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LITHIUM BATTERY SAFETY PROTECTION SYSTEM FOR UNDERGROUND COAL MINING EQUIPMENT.

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The disclosure discloses a lithium battery safety protection system for underground coal mining equipment, including an overdischarge/overcharge monitoring module, a short-circuit monitoring module and a logical judgment and drive module. When a lithium battery is overcharged or overdischarged, the overdischarge/overcharge monitoring module respectively generates an overcharge output signal or an overdischarge output signal to the logical judgment and drive module. When an overcurrent/short-circuit occurs to a power supply loop of the lithium battery, the short-circuit monitoring module generates a low-level overcurrent/short-circuit output signal to the logical judgment and drive module. The logical judgment and drive module controls the charge, discharge or power supply of the lithium battery to be off when receiving the corresponding output signal. The disclosure can monitor the overcharge, overdischarge or overcurrent/short-circuit of the lithium battery and realize the automatic protection function according to the monitoring results.

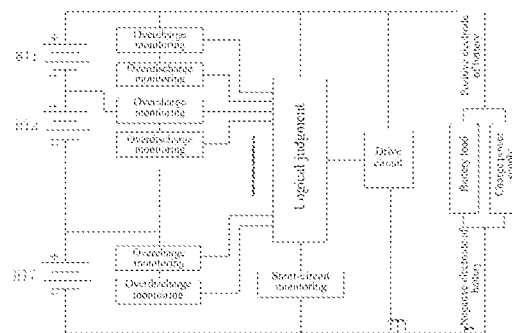


FIG. 1

LITHIUM BATTERY SAFETY PROTECTION SYSTEM FOR UNDERGROUND COAL MINING EQUIPMENT

TECHNICAL FIELD

The disclosure relates to the field of lithium battery protection systems, in particular to a lithium battery safety protection system for underground coal mining equipment.

BACKGROUND

In order to ensure safety in production, underground coal mining equipment such as local ventilation fans and mobile extractor pumps has high requirements for the continuity of power supply. However, due to the complex underground working environment, it is prone to a power failure and thus deenergization of equipment. Therefore, the underground coal mining equipment also has high requirements for backup power supplies. A lithium battery, due to its high specific energy, high discharge rate and no memory effect as well as good high/low temperature performance and higher operating voltage, is an ideal option as a backup power supply.

The lithium battery is different from cadmium-nickel and nickel-hydrogen batteries in that the safety of the lithium battery must be considered when charging and discharging. A deep overcharge may lead to decomposition of organic electrolyte in the lithium battery and production of gas, and in severe cases, the case will be deformed or even burst. An overdischarge will change the lattice structure of the positive electrode material of the battery, causing degradation of electrical performance and capacity. A short-circuit may generate a large current in an instant and a sharp increase in the internal temperature of the battery, causing safety accidents such as battery leakage and fire. As a result, the lithium battery must be designed with reliable overcharge, undervoltage and short-circuit protection circuits to prevent the lithium battery from overcharge, overdischarge and overcurrent.

Industrial and civil lithium batteries at home and abroad usually use a charge/discharge protection chip as the core part for lithium battery protection. The charge/discharge protection chip realizes various functions of lithium battery protection. The charge/discharge protection chip not only controls charge parameters such as current and voltage, but also protects the charge/discharge process. The charge/discharge protection chip is a key part of the performance of the lithium battery. After the lithium battery is discharged to a certain voltage, the battery voltage drops sharply, and a further discharge after that point will have a bad effect on the service life of the battery. The overdischarged battery has a voltage of a linear resistance, and serious overdischarge of the lithium battery will cause a short-circuit failure in the lithium battery.

Moreover, the lithium battery requires a high accuracy for the charge cut-off voltage, and the error cannot exceed 1% of the rated value. A too high cut-off voltage will affect the life of the lithium battery, and even cause overcharge, causing permanent damage to the battery. A too low cut-off voltage will lead to incomplete charge, which may reduce the service life of the battery. When a short-circuit occurs in the lithium battery, there is a sharp increase in the discharge current and a sharp increase in the internal temperature of the battery in an instant. If no protective measures are taken, safety problems may occur. Therefore, the main mechanisms that affect the reliability, safety and life of lithium batteries are overdischarge, overcharge and external short-circuit caused by improper use.

SUMMARY

An object of the disclosure is to provide a lithium battery safety protection system for underground coal mining equipment, in order to solve the problems of an overcharge, an overdischarge and an overcurrent/short-circuit in the lithium battery in the prior art.

In order to achieve the above object, the technical solution adopted by the disclosure is:

A lithium battery safety protection system for underground coal mining equipment includes an overdischarge/overcharge monitoring module, a short-circuit monitoring

module and a logical judgment and drive module.

The overdischarge/overcharge monitoring module includes a first dual operational amplifier chip, a first voltage divider circuit and a second voltage divider circuit. The two voltage divider circuits are respectively connected between a positive electrode and a negative electrode of a lithium battery. The first dual operational amplifier chip samples a voltage of the lithium battery being charged through the first voltage divider circuit, and the first dual operational amplifier chip samples a voltage of the lithium battery being discharged through the second voltage divider circuit. When the sampled voltage of the lithium battery being charged is greater than a charge cut-off voltage, a voltage sampled by the first dual operational amplifier chip from the first voltage divider circuit is greater than a reference voltage of the first dual operational amplifier chip, and in this case, an output pin of the first dual operational amplifier chip outputs a low-level overcharge output signal to the logical judgment and drive module. When the sampled voltage of the lithium battery being discharged is less than a discharge cut-off voltage, a voltage sampled by the first dual operational amplifier chip from the second voltage divider circuit is less than the reference voltage of the first dual operational amplifier chip, and in this case, another output pin of the first dual operational amplifier chip outputs a low-level overdischarge output signal to the logical judgment and drive module.

The short-circuit monitoring module includes a second dual operational amplifier chip, a power resistor and a third voltage divider circuit. The power resistor is connected to a loop formed by the lithium battery and a load. The power resistor is connected in parallel with the third voltage divider circuit to form a shunt circuit, and the second dual operational amplifier chip samples a voltage through the third voltage divider circuit. When an overcurrent or an open circuit occurs to the loop formed by the lithium battery and the load, a current in a branch of the power resistor in the shunt circuit and a current in a branch formed by the third voltage divider circuit both increase, a voltage sampled by the second dual operational amplifier chip from the third voltage divider circuit is greater than the reference voltage of the dual operational amplifier chip, and in this case, an output pin of the second dual operational amplifier chip outputs a low-level

overcurrent/short-circuit output signal to the logical judgment and drive module.

The logical judgment and drive module includes two MOS switch transistors and four transistors. The two MOS switch transistors are connected in inverse series through sources and drains and then connected between one electrode of the lithium battery and the load. Gates of the two MOS switch transistors are connected to collectors of two of the transistors in one-to-one correspondence. Sources of the two transistors connected to the MOS switch transistors are respectively connected between the other electrode of the lithium battery and the load. Bases of the two transistors connected to the MOS switch transistors are connected to collectors of the rest two transistors in one-to-one correspondence. Emitters of the rest two transistors are connected together between the inverse series connection branch formed by the two MOS switch transistors and the corresponding electrode of the lithium battery. A base of one of the rest two transistors is connected to the output pin of the first dual operational amplifier chip outputting the overcharge output signal in the overdischarge/overcharge monitoring module. A base of the other transistor is connected to an output terminal of a NAND gate. One input terminal of the NAND gate is connected to the output pin of the first dual operational amplifier chip outputting the overdischarge output signal in the overdischarge/overcharge monitoring module, and the other input terminal of the NAND gate is connected to the output pin of the second dual operational amplifier chip outputting the overcurrent/short-circuit output signal in the short-circuit monitoring module. When an overcharge occurs, the transistor corresponding to the overcharge output signal and the transistor connected to the collector thereof are both in a cut-off state, and at this time, the corresponding MOS switch transistor is turned off and the lithium battery is incapable of being charged. When an overdischarge or an overcurrent/short-circuit occurs, the transistor corresponding to the NAND gate and the transistor connected to the collector thereof are both in a cut-off state, and at this time, the corresponding other MOS switch transistor is turned off and the lithium battery is incapable of being discharged.

Further, when the lithium battery includes a plurality of lithium cells and the

plurality of lithium cells are connected in series for power supply, each lithium cell is provided with one overdischarge/overcharge monitoring module, and a series structure formed by the plurality of lithium cells shares one short-circuit monitoring module.

Further, the first dual operational amplifier chip in the overdischarge/overcharge monitoring module and the second dual operational amplifier chip in the short-circuit monitoring module are both powered by the lithium battery.

Further, the overdischarge/overcharge monitoring module further includes a hysteresis discharge protection circuit. One end of the hysteresis discharge protection circuit is connected to the output pin of the first dual operational amplifier chip outputting the overcharge output signal, and the other end of the hysteresis discharge protection circuit is connected to the first voltage divider circuit.

Further, in the short-circuit monitoring module, a magnitude of a resistance of either the power resistor or the third voltage divider circuit is adjusted to set a magnitude of a current output by the lithium battery to the load.

Further, in the logical judgment and drive module, when an overcharge occurs, the corresponding MOS switch transistor is turned off such that the lithium battery is incapable of being charged, and at this time, the lithium battery is discharged through the MOS switch transistor.

Further, in the logical judgment and drive module, when an overdischarge or an overcurrent/short-circuit occurs, the corresponding MOS switch transistor is turned off such that the lithium battery is incapable of being discharged, and at this time, the lithium battery is charged through the MOS switch transistor.

Compared with the prior art, the disclosure has the following advantages:

For the safety of the backup power supply for underground coal mining equipment, the disclosure provides a lithium battery safety protection system for underground coal mining equipment, which can monitor the overcharge, overdischarge and overcurrent/short-circuit of the lithium battery and realize an automatic protection function according to the monitoring results, thereby improving the safety of the underground coal mining equipment.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a structural block diagram of a system of the disclosure;

FIG. 2 is a circuit diagram of an overdischarge/overcharge monitoring module of the disclosure;

FIG. 3 is a circuit diagram of a short-circuit monitoring module of the disclosure; and

FIG. 4 is a circuit diagram of a logical judgment and drive module of the disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

The disclosure will be further described below in conjunction with the accompanying drawings and the examples.

As shown in FIG. 1, the disclosure provides a lithium battery safety protection system for underground coal mining equipment, which is used for a lithium battery formed by connecting a plurality of lithium cells in series and includes an overdischarge/overcharge monitoring module, a short-circuit monitoring module and a logical judgment and drive module.

In the disclosure, there are a plurality of the overdischarge/overcharge monitoring modules each configured for each lithium cell in one-to-one correspondence. Each overdischarge/overcharge monitoring module is used for monitoring an overcharge or an overdischarge of the corresponding lithium cell and correspondingly outputting an overcharge output signal and an overdischarge output signal to the logical judgment and drive module.

Specifically, as shown in FIG. 2, the overdischarge/overcharge monitoring module includes an LM158 first dual operational amplifier chip U2, a first voltage divider circuit and a second voltage divider circuit. The first voltage divider circuit is formed by connecting a resistor R3 and a resistor R4 in series, and the second voltage divider circuit is formed by connecting a resistor R1 and a resistor R2 in series. One end of the first voltage divider circuit is connected to a positive electrode of the corresponding lithium cell BT, and the other end is connected to a negative electrode of the corresponding

lithium cell BT. Similarly, one end of the second voltage divider circuit is connected to the positive electrode of the corresponding lithium cell BT, and the other end is connected to the negative electrode of the corresponding lithium cell BT.

A 1IN- pin of the first dual operational amplifier chip U2 is connected between the resistor R3 and the resistor R4 in the first voltage divider circuit. A 1IN+ pin of the first dual operational amplifier chip U2 and a 2IN- pin of the first dual operational amplifier chip U2 are connected together and then connected to a negative electrode of a precision voltage reference U1 through a resistor. The negative electrode of the precision voltage reference U1 is also connected to an negative electrode of the lithium cell BT through another resistor. A positive electrode of the precision voltage reference U1 is connected to the positive electrode of the lithium cell BT. The lithium cell BT supplies power to the precision voltage reference U1, and the precision voltage reference U1 outputs a reference voltage to the first dual operational amplifier chip U2. A 2IN+ pin of the first dual operational amplifier chip U2 is connected between the resistor R1 and the resistor R2 in the second voltage divider circuit. The second voltage divider circuit and a capacitor C are connected in parallel between the positive electrode and the negative electrode of the lithium cell BT.

A VCC pin of the first dual operational amplifier chip U2 is connected to the negative electrode of the lithium cell BT, and a GND pin of the first dual operational amplifier chip U2 is connected to the positive electrode of the lithium cell BT. The lithium cell BT supplies power to the first dual operational amplifier chip U2. A 1OUT pin of the first dual operational amplifier chip U2 is used as an output pin for outputting the overdischarge output signal to the logical judgment and drive module, and a 2OUT pin of the first dual operational amplifier chip U2 is used as an output pin for outputting the overcharge output signal to the logical judgment and drive module.

The overdischarge/overcharge monitoring module further includes a hysteresis discharge protection circuit formed by connecting a diode D and a resistor R5 in series. A negative electrode of the diode D in the hysteresis discharge protection circuit is connected to one end of the resistor R5 to form a series connection. The positive electrode

of the diode D is connected between the resistor R1 and the resistor R2 in the second voltage divider circuit. The other end of the resistor R5 is connected to the 2OUT pin of the first dual operational amplifier chip U2.

In the overdischarge/overcharge monitoring module, in order to ensure equalization of the lithium battery during the charge/discharge, the precision voltage reference U1 and the first dual operational amplifier chip U2 in the circuit are respectively powered by the corresponding monitored lithium cell BT.

The first dual operational amplifier chip U2 samples a voltage of the lithium cell BT through a voltage division between the resistors R3 and R4 of the first voltage divider circuit, and compares the sampled voltage with the reference voltage (1.25 V) output by the precision voltage reference U1 to the first dual operational amplifier chip U2. When the voltage of the lithium cell is greater than a charge cut-off voltage (4.2 V), a voltage sampled by the first dual operational amplifier chip U2 from the voltage division of the first voltage divider circuit is greater than the reference voltage (1.25 V), and the 2OUT pin of the first dual operational amplifier chip U2 outputs a low-level overcharge output signal to the logical judgment and drive module, such that the logical judgment and drive module shuts off charge of the lithium cell BT, thereby preventing the lithium battery from being overcharged.

The first dual operational amplifier chip U2 samples a voltage of the lithium cell BT through a voltage division between the resistors R1 and R2 of the second voltage divider circuit, and compares the sampled voltage with the reference voltage (1.25 V) output by the precision voltage reference U1 to the first dual operational amplifier chip U2. When the voltage of the lithium cell is less than a discharge cut-off voltage (3.0 V), a voltage sampled by the first dual operational amplifier chip U2 from the voltage division of the second voltage divider circuit is less than the reference voltage (1.25 V), and the 1OUT pin of the first dual operational amplifier chip U2 outputs a low-level overdischarge output signal to the logical judgment and drive module, such that the logical judgment and drive module shuts off discharge of the lithium cell BT, thereby preventing the lithium battery from being overdischarged.

In the overdischarge/overcharge monitoring module, the diode D and the resistor R5 are used for hysteresis discharge protection. A forward voltage of the diode D is a hysteresis voltage. This design can avoid the problem of deep overdischarge caused by voltage rebound and hiccup after the end of discharge of the lithium battery.

In the disclosure, there is one short-circuit monitoring module. The lithium cells connected in series in the lithium battery share the short-circuit monitoring module. The short-circuit monitoring module collects a current in a loop where the lithium battery supplies power to the load, and outputs an overcurrent/short-circuit output signal to the logical judgment and drive module when an overcurrent/short-circuit occurs.

Specifically, as shown in FIG. 3, the short-circuit monitoring module includes an LM158 second dual operational amplifier chip U4, a power resistor Rx and a third voltage divider circuit. In a lithium battery formed by connecting lithium cells BT1, BT2, ..., BTn in series, the lithium cells share the short-circuit monitoring module, and the lithium battery is connected to a load to form a loop.

The third voltage divider circuit is formed by connecting a R11 and a resistor R10 in series. One end of the third voltage divider circuit is connected to a total negative electrode of the lithium battery, and the other end of the third voltage divider circuit is connected to a 2IN+ pin of the second dual operational amplifier chip U4 through a resistor R12. The other end of the third voltage divider circuit and the resistor R12 are connected to a negative electrode of a precision voltage reference U3 through a resistor R7. The negative electrode of the precision voltage reference U3 is also connected to a total positive electrode of the lithium battery through a resistor R6. A positive electrode of the precision voltage reference U3 is connected to the total negative electrode of the lithium battery. The lithium battery supplies power to the precision voltage reference U3, and the precision voltage reference U3 supplies a reference voltage to the second dual operational amplifier chip U4. A 1IN- pin of the second dual operational amplifier chip U4 is connected between the resistor R11 and the resistor R10 in the third voltage divider circuit so as to divide the sampled voltage.

One end of the power resistor Rx is connected between the third voltage divider

circuit and the total negative electrode of the lithium battery, and the other end of the power resistor Rx is connected to the load. Thereby, the power resistor Rx and the third voltage divider circuit are connected in parallel, and the lithium battery supplies power to the load through the parallel circuit formed by the power resistor Rx and the third voltage divider circuit.

A VCC pin of the second dual operational amplifier chip U4 is connected to the total negative electrode of the lithium battery through a capacitor C3. The VCC pin of the second dual operational amplifier chip U4 is also directly connected to the total positive electrode of the lithium battery. A GND pin and a 1IN+ pin of the second dual operational amplifier chip U4 are connected together and then connected between the power resistor Rx and the load. The lithium battery supplies power to the second dual operational amplifier chip U4.

A 2OUT pin of the second dual operational amplifier chip U4 is used as an output pin for outputting an overcurrent/short-circuit output signal to the logical judgment and drive module. A 2IN- pin of the second dual operational amplifier chip U4 is connected to the total negative electrode of the lithium battery through a resistor R8 and a capacitor C4 that are connected in parallel. Moreover, a 1OUT pin of the second dual operational amplifier chip U4 is also connected to the 2IN- pin of the second dual operational amplifier chip U4 through a clamping circuit. The clamping circuit includes a diode D3 and a resistor R9. One end of the resistor R9 is connected to a positive electrode of the diode D3. A negative electrode of the diode D3 is connected to the 2IN- pin of the second dual operational amplifier chip U4. The other end of the resistor R9 is connected to the 1OUT pin of the second dual operational amplifier chip U4.

In order to prevent damage of the lithium battery due to an overcurrent or a short-circuit, a discharge current of the lithium battery generally does not exceed 0.5 C. In the short-circuit monitoring module, the power resistor Rx connected in series in the loop formed by the lithium battery and the load is utilized to control the sampled discharge current. The resistance of Rx is in milliohms. The reference voltage (1.25 V) output by the precision voltage reference U3 is divided by the third voltage divider circuit formed

by the resistors R10 and R11, and the second dual operational amplifier chip U4 samples a voltage division value between the resistor R10 and the resistor R11. When an overcurrent or a short-circuit occurs to the loop formed by the lithium battery and the load, currents flowing through the power resistor Rx and a third branch both increase. At this time, a voltage sampled by the second dual operational amplifier chip U4 increases. When the voltage sampled by the second dual operational amplifier chip U4 is greater than the reference voltage output by the precision voltage reference U3, the 1OUT pin of the dual operational amplifier chip U4 outputs a high level, which is clamped to the 2IN-pin of the second dual operational amplifier chip U4 through the resistor R9 and the diode D. Then, the 2OUT pin of the second dual operational amplifier chip U4 outputs a low-level overcurrent/short-circuit output signal to the logical judgment and drive module, such that the logical judgment and drive module turns off the loop between the lithium battery and the load. At this time, the lithium battery enables output protection and does not provide output power.

In the short-circuit monitoring module, after any one of a resistance of the power resistor Rx and the resistors R10 and R11 in the third voltage divider circuit is determined or the resistance of the power resistor Rx is determined, a ratio of the resistor R10 to the resistor R11 may be changed to adjust a magnitude of a maximum output current output by the lithium battery to the load.

In the disclosure, the logical judgment and drive module is used for cutting off the corresponding circuit according to the overcharge output signal, the overdischarge output signal and the overcurrent/short-circuit output signal so as to realize the protection function.

Specifically, as shown in FIG. 4, the logical judgment and drive module includes MOS switch transistors Q1 and Q2, and transistors Q3, Q4, Q5 and Q6. A source of the MOS switch transistor Q1 is connected to a source of the MOS switch transistor Q2 to form an inverse series structure. A drain of the MOS switch transistor Q1 is connected to the total negative electrode of the lithium battery. A drain of the MOS switch transistor Q2 is connected to one end of the load, and the other end of the load is connected to the

total positive electrode of the lithium battery. In this way, the MOS switch transistor Q1 and the MOS switch transistor Q2 may be used for cutting off the loop between the lithium battery and the load.

The source of the MOS switch transistor Q1 is connected to a positive electrode of a Zener diode D1. A negative electrode of the Zener diode D1 is connected to a gate of the MOS switch transistor Q1. The gate of the MOS switch transistor Q1 is also connected to a collector of the transistor Q5 through a resistor R501. A drain of the MOS switch transistor Q2 is connected to the positive electrode of the Zener diode D2. The negative electrode of the Zener diode D2 is connected to a gate of the MOS switch transistor Q2. The gate of the MOS switch transistor Q2 is also connected to a collector of the transistor Q6 through a resistor R601. Emitters of the transistor Q5 and the transistor Q6 are connected together and then connected between the total positive electrode of the lithium battery and the load.

A base of the transistor Q5 is connected to a collector of the transistor Q3 through a resistor R301. A base of the transistor Q6 is connected to a collector of the transistor Q4 through a resistor R401. Emitters of the transistor Q3 and the transistor Q4 are connected together and then connected between the total negative electrode of the lithium battery and the drain of the MOS switch transistor Q1.

A base of the transistor Q3 is connected through a resistor R101 to the 2OUT pin of the first dual operational amplifier chip U2 outputting the overcharge output signal in the overdischarge/overcharge monitoring module, so that the low-level overcharge output signal is introduced to the logical judgment and drive module.

A base of the transistor Q4 is connected to an output terminal of a NAND gate through a resistor R201, and one input terminal of the NAND gate is connected to the 1OUT pin of the first dual operational amplifier chip U2 outputting the overdischarge output signal in the overdischarge/overcharge monitoring module, so that the low-level overdischarge output signal is introduced to the logical judgment and drive module. The other input terminal of the NAND gate is connected to the 2OUT pin of the second dual operational amplifier chip U4 outputting the overcurrent/short-circuit output signal in the

short-circuit monitoring module, so that the low-level overcurrent/short-circuit output signal is introduced to the logical judgment and drive module.

The logical judgment and drive module monitors each lithium cell in the lithium battery. If an overcharge, an overdischarge or a short-circuit occurs to any of the lithium cells, the protection circuit enables the protection function. Therefore, the output of the monitoring circuit for the lithium cells is of OR logic.

In the logical judgment and drive module, when the lithium battery works normally, the bases of the transistors Q3 and Q4 are both set to a high level. When an overcharge occurs, the base of the transistor Q3 is set to a low level. When an overdischarge or an overcurrent/short-circuit occurs, the base of the transistor Q4 is set to a low level.

When the battery works normally, the transistors Q3 and Q4 both work in a saturated state. The MOS switch transistors Q1 and Q2 are driven to be turned on, and the lithium battery can be charged/discharged normally. When an overcharge occurs, the transistors Q3 and Q5 both work in a cut-off state, the MOS switch transistor Q1 is turned off, and the lithium battery is incapable of being charged. However, the MOS switch transistor Q2 is in an on state, and the lithium battery may be discharged through a body diode of the MOS switch transistor Q1. When an overdischarge or an overcurrent/short-circuit occurs, the transistors Q4 and Q6 both work in a cut-off state, the MOS switch transistor Q2 is turned off, and the lithium battery is incapable of being discharged. However, the MOS switch transistor Q1 is in an on state, and the lithium battery may be charged through a body diode of the MOS switch transistor Q2.

Thereby, the disclosure can monitor the overcharge, overdischarge or overcurrent/short-circuit of the lithium battery or the lithium cells and realize the automatic (cut-off) protection function according to the monitoring results.

The examples of the disclosure are merely descriptions for preferred embodiments of the disclosure and are not intended to limit the concept and scope of the disclosure. Without departing from the design concept of the disclosure, various modifications and improvements made by those skilled in the art to the technical solutions of the disclosure shall fall within the scope of protection of the disclosure, and the technical contents

claimed in the disclosure have all been recorded in the appended claims.

CLAIMS

1. A lithium battery safety protection system for underground coal mining equipment, comprising an overdischarge/overcharge monitoring module, a short-circuit monitoring module and a logical judgment and drive module, wherein

the overdischarge/overcharge monitoring module comprises a first dual operational amplifier chip, a first voltage divider circuit and a second voltage divider circuit, wherein the two voltage divider circuits are respectively connected between a positive electrode and a negative electrode of a lithium battery, the first dual operational amplifier chip samples a voltage of the lithium battery being charged through the first voltage divider circuit, and the first dual operational amplifier chip samples a voltage of the lithium battery being discharged through the second voltage divider circuit; when the sampled voltage of the lithium battery being charged is greater than a charge cut-off voltage, a voltage sampled by the first dual operational amplifier chip from the first voltage divider circuit is greater than a reference voltage of the first dual operational amplifier chip, and in this case, an output pin of the first dual operational amplifier chip outputs a low-level overcharge output signal to the logical judgment and drive module; when the sampled voltage of the lithium battery being discharged is less than a discharge cut-off voltage, a voltage sampled by the first dual operational amplifier chip from the second voltage divider circuit is less than the reference voltage of the first dual operational amplifier chip, and in this case, another output pin of the first dual operational amplifier chip outputs a low-level overdischarge output signal to the logical judgment and drive module;

the short-circuit monitoring module comprises a second dual operational amplifier chip, a power resistor and a third voltage divider circuit, wherein the power resistor is connected to a loop formed by the lithium battery and a load, the power resistor is connected in parallel with the third voltage divider circuit to form a shunt circuit, and the second dual operational amplifier chip samples a voltage through the third voltage divider circuit; when an overcurrent or an open circuit occurs to the loop formed by the lithium battery and the load, a current in a branch of the power resistor in the shunt circuit and a current in a branch formed by the third voltage divider circuit both increase, a voltage sampled by the second dual operational

amplifier chip from the third voltage divider circuit is greater than the reference voltage of the dual operational amplifier chip, and in this case, an output pin of the second dual operational amplifier chip outputs a low-level overcurrent/short-circuit output signal to the logical judgment and drive module;

the logical judgment and drive module comprises two MOS switch transistors and four transistors, wherein the two MOS switch transistors are connected in inverse series through sources and drains and then connected between one electrode of the lithium battery and the load, gates of the two MOS switch transistors are connected to collectors of two of the transistors in one-to-one correspondence, sources of the two transistors connected to the MOS switch transistors are respectively connected between the other electrode of the lithium battery and the load, bases of the two transistors connected to the MOS switch transistors are connected to collectors of the rest two transistors in one-to-one correspondence, and emitters of the rest two transistors are connected together between the inverse series connection branch formed by the two MOS switch transistors and the corresponding electrode of the lithium battery; a base of one of the rest two transistors is connected to the output pin of the first dual operational amplifier chip outputting the overcharge output signal in the overdischarge/overcharge monitoring module, a base of the other transistor is connected to an output terminal of a NAND gate, one input terminal of the NAND gate is connected to the output pin of the first dual operational amplifier chip outputting the overdischarge output signal in the overdischarge/overcharge monitoring module, and the other input terminal of the NAND gate is connected to the output pin of the second dual operational amplifier chip outputting the overcurrent/short-circuit output signal in the short-circuit monitoring module; when an overcharge occurs, the transistor corresponding to the overcharge output signal and the transistor connected to the collector thereof are both in a cut-off state, and at this time, the corresponding MOS switch transistor is turned off and the lithium battery is incapable of being charged; and when an overdischarge or an overcurrent/short-circuit occurs, the transistor corresponding to the NAND gate and the transistor connected to the collector thereof are both in a cut-off state, and at this time, the corresponding other MOS switch transistor is turned off and the lithium battery is incapable of being discharged.

2. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein when the lithium battery comprises a plurality of lithium cells and the plurality of lithium cells are connected in series for power supply, each lithium cell is provided with one overdischarge/overcharge monitoring module, and a series structure formed by the plurality of lithium cells shares one short-circuit monitoring module.

3. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein the first dual operational amplifier chip in the overdischarge/overcharge monitoring module and the second dual operational amplifier chip in the short-circuit monitoring module are both powered by the lithium battery.

4. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein the overdischarge/overcharge monitoring module further comprises a hysteresis discharge protection circuit, one end of the hysteresis discharge protection circuit being connected to the output pin of the first dual operational amplifier chip outputting the overcharge output signal, and the other end of the hysteresis discharge protection circuit being connected to the first voltage divider circuit.

5. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein in the short-circuit monitoring module, a magnitude of a resistance of either the power resistor or the third voltage divider circuit is adjusted to set a magnitude of a current output by the lithium battery to the load.

6. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein in the logical judgment and drive module, when an overcharge occurs, the corresponding MOS switch transistor is turned off such that the lithium battery is incapable of being charged, and at this time, the lithium battery is discharged through the MOS switch transistor.

7. The lithium battery safety protection system for underground coal mining equipment according to claim 1, wherein in the logical judgment and drive module, when an overdischarge or an overcurrent/short-circuit occurs, the corresponding MOS switch transistor is turned off such that the lithium battery is incapable of being discharged, and at this time, the lithium battery is charged through the MOS switch transistor.

Patentansprüche

1. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte, umfassend ein Überentladungs- und Überladungsüberwachungsmodul, ein Kurzschlussüberwachungsmodul, ein Logikbeurteilungs- und Antriebsmodul, dadurch gekennzeichnet, dass

das Überentladungs- und Überladungsüberwachungsmodul einen ersten Doppeloperationsverstärkerchip und zwei Partialspannungsschaltungen umfasst, wobei die zwei Partialspannungsschaltungen jeweils zwischen der positiven Elektrode und der negativen Elektrode der Lithiumbatterie verbunden sind, wobei der erste Doppeloperationsverstärkerchip eine Spannung abtastet, wenn die Lithiumbatterie durch die erste Partialspannungsschaltung geladen wird, wobei der erste Doppeloperationsverstärkerchip eine Spannung abtastet, wenn die Lithiumbatterie durch die zweite Partialspannungsschaltung entladen wird; Wenn die Abtastspannung beim Laden der Lithiumbatterie größer als die Ladeendspannung ist, ist die Spannung, die von dem ersten Doppeloperationsverstärkerchip von der ersten Partialspannungsschaltung abgetastet wird, größer als die Referenzspannung des ersten Doppeloperationsverstärkerchips, so dass ein Ausgangsfuß des ersten Doppeloperationsverstärkerchips ein Überladeausgangssignal mit niedrigem Pegel an das Logikbeurteilungs- und Antriebsmodul ausgibt; Wenn die Abtastspannung beim Entladen der Lithiumbatterie niedriger als die Entladungsabschaltspannung ist, ist die Spannung, die von dem ersten Doppeloperationsverstärkerchip von der zweiten Partialspannungsschaltung abgetastet wird, kleiner als die Referenzspannung des ersten Doppeloperationsverstärkerchips, so dass der andere Ausgangsfuß des ersten Doppeloperationsverstärkerchips ein Überentladeausgangssignal mit niedrigem Pegel an das Logikbeurteilungs- und Antriebsmodul ausgibt;

das Kurzschlussüberwachungsmodul einen zweiten Doppeloperationsverstärkerchip, einen Leistungswiderstand und eine dritte Partialspannungsschaltung umfasst, wobei der Leistungswiderstand mit einer Schleife verbunden ist, die aus einer Lithiumbatterie und einer Last besteht, wobei der Leistungswiderstand parallel zu der dritten Partialspannungsschaltung geschaltet ist, um eine Shunt-Schaltung zu bilden, wobei der zweite Doppeloperationsverstärkerchip eine Spannung durch die dritte Partialspannungsschaltung abtastet; Wenn die Schleife, die durch die Lithiumbatterie und die Last gebildet wird,

überströmt oder unterbrochen wird, nehmen der Strom des Leistungswiderstandszweigs in der Shunt-Schaltung und der Strom in dem Zweig, der durch die dritte Partialspannungsschaltung gebildet wird, zu; Zu diesem Zeitpunkt ist die Spannung, die von dem zweiten Doppeloperationsverstärkerchip von der dritten Partialspannungsschaltung abgetastet wird, größer als die Referenzspannung des Doppeloperationsverstärkerchips, so dass ein Ausgangsfuß des zweiten Doppeloperationsverstärkerchips ein Überstrom-/Kurzschlussausgangssignal mit niedrigem Pegel an das Logikbeurteilungs- und Antriebsmodul ausgibt;

das Logikbeurteilungs- und Antriebsmodul zwei MOS-Schaltröhren und vier Transistoren umfasst, wobei die zwei MOS-Schaltröhren durch die Quelle und den Drain in umgekehrter Reihe geschaltet und dann mit einer Elektrode und einer Last der Lithiumbatterie verbunden sind, wobei das Gate der zwei MOS-Schaltröhren eins nach dem anderen mit den Kollektoren der zwei Transistoren verbunden ist, wobei die Quellen der zwei Transistoren, die mit der MOS-Schaltröhre verbunden sind, jeweils mit einer anderen Elektrode der Lithiumbatterie und der Last verbunden sind, wobei die Basis der zwei Transistoren, die mit der MOS-Schaltröhre verbunden sind, eins nach dem anderen mit den Kollektoren der verbleibenden zwei Transistoren verbunden ist, wobei die Emitter der verbleibenden zwei Transistoren mit einem umgekehrten Reihenzweig verbunden sind, der aus zwei MOS-Schaltröhren besteht, und einer Elektrode, die einer Lithiumbatterie entspricht, wobei die Basis eines der verbleibenden zwei Transistoren mit dem Ausgangsfuß zum Ausgeben des Überladeausgangssignals des ersten Doppeloperationsverstärkerchips in dem Überentladungs- und Überladungsüberwachungsmodul verbunden ist, wobei die Basis eines anderen Transistors mit dem Ausgang eines NAND-Gates verbunden ist, wobei der Eingang eines NAND-Gates mit dem Ausgangsfuß zum Ausgeben des Überladeausgangssignals des ersten Doppeloperationsverstärkerchips in dem Überentladungs- und Überladungsüberwachungsmodul verbunden ist, wobei der andere Eingang eines NAND-Gates mit dem Ausgangsfuß zum Ausgeben des Überstrom-/Kurzschlussausgangssignals des zweiten Doppeloperationsverstärkerchips in dem Kurzschlussüberwachungsmodul verbunden ist; Wenn eine Überladung auftritt, befinden sich der Transistor, der dem Überladeausgangssignal entspricht, und der Transistor, der mit dem Kollektor verbunden ist, in einem Abschaltzustand, so dass die entsprechende MOS-Schaltröhre zu diesem Zeitpunkt ausgeschaltet ist und die Lithiumbatterie nicht geladen werden kann; Wenn eine Überentladung oder ein Überstrom/Kurzschluss auftritt, befinden sich der Transistor, der dem

NAND-Gate entspricht, und der Transistor, der mit dem Kollektor des Transistors verbunden ist, in einem Abschaltzustand, so dass die entsprechende andere MOS-Schaltröhre zu diesem Zeitpunkt ausgeschaltet ist und der Lithiumbatteriepack nicht entladen werden kann.

2. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach Anspruch 1, dadurch gekennzeichnet, dass jede einzelne Lithiumbatterie jeweils mit einem Überentladungs- und Überladungsüberwachungsmodul ausgestattet ist, so dass eine Reihenstruktur, die aus einer Vielzahl von Lithiumbatterien besteht, ein Kurzschlussüberwachungsmodul teilt, wenn die Lithiumbatterie durch eine Vielzahl von Lithiumbatterien in Reihe betrieben wird.

3. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach Anspruch 1, dadurch gekennzeichnet, dass der erste Doppeloperationsverstärkerchip in dem Überentladungs- und Überladungsüberwachungsmodul und der zweite Doppeloperationsverstärkerchip in dem Kurzschlussüberwachungsmodul von einer Lithiumbatterie betrieben werden.

4. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach Anspruch 1, dadurch gekennzeichnet, dass das Überentladungs- und Überladungsüberwachungsmodul auch eine Hystereseeentladungsschutzschaltung umfasst, wobei ein Ende der Hystereseeentladungsschutzschaltung mit dem Ausgangsfuß zum Ausgeben des Überladeausgangssignals des ersten Doppeloperationsverstärkerchips verbunden ist, wobei das andere Ende der Hystereseeentladungsschutzschaltung mit der ersten Partialspannungsschaltung verbunden ist.

5. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach Anspruch 1, dadurch gekennzeichnet, dass einer der Widerstandswerte des Leistungswiderstands und der dritten Partialspannungsschaltung in dem Kurzschlussüberwachungsmodul so eingestellt wird, dass der von der Lithiumbatterie an die Last abgegebene Strom festgelegt wird.

6. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach Anspruch 1, dadurch gekennzeichnet, dass die entsprechende MOS-Schaltröhre in dem Logikbeurteilungs- und Antriebsmodul ausgeschaltet ist, so dass die Lithiumbatterie nicht geladen werden kann und die Lithiumbatterie zu diesem Zeitpunkt durch die MOS-Schaltröhre entladen werden kann, wenn eine Überladung auftritt.

7. Lithiumbatterie-Sicherheitsschutzsystem für unterirdische Kohlebergbaugeräte nach LU504388 Anspruch 1, dadurch gekennzeichnet, dass die entsprechende MOS-Schaltröhre in dem Logikbeurteilungs- und Antriebsmodul ausgeschaltet ist, so dass die Lithiumbatterie nicht entladen werden kann und die Lithiumbatterie zu diesem Zeitpunkt durch die MOS-Schaltröhre geladen werden kann, wenn eine Überentladung oder ein Überstrom/Kurzschluss auftritt.

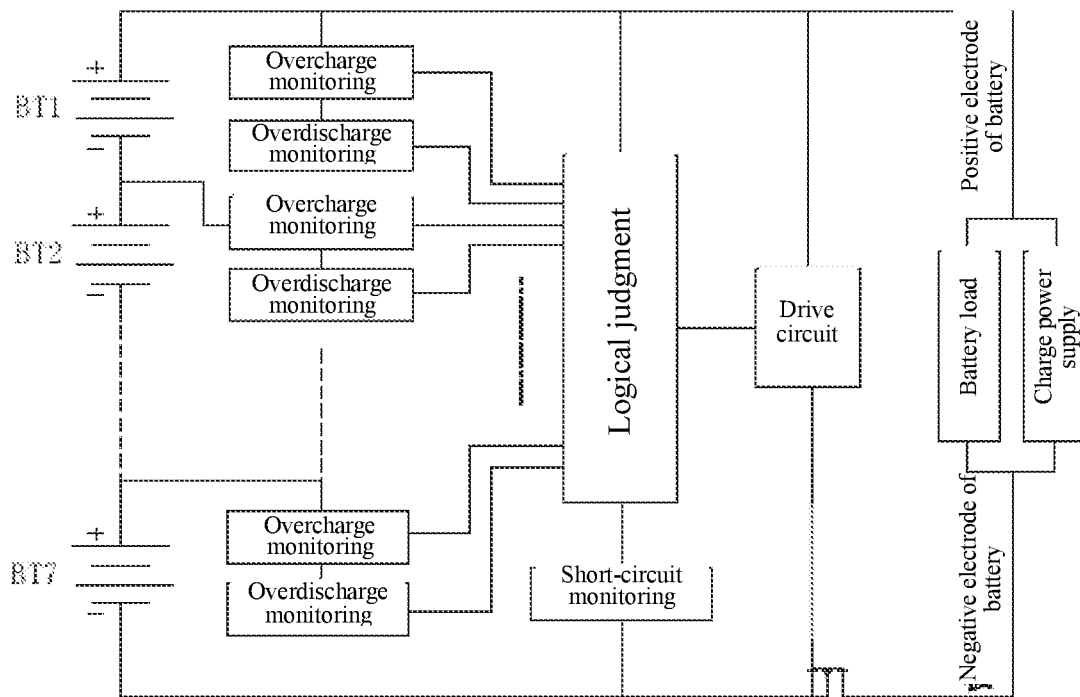


FIG. 1

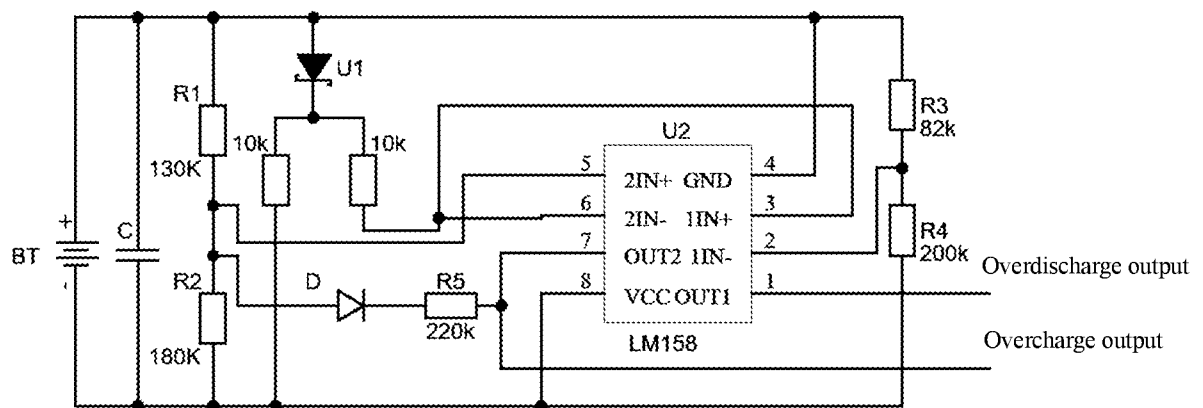


FIG. 2

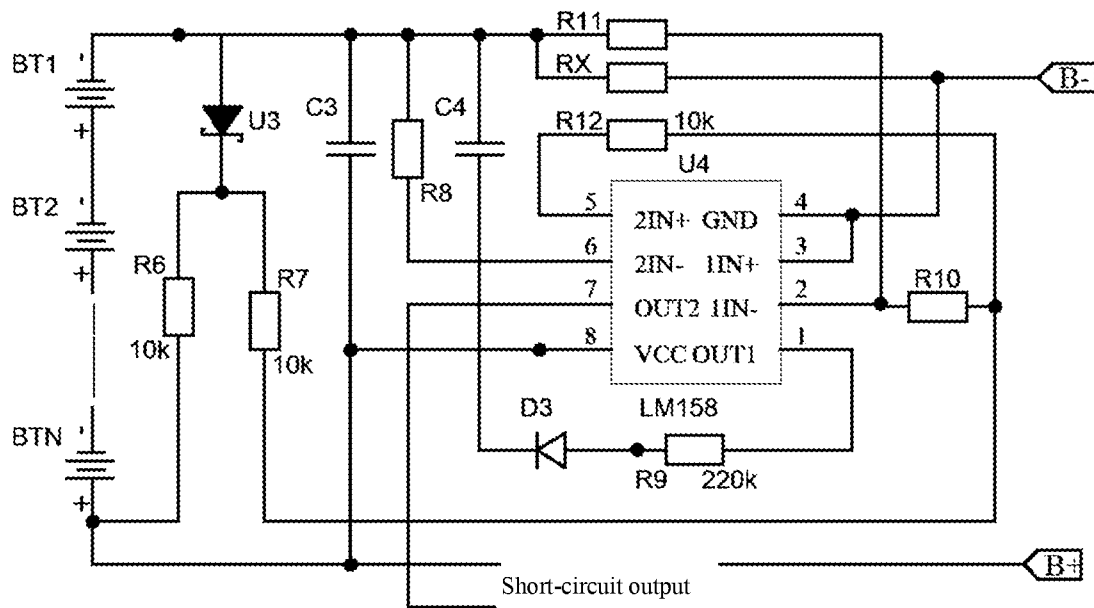


FIG. 3

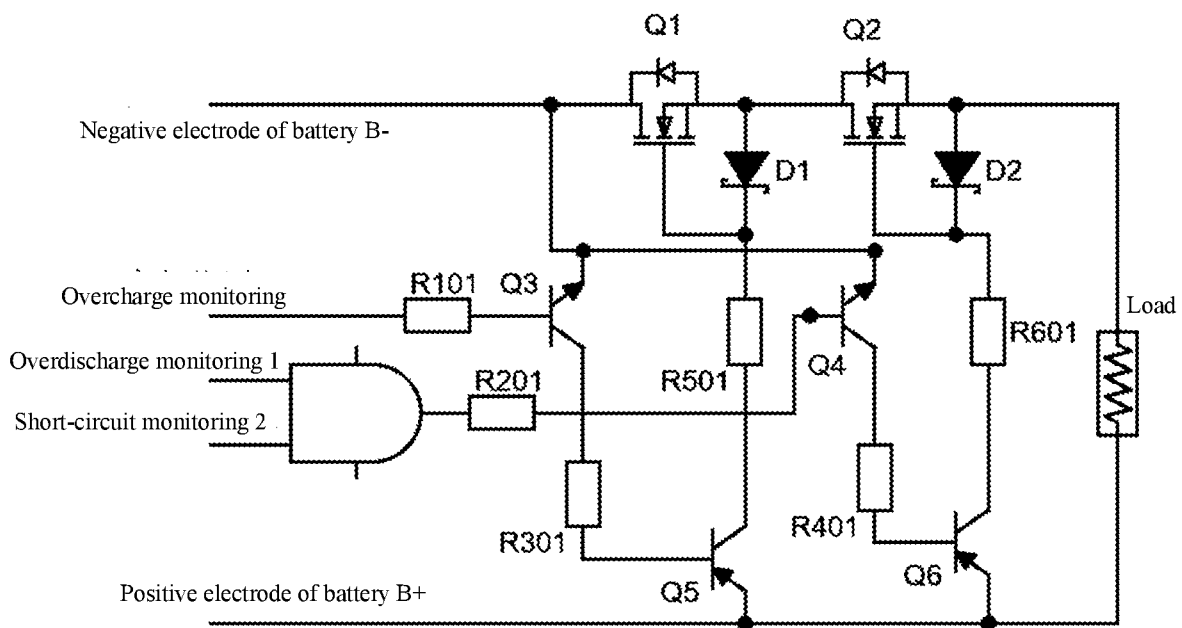


FIG. 4