

(43) International Publication Date
28 June 2012 (28.06.2012)

(51) International Patent Classification:

H01M 10/42 (2006.01) *H05B 3/00* (2006.01)
H01M 10/50 (2006.01) *H02J 7/00* (2006.01)

(21) International Application Number:

PCT/CN2011/074433

(22) International Filing Date:

20 May 2011 (20.05.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201010603414.5 23 December 2010 (23.12.2010) CN

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: BATTERY HEATING CIRCUIT

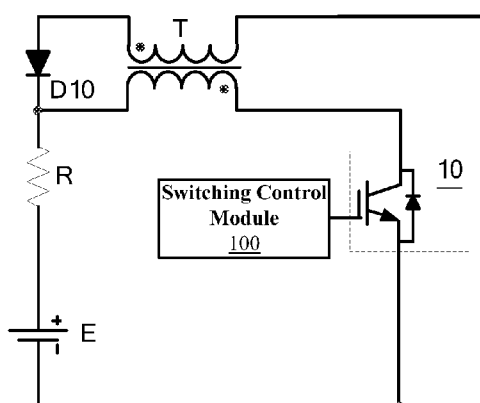


Figure 1

(57) Abstract: The present invention provides a battery heating circuit, comprising a switch unit (10), a switching control module (100), a one-way semiconductor element D10, a damping element R, and a transformer (T), wherein, the switching control module (100) is electrically connected with the switch unit (10); the battery, damping element R, first winding of the transformer (T), and switch unit (10) are connected in series with each other to constitute a battery discharging circuit; the battery, damping element R, second winding of the transformer (T), and one-way semiconductor element D10 are connected in series with each other to constitute a battery charging circuit. The transformer in the present invention serves as an energy storage element, and has current limiting function. The present invention not only can limit the magnitude of current in the battery charging/discharging circuit, thereby the battery and switch unit can be protected against damage by heavy current, but also can reduce the energy loss in the heating process.



WO 2012/083635 A1

BATTERY HEATING CIRCUIT

Technical Field of the Invention

The present invention pertains to electric and electronic field, in particular to a battery
5 heating circuit.

Background of the Invention

In view cars have to run under complex road conditions and environmental conditions or
some electronic devices are used under harsh environmental conditions, the battery, which
10 serves as the power supply unit for electric motor cars or electronic devices, must be adaptive
to these complex conditions. In addition, besides these conditions, the service life and
charging/discharging cycle performance of battery must be considered; especially, when
electric motor cars or electronic devices are used in low temperature environments, the battery
must have outstanding low temperature charging/discharging performance and higher
15 input/output power.

Usually, under low temperature conditions, the resistance of battery will increase, and the
polarization will increase; therefore, the capacity of battery will be reduced.

To keep the capacity of battery and improve the charging/discharging performance of
battery under low temperature conditions, the present invention provides a battery heating
20 circuit.

Summary of the Invention

The object of the present invention is to provide a battery heating circuit, in order to
solve the problem of decreased capacity of battery caused by increased resistance and
25 polarization of battery under low temperature conditions.

The battery heating circuit provided by the present invention comprises a switch unit, a
switching control module, a one-way semiconductor element, a damping element and a
transformer, wherein the switching control module is electrically connected with the switch
unit; the battery, damping element, first winding of the transformer, and switch unit are

connected in series with each other to constitute a battery discharging circuit; the battery, damping element, second winding of the transformer, and one-way semiconductor element are connected in series with each other to constitute a battery charging circuit.

When the battery is to be heated up, the switch unit can be controlled by the switching
5 control module to switch on, and then can be controlled to switch off when the current in the battery discharging circuit reaches to a preset value; after that, the transformer transfers the stored energy back to the battery. In that process, the damping element generates heat as the current flows through it, and thereby heats up the battery. The transformer takes a current limiting role; in addition, the preset value can be set according to the properties of the battery;
10 therefore, the magnitude of current in the battery charging/discharging circuit is controllable, and damages to the battery caused by over-current can be avoided. In addition, since the magnitude of current is controllable, the switch unit is protected against burnt due to generation of vast heat.

Moreover, the transformer in the present invention serves as an energy storage element,
15 and has current limiting function. It can transfer the energy stored in it back to the battery through the battery charging circuit, and thereby can reduce the energy loss in the heating process.

Other characteristics and advantages of the present invention will be further detailed in the embodiments hereunder.

20

Brief Description of the Drawings

The accompanying drawings are provided here to facilitate further understanding on the present invention, and are a part of this document. They are used together with the following embodiments to explain the present invention, but shall not be comprehended as
25 constituting any limitation to the present invention. In the figures:

Figure 1 is a circuit diagram of the heating circuit provided in the present invention;

Figure 2 is a timing sequence diagram of waveform of the heating circuit provided in the present invention;

Figure 3 is a circuit diagram of the heating circuit according to the first embodiment of
30 the present invention;

Figure 4 is a circuit diagram of the heating circuit according to the second embodiment of the present invention;

Figure 5 is a circuit diagram of the heating circuit according to the third embodiment of the present invention;

5 Figure 6 is a circuit diagram of an embodiment of the switch unit in the heating circuit provided in the present invention; and

Figure 7 is a circuit diagram of another embodiment of the switch unit in the heating circuit provided in the present invention.

10 Detailed Description of the Embodiments

Hereunder the embodiments of the present invention will be detailed, with reference to the accompanying drawings. It should be appreciated that the embodiments described here are only provided to describe and explain the present invention, but shall not be deemed as constituting any limitation to the present invention.

15 Please note: unless otherwise specified, where mentioned in the following text, the term "switching control module" refers to any controller that can output control commands (e.g., pulse waveform) under preset conditions or at preset times and thereby controls the switch unit connected to it to switch on or switch off accordingly, for example, the switching control module can be a PLC; where mentioned in the following text, the term "switch" refers to a
20 switch that achieve ON/OFF control by means of electrical signals or achieve ON/OFF control on the basis of the characteristics of the element or component, which is to say, the switch can be an one-way switch (e.g., a switch composed of a two-way switch and a diode connected in series, which can switch on in one direction) or a two-way switch (e.g., a Metal Oxide Semiconductor Field Effect Transistor (MOSFET) or an IGBT with an anti-parallel
25 freewheeling diode); where mentioned in the following text, the term "two-way switch" refers to a switch that can switch on in two ways, which can achieve ON/OFF control by means of electrical signals or achieve ON/OFF control on the basis of the characteristics of the element or component, for example, the two-way switch can be a MOSFET or an IGBT with an anti-parallel freewheeling diode; where mentioned in the following text, the term "one-way
30 semiconductor element" refers to a semiconductor element that can switch on in one direction,

such as an diode; where mentioned in the following text, the term "charge storage element" refers to any device that can implement charge storage, such as a capacitor; where mentioned in the following text, the term "current storage element" refers to any device that can store current, such as an inductor; where mentioned in the following text, the term "forward
5 direction" refers to the direction in which the energy flows from the battery to the energy storage circuit, and the term "reverse direction" refers to the direction in which the energy flows from the energy storage circuit to the battery; where mentioned in the following text, the term "battery" comprises primary battery (e.g., dry battery or alkaline battery, etc.) and secondary battery (e.g., lithium-ion battery, nickel-cadmium battery, nickel-hydrogen battery,
10 or lead-acid battery, etc.); where mentioned in the following text, the term "damping element" refers to any device that inhibits current flowing and thereby achieves energy consumption, such as a resistor; where mentioned in the following text, the term "main loop" refers to a loop composed of battery, damping element, switch unit and energy storage circuit connected in series.

15 It should be noted specially: in view different types of batteries have different characteristics, in the present invention, the "battery" refers to an ideal battery that doesn't have internal parasitic resistance and inductance or has very low internal parasitic resistance and inductance, or refers to a battery pack that has internal parasitic resistance and inductance; therefore, those skilled in the art should appreciate: if the battery is an ideal battery that
20 doesn't have internal parasitic resistance and inductance or has very low internal parasitic resistance and inductance, the damping element R refers to an damping element external to the battery; if the battery is a battery pack that has internal parasitic resistance and inductance, the damping element R refers to a damping element external to the battery, or refers to the parasitic resistance in the battery pack.

25 To ensure the normal service life of the battery, the battery can be heated under low temperature condition, which is to say, when the heating condition is met, the heating circuit is controlled to start heating for the battery; when the heating stop condition is met, the heating circuit is controlled to stop heating.

In the actual application of battery, the battery heating condition and heating stop
30 condition can be set according to the actual ambient conditions, to ensure normal

charging/discharging performance of the battery.

Figure 1 is a circuit diagram of the heating circuit provided in the present invention. As shown in Figure 1, the present invention provides a battery heating circuit, comprising a switch unit 10, a switching control module 100, a one-way semiconductor element D10, a damping element R and a transformer T, wherein, the switching control module 100 is electrically connected with the switch unit 10; the battery E, damping element R, first winding of the transformer T, and switch unit 10 are connected in series with each other to constitute a battery discharging circuit; and the battery E, damping element R, second winding of the transformer T, and one-way semiconductor element D10 are connected in series with each other to constitute a battery charging circuit.

Wherein, the switching control module 100 can control the switch unit 10 to switch off when the current flowing through the battery E reaches to a preset value in the positive half cycle, and can control the switch unit 10 to switch on when the current flowing through the battery E reaches to zero in the negative half cycle. By keeping the current flowing through the damping element R continuously, the damping element R generates heat, and thereby heats up the battery E.

Figure 2 is a timing sequence diagram of waveform of the heating circuit provided in the present invention. Hereunder the working process of the heating circuit provided in the present invention will be described, with reference to Figure 2. First, the switching control module 100 controls the switch unit 10 to switch on; now, the positive electrode of the battery E is connected with the negative electrode of the battery E and forms a closed circuit; thus, the current I_{main} in the battery E rises up slowly due to the existence of the inductance in transformer T (see the time period t1), and some energy is stored in the transformer T. When the current I_{main} in the battery E reaches to a preset value, the switching control module 100 controls the switch unit 10 to switch off; now, the transformer T transfers the energy stored in it back to the battery through the one-way semiconductor element D10, as indicated by the time period t2. After that, when the current in the battery E is zero, the switching control module 100 controls the switch unit 10 to switch on again, and thus another cycle starts. The cycles continue on and on, till the battery E is heated up satisfactorily.

In the working process of the heating circuit described above, owing to the existence of

the inductance in the transformer T, the current I_{main} in the battery E is limited; alternatively, the magnitude of the current I_{main} in the battery E can be controlled by controlling the switch-off time of the switch unit 10 with the switching control module 100. Moreover, the magnitude of the charging/discharging current of the battery E can be controlled by changing the ratio of winding between the first winding (i.e., primary coil) and the second winding (i.e., secondary coil) of the transformer T. The higher the ratio of winding between the first winding and the second winding is, the smaller the current charged back from the second wiring to the battery E will be.

When the switch unit 10 switches from ON state to OFF state, very high voltage will be induced in the first winding of the transformer T; when the induced voltage is superposed with the voltage of the battery E on the switch unit 10, damage to the switch unit 10 may occur. Preferably, as shown in Figure 3, the heating circuit can further comprises a first voltage absorption circuit 210, which is connected in parallel between the ends of the first winding of the transformer T, and the first voltage absorption circuit 210 is configured to consume the voltage induced in the first winding when the switch unit 10 switches off, so as to protect the switch unit 10 from damaged by the induced voltage. The first voltage absorption circuit 210 can comprise a one-way semiconductor element D1, a charge storage element C1 and a damping element R1, wherein, the one-way semiconductor element D1 is connected in series with the charge storage element C1, and the damping element R1 is connected in parallel between the ends of the charge storage element C1. Thereby, when the switch unit 10 switches from ON state to OFF state, the voltage induced in the first winding of the transformer T will force the one-way semiconductor element D1 to switch on, and the electric energy will be sustained via the charge storage element C1; in addition, after that, the electric energy is consumed by the damping element R1, and thereby the voltage induced in the first winding of the transformer T is absorbed, to avoid damage to the switch unit 10.

Preferably, as shown in Figure 4, the heating circuit can further comprise a second voltage absorption circuit 220 connected in parallel between the ends of the switch unit 10, which is also configured to consume the voltage induced in the first winding of the transformer T, so as to avoid damage to the switch unit 10. The second voltage absorption circuit 220 comprises a one-way semiconductor element D2, a charge storage element C2 and

a damping element R2, wherein, the one-way semiconductor element D2 is connected in series with the charge storage element C2, the damping element R2 is connected in parallel between the ends of the one-way semiconductor element D2. Thereby, when the switch unit 10 switches from ON state to OFF state, the voltage induced in the first winding of the transformer T will force the one-way semiconductor element D2 to switch on, and the electric energy will be sustained via the charge storage element C2; in addition, after that, the electric energy is consumed by the damping element R2 when the switch unit 10 switches on, and thereby the voltage induced in the first winding of the transformer T is absorbed, to avoid damage to the switch unit 10.

The first voltage absorption circuit 210 and second voltage absorption circuit 210 can be contained in the heating circuit provided in the present invention at the same time, as shown in Figure 5; in that case, better voltage absorption effect can be achieved, and the switch unit 10 can be protected better. Of course, the structure of the first voltage absorption circuit 210 and second voltage absorption circuit 210 is not limited to the circuit structure described above, which is to say, any applicable absorption circuit can be used here.

In addition, it should be noted: the "preset value" mentioned above shall be set according to the current endurable by the battery E and other elements/components in the heating circuit, with comprehensive consideration of heating efficiency and protection of battery E against damages, as well as the size, weight and cost of the heating circuit.

Figure 6 is a circuit diagram of an embodiment of the switch unit in the heating circuit provided in the present invention. As shown in Figure 6, the switch unit 10 can comprise a switch K11 and a one-way semiconductor element D11 connected in parallel with the switch K11 in reverse direction, wherein, the switching control module 100 is electrically connected with the switch K11, and is configured to control ON/OFF of the branches of the switch unit 10 in forward direction by controlling ON/OFF of the switch K11.

Figure 7 is a circuit diagram of another embodiment of the switch unit in the heating circuit provided in the present invention. As shown in Figure 7, the switch unit 10 can comprise a switch K12 and a one-way semiconductor element D12 connected in series with each other, wherein, the switching control module 100 is electrically connected with the switch K12, and is configured to control ON/OFF of the switch unit 10 by controlling

ON/OFF of the switch K12.

The heating circuit provided in the present invention has the following advantages:

(1) With the current limiting function of the transformer T, the magnitude of current in the battery charging/discharging circuit can be limited, and thereby the battery and switch unit
5 can be protected against damage by heavy current;

(2) The magnitude of current in the battery charging/discharging circuit can also be controlled by controlling the switch-off time of the switch unit 10, so as to protect the battery and switch unit against damage by heavy current; and

(3) The transformer T is an energy storage element, which can store the energy in the
10 battery discharging process, and then charge back the energy to the battery, so as to reduce the energy loss in the battery heating process.

While some preferred embodiments of the present invention are described above with reference to the accompanying drawings, the present invention is not limited to the details in those embodiments. Those skilled in the art can make modifications and variations to the
15 technical scheme of the present invention, without departing from the spirit of the present invention. However, all these modifications and variations shall be deemed as falling into the protected domain of the present invention.

In addition, it should be noted: the specific technical features described in above embodiments can be combined in any appropriate form, provided that there is no conflict.
20 To avoid unnecessary repetition, the possible combinations are not described specifically in the present invention. Moreover, the different embodiments of the present invention can be combined freely as required, as long as the combinations don't deviate from the ideal and spirit of the present invention. However, such combinations shall also be deemed as falling into the scope disclosed in the present invention.

Claims

1. A battery heating circuit, comprising a switch unit (10), a switching control module (100), a one-way semiconductor element D10, a damping element R and a transformer (T),
5

wherein the switching control module (100) is electrically connected with the switch unit (10);

the battery, the damping element R, the first winding of the transformer (T), and the switch unit (10) are connected in series with each other to constitute a battery
10 discharging circuit;

the battery, the damping element R, the second winding of the transformer (T), and the one-way semiconductor element D10 are connected in series with each other to constitute a battery charging circuit.

15 2. The battery heating circuit according to claim 1, wherein the damping element R is the parasitic resistance in the battery.

3. The battery heating circuit according to claim 1, wherein the heating circuit further comprises a first voltage absorption circuit (210) connected in parallel between
20 the ends of the first winding of the transformer (T), and the first voltage absorption circuit (210) is configured to consume the voltage induced in the first winding when the switch unit (10) switches off.

4. The battery heating circuit according to claim 3, wherein the first voltage
25 absorption circuit (210) comprises a one-way semiconductor element D1, a charge storage element C1 and a damping element R1, wherein the one-way semiconductor element D1 is connected in series with the charge storage element C1, and the damping element R1 is connected in parallel between the ends of the charge storage element C1.

30

5. The battery heating circuit according to claim 4, wherein the charge storage element C1 is a capacitor, and the damping element R1 is a resistor.

6. The battery heating circuit according to claim 1 or 3, wherein the heating circuit further comprises a second voltage absorption circuit (220) connected in parallel between the ends of the switch unit (10), the second voltage absorption circuit (220) is configured to consume the voltage induced in the first winding when the switch unit (10) switches off.

7. The battery heating circuit according to claim 6, wherein the second voltage absorption circuit (220) comprises a one-way semiconductor element D2, a charge storage element C2 and a damping element R2, wherein the one-way semiconductor element D2 is connected in series with the charge storage element C2, and the damping element R2 is connected in parallel between the ends of the one-way semiconductor element D2.

8. The battery heating circuit according to claim 7, wherein the charge storage element C2 is a capacitor, and the damping element R2 is a resistor.

9. The battery heating circuit according to claim 1, wherein the switch unit (10) comprises a switch K11 and a one-way semiconductor element D11 connected in parallel with the switch K11 in reverse direction, and the switching control module (100) is electrically connected with the switch K11, and the switching control module (100) is configured to control ON/OFF of the branches of the switch unit (10) in forward direction by controlling ON/OFF of the switch K11.

10. The battery heating circuit according to claim 1, wherein the switch unit (10) comprises a switch K12 and a one-way semiconductor element D12 connected in series with each other, and the switching control module (100) is electrically connected with the switch K12, and the switching control module (100) is configured to control ON/OFF of the switch unit (10) by controlling ON/OFF of the switch K12.

11. The battery heating circuit according to claim 1, wherein the switching control module (100) controls the switch unit (10) to switch off when the current flowing through the battery reaches to a preset value in the positive half cycle, and controls the switch unit (10) to switch on when the current flowing through the battery reaches to zero in the negative half cycle.

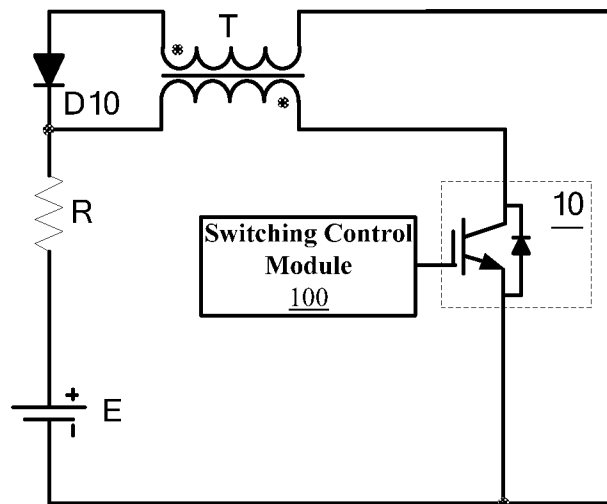


Figure 1

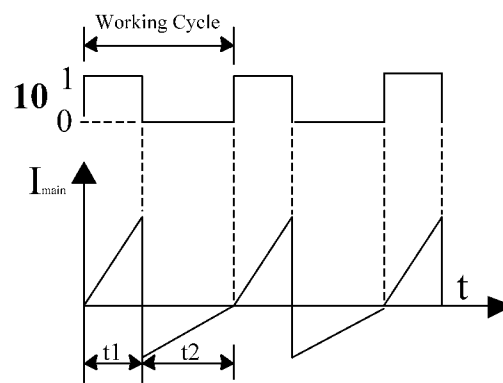


Figure 2

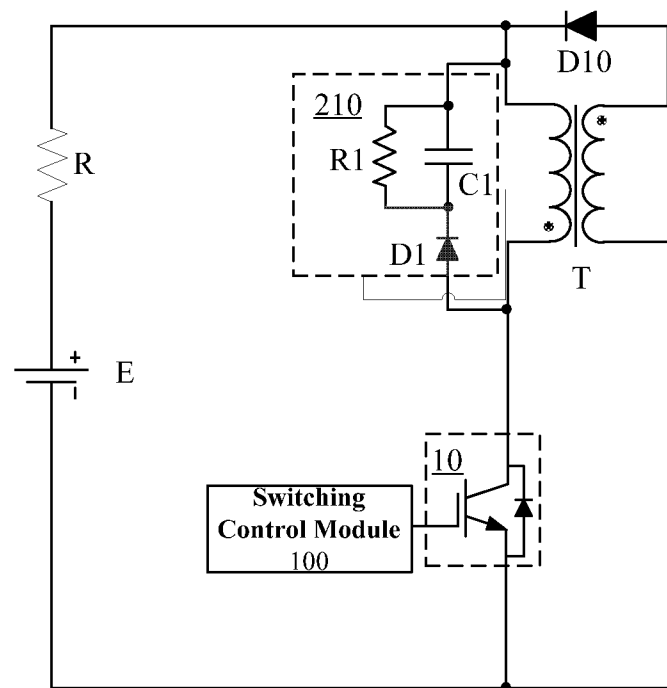


Figure 3

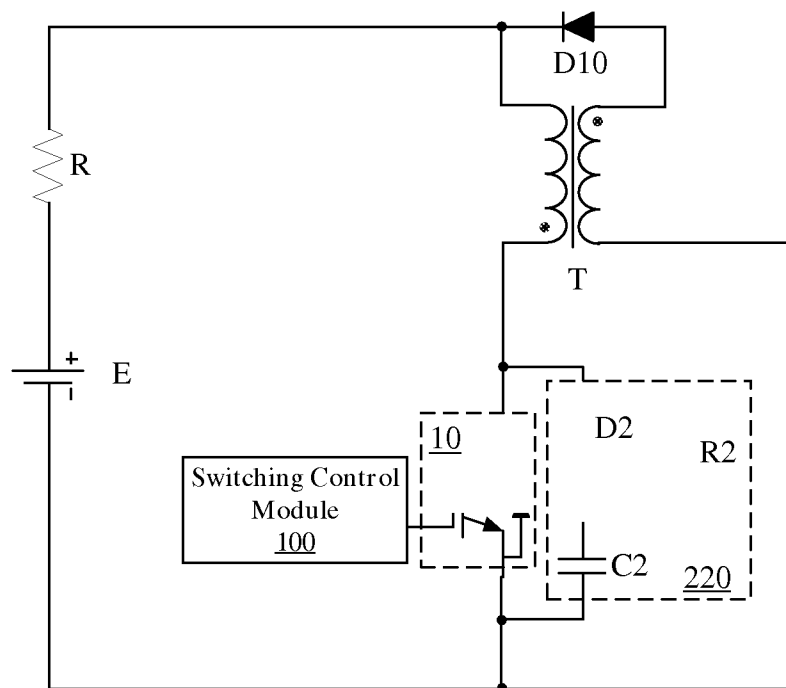


Figure 4

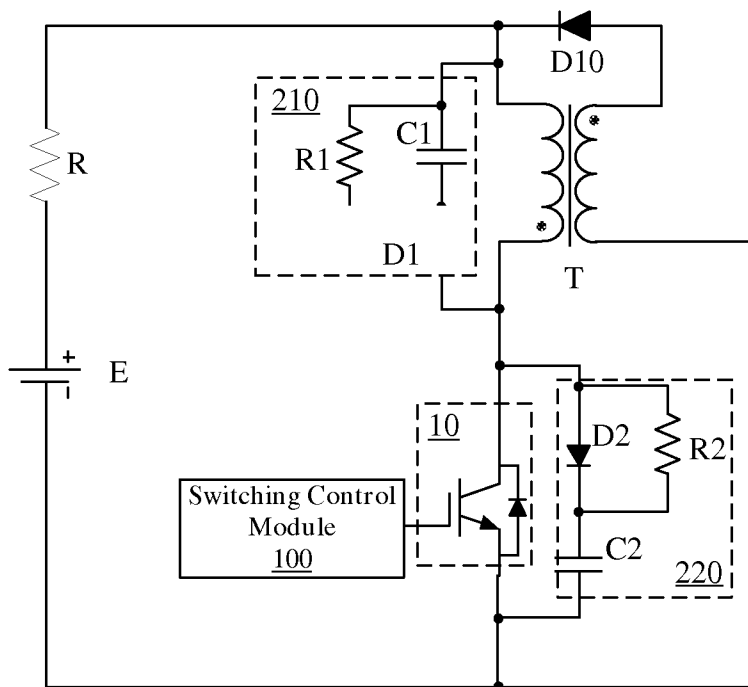


Figure 5

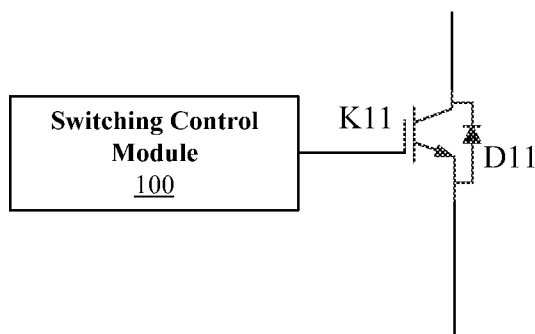


Figure 6

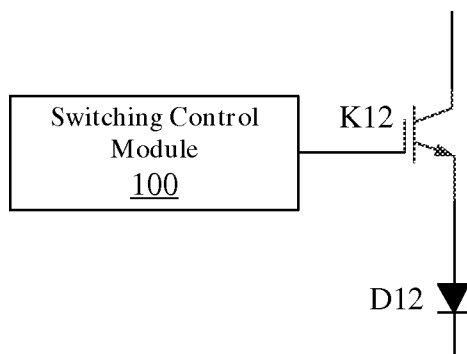


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/074433

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01M, H02J7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, VEN, CNKI, battery, cell, transformer, switch, heating, discharge, charge

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP4016045B2 (NTT DATA EX TECHNO CORP) 05 Dec. 2007 (05.12.2007) The whole document	1-11
A	CN1836356A (UNIV LEICESTER) 20 Sep. 2006 (20.09.2006) the whole document	1-11

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 05 Jul. 2011 (05.07.2011)	Date of mailing of the international search report 11 Aug. 2011 (11.08.2011)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer YIN, Lumin Telephone No. (86-10)62411544

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/074433

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP4016045B2	05.12.2007	JP2007166779A	28.06.2007
CN1836356A	20.09.2006	GB2403609A	05.01.2005
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/074433

A. CLASSIFICATION OF SUBJECT MATTER

H01M 10/42 (2006.01) i

H01M 10/50 (2006.01) i

H05B 3/00 (2006.01) i

H02J 7/00 (2006.01) i