 10 and the capacitor 20.

[0011]

When the storage battery voltage 10 drops below the reference voltage due to discharge to the load, the energy of the storage battery 10 is transferred to the capacitor 20 by the switching power converting device 30, and the drop is compensated by the charging voltage of the capacitor 20 that is connected in series. FIG. 2 shows operating modes during switching control at this time. After energy passes from the storage battery 10 along a path through an inductor 31 and a switch 33, the energy of the inductor 31 is transferred to the capacitor through a path including the switch 32 and the capacitor 20.

[0012]

The control block 50 generates a PWM control signal for switches 33 and 32 of the switching power converting device 30 such that the output voltage of the storage battery 10 and the capacitor 20 that are connected in series is a constant reference value.

[0013]

The control input amount that generates the PWM control signal for the switches 33 and 32 has a value that is proportional to the voltage of the storage battery 10, and therefore the voltage of the storage battery can be monitored from the signal of the control circuit, so the remaining capacity can be utilized until the moment that the storage battery reaches the final discharge voltage.

[0014]

On the other hand, when the series voltage of the storage battery 10 and the capacitor 20 rises above the reference voltage due to regenerative current from the load, or the like, the load terminal voltage can be kept constant by transferring the energy of the capacitor 20 to the storage battery 10 by the switching power converting device 30, and performing discharge voltage control of the capacitor 20. FIG. 3 shows operating modes during switching control at this time. After energy passes from the capacitor 20 along a path through the inductor 31 and a switch 32, the energy of the inductor 31 is transferred to the storage battery along a path through the switch 33 and the storage battery 10.

[0015]

The control block 50 similarly generates a PWM control signal for the switches 33 and 32 of the switching power converting device 30 and can monitor the voltage of the storage battery from the signal of the control circuit because the control input level that generates the PWM control signal to the switches 33 and 32 is a value proportional to the voltage of the storage battery 10, and therefore the storage battery can be charged until the storage battery reaches the overcharge voltage.

[0016]

As described above, by controlling the voltage of the capacitor 20 connected in series with the storage battery 10 by the switching power converter 30 and the control block 50, the output voltage of the series connection of the storage battery 10 and the capacitor 20 applied to the load 40 can be actively kept constant. Therefore, the storage battery system of the present invention is called an "active control storage battery".

EFFECT OF THE INVENTION

[0017]

FIG. 4 shows a configuration of an output voltage constant control circuit using a conventional chopper circuit. A method of obtaining a constant controlled output voltage source from a storage battery 10 with voltage fluctuations generally includes a method of directly controlling the output voltage from the storage battery that is applied to the load 40 by the switching power converting device 30, but this requires the output terminal to have a large withstand voltage that exceeds the storage battery voltage, and a high capacity capacitor 21 is required.

[0018]

The active storage battery system of the present invention can be configured such that the voltage change of the storage battery 10 is compensated by a capacitor 20 in series, and therefore the withstand voltage required of the capacitor 20 can be achieved by a capacitor that has an extremely small voltage variation range, and the voltage of the storage battery can be monitored by a control amount of a control circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 shows a main circuit configuration and control system of the active storage battery system of the present invention.

FIG. 2 shows compensation circuit operation when the output voltage of the storage battery system drops below a reference value.

FIG. 3 shows compensation circuit operation when the output voltage of the storage battery system is above a reference value.

FIG. 4 shows a conventional voltage control circuit that directly controls the output voltage to be constant

FIG. 5 shows operation waveforms during discharge operation and regeneration operation of the active storage battery of the present invention.

FIG. 6 shows a comparison between the detected value E_x of the storage battery voltage and the storage battery voltage E_B based on the amount of calculation by the control circuit.

FIG. 7 shows an application example of a secondary battery for an inverter that drives an AC motor for an electric vehicle.

FIG. 8 shows an application example of an active storage battery adapter for primary batteries such as dry batteries or the like.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020]

In the main circuit configuration shown in FIG. 1, the simulation constants are the capacitance C of the capacitor 20 = 1000 μ F, the inductance L of the reactor 31 = 1 mH, and as a model of the storage battery, E_B = 160 V, simulating the voltage fluctuation due to the charging and discharging control of the storage battery. Therefore, the storage battery 10 is simulated by connecting a capacitance C_0 = 0.35 F in series with the storage battery.

[0021]

FIG. 5 shows operation waveforms obtained by simulation analysis during discharge operation and regeneration operation of the active storage battery of the present invention. In FIG. 5, I_L represents the load current, E_o represents the direct current voltage applied to the load, E_B represents the voltage of the battery 10, and E_C represents the voltage of the capacitor 20, in order from the top. Although the battery voltage E_B fluctuates due to the power running to the load 40 and the regenerated current I_L from the load, it can be confirmed that the battery voltage fluctuation is compensated for by charging and discharging the capacitor 20, and thus the direct current voltage E_o applied to the load 40 can remain constant.

[0022]

Herein, assuming that the control amount input to the PWM block of the control circuit is E_x , the average voltage E_{s2} across both terminals of the switch S2 is given by the following equation.

[Equation 1]

$$E_{s2} = E_o \times E_x$$

Furthermore, since the average voltage applied across both terminals of the reactor 31 is zero, the average voltage E_{s2} is equal to the storage battery voltage E_B , and is expressed by the following equation.

[Equation 2]

$$E_{s2} = E_B$$

From both equations, the voltage E_B can be calculated by the following equation.

[Equation 3]

$$E_B = E_o \times E_x$$

Therefore, the voltage E_B of the storage battery 10 is obtained as a value obtained by multiplying the output voltage E_o by the control amount E_x .

[0023]

FIG. 6 shows the simulation results where the calculation amount E_x of the control circuit is extracted, and it can be confirmed that the control amount E_x and the storage battery voltage E_B match. Therefore, the voltage E_B of the storage battery can be read from the input control amount E_x of the PWM control block.

Embodiment 1

[0024]

FIG. 7 shows an embodiment applied to a storage battery for an electric vehicle as an example of using a secondary battery as the storage battery. In a configuration in which a storage battery is used as a power source to drive an alternating current motor via an inverter, in the general case where the storage battery is directly used as a direct current power source for the inverter, the voltage drops as the remaining capacity of the storage battery decreases. Therefore, inverter driving properties cannot be sufficiently obtained, and the need to charge the storage battery becomes urgent even though there is remaining capacity that can be used. When the active storage battery of the present invention is used, even if the discharge of the storage battery progresses and the terminal voltage drops, the terminal voltage can be kept constant until the remaining capacity is exhausted, and the battery can be used to the final discharge voltage. Therefore the capacity of the secondary battery can be sufficiently used.

Embodiment 2

[0025]

FIG. 8 shows an embodiment in which the active storage battery of the present invention is applied to a dry battery, as an example of using a primary battery as a storage battery. With manganese batteries in particular, the terminal voltage drops as the remaining capacity decreases, but by applying the active storage battery of the present invention, the battery can be used at a constant voltage until the final discharge voltage.

INDUSTRIAL APPLICABILITY

[0026]

The present invention proposes a system with a new concept of an active storage battery for the purpose of developing a storage battery system that can use the battery without affecting the performance of the device used, even if the voltage of the battery drops. The operation was confirmed by simulation. As a result, the voltage fluctuation caused by charging and discharging of the battery can be compensated actively by charging and discharging the capacitor. It can be confirmed that the voltage information can be read by extracting the voltage fluctuation of the battery from the calculation amount of the control circuit. By operating the inverter, it could be confirmed that the operation could continue without being affected, even if the voltage of the battery dropped. As an example of application to secondary batteries, the present invention is highly useful as an active storage battery for electric vehicles, and as an example of application to primary batteries, the present invention is highly useful as an active storage battery for manganese dry batteries, which have a large drop in terminal voltage when the remaining capacity decreases.

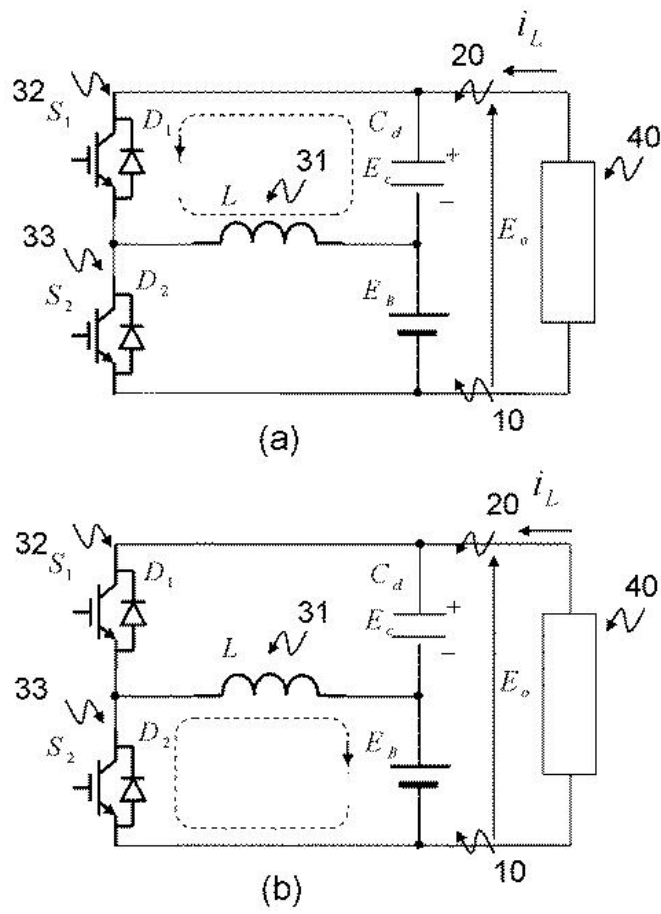
DESCRIPTION OF CODES

[0027]

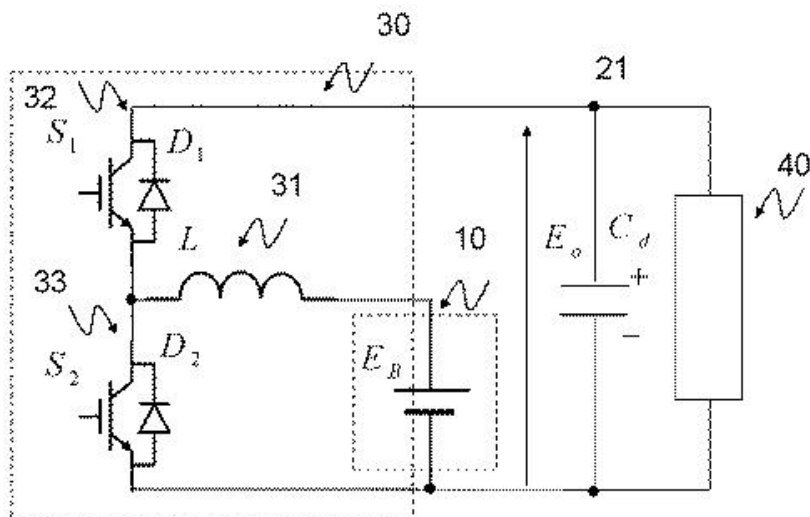
- 10 ... Storage battery
- 20 ... Capacitor
- 30 ... Energy transfer circuit between storage battery and capacitor
- 31 ... Reactor
- 32 ... Switch circuit
- 33 ... Switch circuit
- 40 ... Load circuit
- 50 ... Control block
- 51 ... Voltage controlled PI controller
- 52 ... Saturation function block
- 53 ... Current controlled PI controller
- 54 ... PWM switch signal generating circuit
- 55 ... Logical reversal

Figure 1 consists of two circuit diagrams, (a) and (b), showing a power electronic converter. Both diagrams feature a half-bridge with two MOSFETs (S_1 , S_2) and two diodes (D_1 , D_2). A load inductor L is connected between the MOSFETs. A capacitor C_d is connected between the MOSFETs and the load. A DC source E_b is connected to the MOSFETs. The output voltage is E_o and the output current is i_L . The diagrams are labeled (a) and (b) at the bottom.

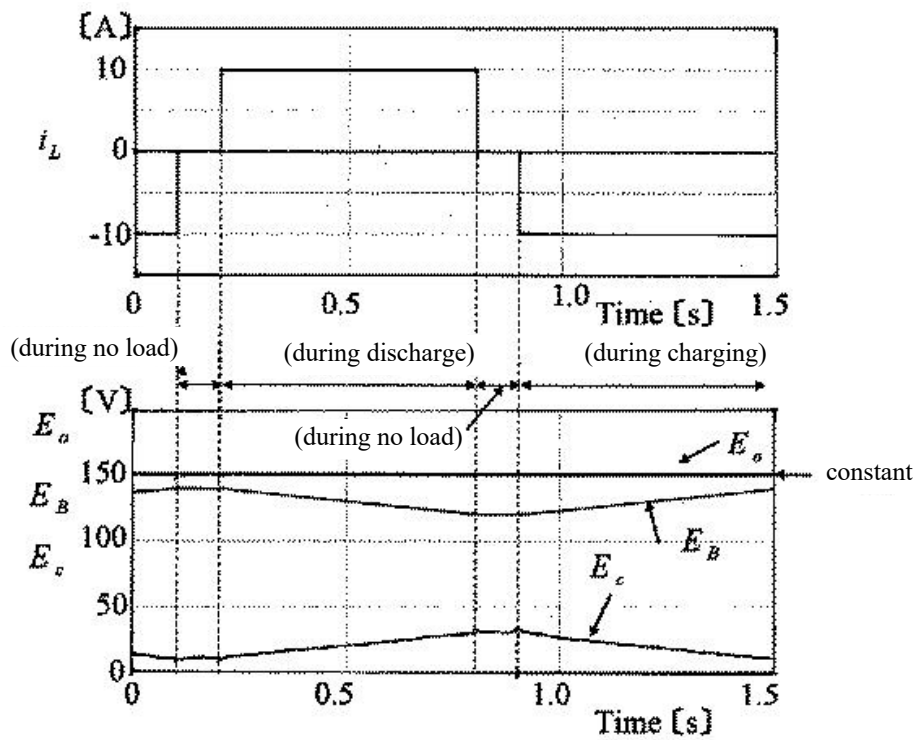
[FIG. 3]



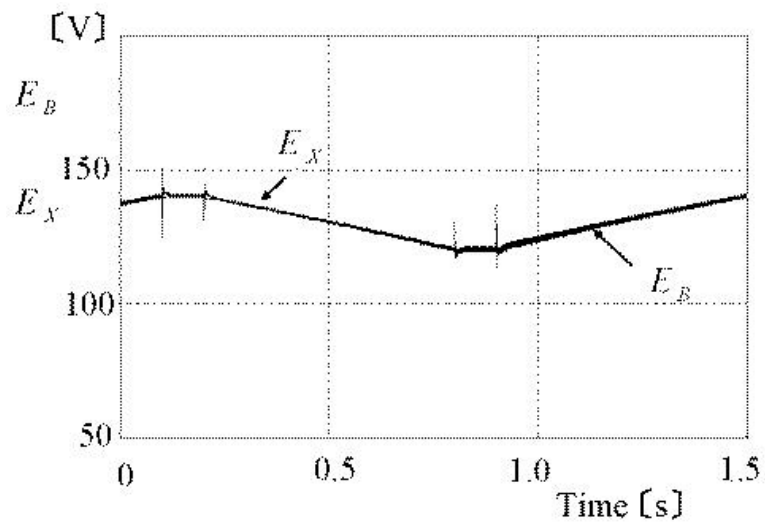
[FIG. 4]



[FIG. 5]

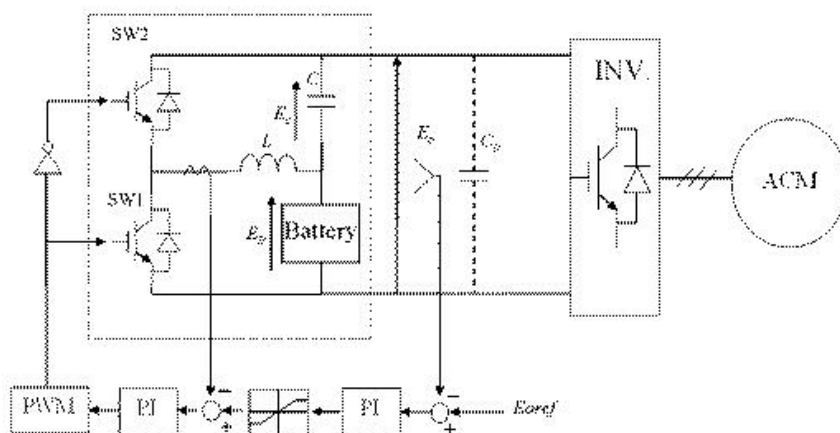


[FIG. 6]



[FIG. 7]

Active storage battery



[FIG. 8]

Active storage battery adapter

