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(54) **ENERGY-SAVING CONTROL METHOD FOR CONTACTOR**

(57) Disclosed is an energy-saving control method for a contactor, including the following steps: connecting the contactor: after a control power supply is turned on, enabling an energy storage circuit to work to charge an energy storage capacitor, and meanwhile, enabling a coil of a contactor KM to generate an attractive magnetic force after receiving a pulse voltage signal, making an action mechanism of the contactor KM act; disconnecting the contactor: when the control power supply is turned off, discharging the energy storage capacitor of the energy storage circuit, so as to provide released electric energy to the coil of the contactor KM, where the released electric energy outputs a pulse with opposite polarity to

a pull-in voltage of the coil of the contactor KM via a full-bridge drive control circuit, and the coil of the contactor KM generates a reverse magnetic force. According to the method provided by the present disclosure, a magnetic holding contactor completely replaces an energy-saving control module of the traditional ordinary contactor, and an ordinary non-magnetic holding contactor can achieve the opening and closing by single-line inching control, so as to solve the problem that the magnetic holding contactor cannot be controlled to open and close by single-line inching. Meanwhile, the power consumption of the coil of the contactor can be reduced by 98%, and the energy-saving effect is obvious.

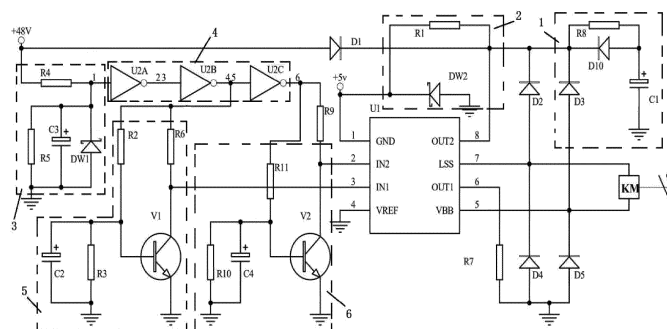


FIG. 1

Description

TECHNICAL FIELD

[0001] The present disclosure belongs to the technical field of electromagnetic control circuits, and in particular to an energy-saving control method for a contactor.

BACKGROUND

[0002] The biggest difference of the magnetic holding contactor from ordinary contactors is that the magnetic holding contactor is mainly used in intensive installation environment or large current on-off control of special equipment, and the main feature of the magnetic holding contactor is that only one forward or reverse instantaneous pulse is required for the on-off operation of the main loop. As the permanent magnet material is used as the closing power of the main loop, the main loop contact is high in pressure, high in working voltage, low in contact resistance, energy-saving and environment-friendly, and reliable in operation under long-time operation, and the coil almost has no energy consumption. However, after the ordinary DC contactor is pulled in, the coil is energized all the time, leading to high energy consumption for long-term work, heating of the coil, and even long-term noise, which not only wastes electric energy, but also causes the insulation aging and the shortened service life due to the heating of the coil.

[0003] However, the magnetic holding contactor needs pulse voltage in both forward and reverse states to control the on and off. Compared with ordinary contactors, the control line is complicated. The control line must be changed in some traditional application fields of machine tool electrical control, and there are two commonly used methods for changing the control line: 1. In two-in and two-out four-wire full-bridge drive and logic interlock, four transistors and logic electronic circuits are required, compared with a single-point control of the ordinary contactor that the only one control line is required for control on and off, the number of control lines and control elements for magnetic holding in such a method is particularly complicated. 2. In trilinear push-pull drive and logic interlock, two coils and logic electronic circuits are required, if the magnetic holding contactor needs to be used in a general power control line, such as forward and reverse handover of a machine tool spindle motor, start-stop holding, inching control and other occasions, the cost of changing the control line will increase geometrically, which is several times or even dozens of times higher than that of the ordinary contactor, leading to the great reduction of reliability, economy and working efficiency. In addition, the magnetic holding contactor cannot be used in some places that require multi-point interlocking and high safety requirements. Meanwhile, the change of the control line is complicated, the reliability is poor. the biggest problem is that the magnetic holding contactor cannot be disconnected in a case of power failure, the safety cannot be

guaranteed, and the magnetic holding contactor cannot be used in general logic control power circuits. Therefore, it is necessary to develop a new control method to solve the existing problems.

SUMMARY

[0004] An objective of the present disclosure is to provide an energy-saving control method for a contactor for achieving high efficiency and energy conversion without changing a controller circuit of an original contactor. A magnetic holding contactor completely replaces an energy-saving control module of the traditional ordinary contactor, and an ordinary non-magnetic holding contactor can achieve the opening and closing by single-line inching control, so as to solve the problem that the magnetic holding contactor cannot be controlled to open and close by single-line inching.

[0005] In order to achieve the objective above, the present disclosure provides the following technical solutions, an energy-saving control method of a contactor includes the following steps: connecting the contactor: after a control power supply is turned on, enabling an energy storage circuit to work to charge an energy storage capacitor, and meanwhile, enabling a coil of a contactor KM to generate an attractive magnetic force after receiving a pulse voltage signal, making an action mechanism of the contactor KM act, where a main loop contact of the contactor KM is connected, a control line of the coil of the contactor KM loses power within set millisecond-scale delay time, and the main loop contact of the contactor KM is continuously kept in a connected state under the action of a pull-in permanent magnet; disconnecting the contactor: when the control power supply is turned off, discharging the energy storage capacitor of the energy storage circuit to provide released electric energy to the coil of the contactor KM, where the released electric energy outputs a pulse with opposite polarity to a pull-in voltage of the coil of the contactor KM via a full-bridge drive control circuit, the coil of the contactor KM generates a reverse magnetic force, a direction of a magnetic force of a magnetic field is reversed, making the action mechanism of the contactor KM act towards a direction opposite to the direction when pulling in, the main loop contact of the contactor KM is disconnected, and after the coil of the contactor KM loses power, the main loop contact of the contactor KM is kept in a disconnected state under the action of a release permanent magnet.

[0006] The energy-saving control method further includes an energy-saving control circuit. The energy-saving control circuit includes a full-bridge driver chip U1 for controlling the function of the contactor KM, the energy storage circuit connected to the control power supply, a voltage-stabilizing circuit connected to the energy storage circuit and configured to send an input voltage to the full-bridge driver chip U1 after voltage stabilization, a voltage signal detection and regulation circuit, a three-stage inverter connected to the voltage signal detection and

regulation circuit, a pull-in delay regulation circuit for generating a pull-in voltage and a contactor KM connecting delay, and a release delay regulation circuit for controlling a release voltage and a contactor KM disconnecting delay. The pull-in delay regulation circuit and the release delay regulation circuit are both connected to the three-stage inverter. The voltage signal detection and regulation circuit and the control power supply are connected for the detection and regulation and filter overvoltage protection of an input voltage signal.

The full-bridge driver chip U1 is internally provided with the full-bridge driver control circuit. The three-stage inverter includes an inverter U2A, an inverter U2B, and an inverter U2C connected in series.

[0007] When the control power supply is turned on, the energy storage capacitor C1 is charged by the energy storage circuit, and meanwhile, the coil of the contactor KM generates an attractive magnetic force after receiving a pulse voltage signal, making the action mechanism of the contactor KM connected under the combined action of the attractive magnetic force generated by the coil of the contactor KM and the attractive magnetic force of the pull-in permanent magnet, and a signal is sent to the full-bridge driver chip U1 through the pull-in delay regulation circuit. The full-bridge driver chip U1, after receiving the signal, controls to turn off a voltage of the coil of the contactor KM, the coil of the contactor KM loses power, and the main loop contact of the contactor KM is kept in a connected state under the action of the pull-in permanent magnet.

When the control power supply is turned off, after the full-bridge driver chip U1 receives a power-off signal of the voltage signal detection and regulation circuit, an electric energy voltage of the energy storage capacitor C1 in the energy storage circuit is sent into the coil of the contactor KM after polarity switching, the coil of the contactor KM generates a magnetic force in an opposite direction of an existing magnetic force, the reverse magnetic force makes the contact KM break away from the attractive magnetic force of the pull-in permanent magnet to be disconnected, the action mechanism of the contactor KM is attached to the release permanent magnet, the main loop contact of the contactor KM is disconnected, and then a signal is sent by the release delay regulation circuit to the full-bridge driver chip U1 to make the coil of the contactor KM lose power. The main loop contact of the contactor KM is kept in a disconnected state under the action of the release permanent magnet.

[0008] The pull-in delay regulation circuit includes a triode V1 connected to an output terminal of the inverter U2B, and a capacitor C2 connected to the triode V1. The output terminal of the inverter U2B is connected to a base electrode of the triode V1 after being connected to a resistor R2 and a resistor R3 in series for voltage division. A collector electrode of the triode V1 is connected to an IN2 pin of the full-bridge driver chip U1 through a resistor R6.

When a charging voltage of the capacitor C2 reaches a

switch-on threshold of the triode V1, electrical level of the IN2 pin of the full-bridge driver chip U1 is pulled down, an OUT1 pin and an OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil of the contactor KM loses power. An input terminal of the inverter U2B is connected to an output terminal of the inverter U2A, and an input terminal of the inverter U2A is connected to a positive electrode of the control power supply through a resistor R4 and a resistor R5, and both terminals of the resistor R5 are connected in parallel with a capacitor C3 and a Zener diode DW1.

[0009] The release delay regulation circuit includes a triode V2 connected to an output terminal of the inverter U2C, and a capacitor C4 connected to the triode V2. The output terminal of the inverter U2C is connected to a base electrode of the triode V2 after being connected to a resistor R10 and a resistor R11 in series for voltage division. A collector electrode of the triode V2 is connected to an IN1 pin of the full-bridge driver chip U1, and the collector electrode of the triode V2 is further connected to the output terminal of the inverter U2C through a resistor R9. When a charging voltage of the capacitor C4 reaches a switch-on threshold of the triode V2, electrical level of the IN1 pin of the full-bridge driver chip U1 is pulled down, the OUT1 pin and the OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil of the contactor KM loses power.

[0010] The positive electrode of the control power supply is also connected to a diode D1, and the diode D1 is also connected to a VBB pin of the full-bridge driver chip U1.

When the control power supply is powered off, the diode D1 is cut off reversely, and the output terminal of the inverter U2C outputs a high electrical level signal to the full-bridge driver chip U1, and the full-bridge driving chip U1 outputs a voltage after polarity switching of the power supply.

[0011] When the control power supply is turned on, a current generated by the control power supply is connected to a Vref pin of the full-bridge driver chip U1 through a circuit in which a resistor R1 and a Zener diode DW2 are connected in series.

[0012] The energy storage capacitor C1 is connected to the control power supply through a buffer resistor R8.

[0013] The resistor R8 is connected to an LSS pin of the full-bridge driver chip U1 through a resistor R7, and a freewheeling diode is arranged between the resistor R7 and the resistor R8. The freewheeling diode includes a diode D3, a diode D5, a diode D2, and a diode D4. The diode D2 and the diode D4 are connected in series, the diode D3 and the diode D5 are connected in series, and then the diode D2 and the diode D4 are connected in parallel with the diode D3 and the diode D5.

[0014] The present disclosure has the technical effects and advantages that the energy-saving control method for a contactor is convenient for installation, simple in wiring, low in cost, and obvious in energy-saving effect. A magnetic holding contactor completely replaces an en-

ergy-saving control module of the traditional common contactor, and the magnetic holding contactor using the control module may have the characteristics of an ordinary non-magnetic holding contactor, which can achieve the opening and closing by single-line inching control, and retain all advantages of the magnetic holding contactor at the same time. The present disclosure conforms to the requirements of energy conservation, emission reduction and environmental protection in China, and has the following advantages:

1. The full-bridge driver chip U1, after receiving a power-off signal of the voltage signal detection and regulation circuit, sends an input voltage of the energy storage circuit after polarity switching to the coil of the contactor KM, and the coil of the contactor KM generates a magnetic force with a direction opposite to that of an existing magnetic force to disconnect the contactor, such that the coil of the contactor KM loses power, and the current of the coil is zero. In such a state, the contactor is kept in a pull-in state all the time by a permanent magnet, and the current of the coil of the contactor KM is zero, in this case, the coil of the contactor KM has zero power consumption, and the total energy consumption of a voltage-division resistor, a voltage-stabilizing tube and a chip in the line in this state is about 0.2 W, while the holding power of the general contactor is about 10 W-30 W, and compared with the power consumption of 0.2 W, the control line of the coil of the contactor KM is in a micro-power consumption state.
2. The coil of the contactor KM connected to the full-bridge driver chip U1 loses power by sending a power-loss signal to the full-bridge driver chip U1 through the pull-in delay regulation circuit, and the coil of the contactor KM loses power by sending a power-loss signal to the full-bridge driver chip U1 through the release delay regulation circuit. The contactor is kept in a disconnected state under the action of the permanent magnet, when the contactor controls the main loop contact to be connected, the coil of contactor KM does not need to be energized for a long time, but only needs an instantaneous pulse voltage, and then the connected state can be kept all the time by means of the magnetic force of the permanent magnet. In a case that the ordinary contactor is desired to keep the connected state all the time, the coil of the contactor KM needs to be energized all the time. According to the present disclosure, the coil of the contactor KM loses power after a delay of 10 mS after being energized, and the coil of the contactor KM obtains two voltage pulse signals with opposite polarities under turn-on and turn-off states of the control power supply, thus achieving the purpose of high efficiency and energy conservation while achieving the same pull-in characteristics of the magnetic holding contactor and the non-magnetic holding contactor.

3. The release characteristics of the power supply voltage in the slow drop process are regulated by adjusting a resistance ratio of the resistor R2 and the resistor R3, and the pull-in characteristics of the power supply voltage in the slow rising process are regulated by adjusting a resistance ratio of the resistor R4 and the resistor R5.

4. The input terminal of the U2A is connected to the positive electrode of the control power supply through the resistor R4 and the resistor R5, both terminals of the resistor R5 are connected in parallel with the capacitor C3 and the Zener diode DW1, and the Zener diode DW1 is configured to prevent the inverter from being damaged when the power supply voltage rises or is debugged.

5. The resistor R8 is connected to the LSS pin of the full-bridge driver chip U1 through the resistor R7, and the diode D3 and the diode D5 are arranged between the resistor R7 and the resistor R8. The diode D3 and the diode D5 are connected in series, and the diode D2 and the diode D4 are connected in series. The diodes D2, D3, D4 and D5 can absorb back electromotive force generated when the coil of the contactor KM works, and the resistor R7 is a current-limiting protection sampling resistor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

- FIG. 1 is a circuit diagram according to the present disclosure;
 FIG. 2 is a circuit diagram of the present disclosure when an access power supply is an AC-DC power supply;
 FIG. 3 is a circuit diagram of the present disclosure when an access power supply is an AC high-voltage power supply;
 FIG. 4 is a functional block diagram of a full-bridge driver chip U1 according to the present disclosure;
 FIG. 5 is a pin distribution diagram of a full-bridge driver chip U1 according to the present disclosure;
 FIG. 6 is a front view of a contactor according to the present disclosure;
 FIG. 7 is a sectional diagram of a contactor according to the present disclosure is a D direction.

[0016] In the drawings: 1-main loop contact; 2-action mechanism; 3-release permanent magnet; 4-coil; 5-pull-in permanent magnet; 6-release delay regulation circuit.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] The following clearly and completely describes the technical solutions in the embodiments of the present disclosure with reference to the accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are merely a part rather

than all of the embodiments of the present disclosure. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present disclosure without creative efforts shall fall within the protection scope of the present disclosure

[0018] The present disclosure provides an energy-saving control method for a contactor shown in FIG. 1 to FIG. 7 is provided by the present disclosure, including the following steps:

Step of connecting the contactor is as follows: as shown in FIG. 1, FIG. 6 and FIG. 7, a control power supply, after being turned on, charges an energy storage circuit, and meanwhile, a coil 4 of a contactor KM generates an attractive magnetic force after receiving a pulse voltage signal, making an action mechanism 2 of the contactor KM to act. A main loop contact 1 of the contactor KM is connected, and a control line of the coil of the contactor KM is disconnected within milliseconds set by the delay. In this embodiment, the set disconnection time is 10 mS, the main loop contact 1 of the contactor KM is continuously kept in a connected state under the action of a pull-in permanent magnet 5. In this embodiment, in the step of connecting the contactor, a pull-in delay regulation circuit includes a triode V1 connected to an output terminal of an inverter U2B, and a capacitor C2 connected to the triode V1. The output terminal of the inverter U2B is connected to a base electrode of the triode V1 after being connected to a resistor R2 and a resistor R3 in series for voltage division, and a collector electrode of the triode V1 is connected to an IN2 pin of a full-bridge driver chip U1 through a resistor R6. When a charging voltage of the capacitor C2 reaches a switch-on threshold of the triode V1, electrical level of the IN2 pin of the full-bridge driver chip U1 is pulled down, an OUT1 pin and an OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil 4 of the contactor KM loses power.

[0019] An input terminal of the inverter U2B is connected to an output terminal of the inverter U2A, and an input terminal of the inverter U2A is connected to a positive electrode of the control power supply through a resistor R4 and a resistor R5, and both terminals of the resistor R5 are connected in parallel with a capacitor C3 and a Zener diode DW1.

[0020] When the control power supply is turned on, the current is sent into the energy storage circuit.

[0021] The energy storage circuit includes an energy storage capacitor C1 for storing electric energy, the energy storage capacitor C1 is connected to the control power supply through a buffer resistor R8, and the control power supply is used to charge the energy storage capacitor C1.

[0022] When the control power supply is turned on, the current is connected to a Vref pin for simulating voltage input of the full-bridge driver chip U1 through a circuit in which a resistor R1 and a Zener diode DW2 are connected in series. The resistor R8 is connected to an LSS pin of the full-bridge driver chip U1 through a resistor R7, and a freewheeling diode is arranged between the resis-

tor R7 and the resistor R8. The freewheeling diode includes a diode D3 and a diode D5, and a diode D2 and a diode D4 which are connected in parallel with the diode D3 and the diode D5.

[0023] Step of disconnecting the contactor is as follows: when the control power supply is turned off, the energy storage circuit discharges to provide released electric energy to the coil 4 of the contactor KM. The released electric energy outputs a pulse with opposite polarity to a pull-in voltage of the coil 4 of the contactor KM via a full-bridge drive control circuit, the full-bridge driver U1, after the full-bridge driver chip U1 receives a power-off signal of a voltage signal detection and regulation circuit, an input voltage of the energy storage circuit is sent into the coil 4 after polarity switching. In this embodiment, the full-bridge driver chip U1 outputs a reverse pulse voltage signal, and the coil 4 of the contactor KM generates a magnetic force in a direction opposite to that of an existing magnetic force to disconnect the main loop contact 1 of the contactor KM. In this embodiment, under the action of the reverse magnetic force generated by the coil 4, the direction of the magnetic force of the magnetic field is reversed, and the action mechanism 2 of the contactor KM acts towards a direction opposite to the direction when pulling in, making the main loop contact 1 of the contactor KM disconnected. After the coil 4 of the contactor KM loses power, the main circuit contact 1 of the contactor KM is kept in a disconnected state under the action of a release permanent magnet 3.

[0024] The energy-saving control method further includes an energy-saving control circuit. The energy-saving control circuit includes a full-bridge driver chip U1 for controlling the function of the contactor KM, the energy storage circuit connected to the control power supply, a voltage-stabilizing circuit connected to the energy storage circuit and configured to send an input voltage to the full-bridge driver chip U1 after voltage stabilization, a voltage signal detection and regulation circuit connected to the control power supply and configured for the detection and regulation and filtering overvoltage protection of an input voltage signal, a three-stage inverter connected to the voltage signal detection and regulation circuit, a pull-in delay regulation circuit for generating a pull-in voltage and a contactor KM connecting delay, and a release delay regulation circuit 6 for controlling a release voltage and a contactor KM disconnecting delay.

[0025] The pull-in delay regulation circuit and the release delay regulation circuit 6 are both connected to the three-stage inverter.

[0026] The full-bridge driver chip U1 is internally provided with the full-bridge driver control circuit.

[0027] The three-stage inverter includes an inverter U2A, an inverter U2B, and an inverter U2C connected in series.

[0028] In the step of connecting the contactor, when the control power supply is turned on, the energy storage capacitor C1 is charged by the energy storage circuit, and meanwhile, the coil 4 of the contactor KM generates

an attractive magnetic force after receiving a pulse voltage signal, making the action mechanism 2 of the contactor KM connected under the combined action of the attractive magnetic force generated by the coil 4 of the contactor KM and the attractive magnetic force of the pull-in permanent magnet 5, and a signal is sent to the full-bridge driver chip U1 through the pull-in delay regulation circuit. The full-bridge driver chip U1, after receiving the signal, controls to turn off a voltage of the coil 4 of the contactor KM, the coil 4 of the contactor KM loses power, and the main loop contact 1 of the contactor KM is kept in a connected state under the action of the pull-in permanent magnet 5.

[0029] In the step of disconnecting the contactor, when the control power supply is turned off, after the full-bridge driver chip U1 receives a power-off signal of the voltage signal detection and regulation circuit, an electric energy voltage of the energy storage capacitor C1 in the energy storage circuit is sent into the coil 4 of the contactor KM after polarity switching, the coil (4) of the contactor KM generates a magnetic force in an opposite direction of an existing magnetic force, i.e., a reverse magnetic force, which makes the contact KM break away from the attractive magnetic force of the pull-in permanent magnet 5 to be disconnected. The action mechanism 2 of the contactor KM is attached to the release permanent magnet 3, the main loop contact 1 of the contactor KM is disconnected, and then a signal is sent by the release delay regulation circuit 6 to the full-bridge driver chip U1 to make the coil 4 of the contactor KM lose power, and the main loop contact 1 of the contactor KM is kept in a disconnected state under the action of the release permanent magnet 3.

[0030] In the step of disconnecting the contactor, the release delay regulation circuit includes a triode V2 connected to an output terminal of the inverter U2C, and a capacitor C4 connected to the triode V2. The output terminal of the inverter U2C is connected to a base electrode of the triode V2 after being connected to a resistor R10 and a resistor R11 in series for voltage division. A collector electrode of the triode V2 is connected to an IN 1 pin of the full-bridge driver chip U1, and the collector electrode of the triode V2 is further connected to the output terminal of the inverter U2C through a resistor R9.

[0031] When a charging voltage of the capacitor C4 reaches a switch-on threshold of the triode V2, electrical level of the IN1 pin of the full-bridge driver chip U1 is pulled down, the OUT1 pin and the OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil 4 of the contactor KM loses power.

[0032] The positive electrode of the control power supply is further connected to a diode D1, the diode D1 is further connected to a VBB pin of the full-bridge driver chip U1 to provide a working voltage for the coil 4 of the contactor KM.

[0033] When the control power supply is turned off, the diode D1 is reversely cut off, and the output terminal of the inverter U2C outputs a high electrical level signal to

the full-bridge driver chip U1, and the full-bridge driving chip U1 outputs a voltage after polarity switching.

[0034] According to the energy-saving control method for a contactor, as shown in FIG. 1, the control power supply is powered on, a positive electrode voltage provides a power supply voltage for the VBB pin of the full-bridge driver chip U1 via the diode D1, i.e., the working voltage of the coil 4 of the contactor KM, and meanwhile, the energy storage capacitor C1 is charged through the buffer resistor R8. A voltage with a regulated voltage of 5V formed through voltage division by the resistor R1 and the Zener diode DW2 is connected to an analog voltage input Vref pin of U1. The positive electrode of the control power supply is connected to an input terminal of the inverter U2A of the three-stage inverter formed by the inverter U2A, the inverter U2B, and the inverter U2C connected in series after being connected to the resistor R4 and the resistor R5 for voltage division. The output terminal of the inverter U2B acquires an electrical level signal synchronous with the input, and the output terminal of the U2C acquires an electrical level signal having a phase opposite to that of the input terminal of the inverter U2A, is connected to the IN1 pin of the full-bridge driver chip U1, and is connected to the IN2 pin of the full-bridge driver chip U1 through the resistor R6. A truth table of the full-bridge driver chip U1 is shown in Table 1.

Table 1

Truth table				
IN1	IN2	OUT1	OUT2	Function
0	1	L	H	Pull-in
1	0	H	L	Release
0	0	Z	Z	Hold

[0035] The OUT1 pin of the full-bridge driver chip U1 outputs a power supply voltage with positive polarity, and the OUT2 pin of the full-bridge driving chip U1 outputs a power supply voltage with negative polarity. The coil 4 of the contactor KM is energized and is kept closed under the action of the permanent magnet. When the control power supply is powered on, the output terminal of the inverter U2B is connected to the base electrode of the triode V1 after being connected to the resistor R2 and the resistor R3 in series for voltage division, so as to charge the capacitor C2. When the charging voltage reaches a switch-on threshold of the triode V1, in this embodiment, the threshold depends on the charging time of the C2, the electrical level of the IN2 pin of the full-bridge driver chip U1 is pulled down, and according to the truth table of the full-bridge driver chip U1, the OUT1 pin and the OUT2 pin of the full-bridge drive pin U1 output high resistance, the coil 4 of the contactor KM loses power, and the current of the coil 4 is zero. In such a state, the contactor is kept in a pull-in state all the time by a permanent magnet, and the current of the coil 4 of the

contactor KM is zero, in this case, the coil of the contactor KM has zero power consumption. The total energy consumption of a voltage-division resistor, a voltage-stabilizing tube and a chip in the line in this state is about 0.2 W, while the holding power of the general contactor is about 10 W-30 W, and compared with the power consumption of 0.2 W, it may be considered that the coil 4 of the contactor KM is in a micro-power consumption state.

[0036] When the control power supply is turned off, the energy storage capacitor C1 discharges to continuously provide power supply for the full-bridge driver chip U1 via a diode D10, as the diode D1 is cut off reversely, high electrical level occurs at the output terminal of the inverter U2C. As can be known from the truth table, the outputs of the OUT1 pin and the OUT2 pin of the full-bridge driver chip U1 are instantaneously flipped, the OUT1 pin outputs a power supply voltage with negative polarity and the OUT2 pin outputs a power supply voltage with positive polarity, the coil 4 of the contactor KM is energized under the action of the energy storage capacitor C1, the direction of the magnetic force generated by the coil is flipped in state to make the main loop contact 1 of the contactor KM kept in a disconnected state under the action of the release permanent magnet. The output terminal of the inverter U2C is connected to the base electrode of the triode V2 after being connected to the resistor R10 and the resistor R11 in series for voltage division, so as to change a capacitor C4 at the same time. When the charging voltage reaches a switch-on threshold of the triode V2, in this embodiment, the threshold depends on the charging time of the C4, the electrical level of the IN1 pin of the full-bridge driver chip U1 is pulled down, and according to the truth value of the full-bridge driver chip U1, the OUT1 pin and the OUT2 pin of the full-bridge driver chip U1 output high resistance, the coil 4 of the contactor KM loses power, and the current of the coil 4 instantaneously becomes zero. The function of the circuit is to make the coil 4 energized for delayed release and then quickly enter a zero-current state to prevent the coil 4 of the contactor KM from being energized all the time at a low voltage.

[0037] In this embodiment, in the whole working process of the circuit, it is set that the coil 4 of the contactor KM loses power after a delay of 10 mS after being energized, the coil 4 of the contactor KM obtains two voltage pulse signals with opposite polarities under turn-on and turn-off states of the control power supply, thus achieving the purpose of high efficiency and energy conservation while achieving the same pull-in characteristics of the magnetic holding contactor and the non-magnetic holding contactor.

[0038] In this embodiment, the release characteristics, i.e., release voltage values, of the power supply voltage in the slow drop process can be regulated by adjusting a resistance ratio of the resistor R2 and the resistor R3. The pull-in characteristics, i.e., pull-in voltage values, of the power supply voltage in the slow rising process can

be regulated by adjusting a resistance ratio of the resistor R4 and the resistor R5. The Zener diode DW1 is used for preventing the inverter from being damaged when the power supply voltage rises or is debugged. The diodes D2, D3, D4 and D5 can absorb back electromotive force generated when the coil of the contactor KM works, and the resistor R7 is a current-limiting protection sampling resistor.

[0039] To simplify the circuit, reduce the size and lower the cost, the full-bridge driver chip U1 using the full-bridge driver chip function in the circuit is shown in FIG. 4 and 5. In this embodiment, when the access control power supply is AC-DC universal power supply, as shown in FIG. 2, an AC-DC conversion circuit is provided at an input terminal of the control power supply.

[0040] When the access control power supply is AC high voltage power supply, as shown in FIG. 3, a transformer is arranged at an input terminal of the AC-DC conversion circuit.

[0041] Finally, it should be noted that the above is only the preferred embodiment of the present disclosure, and it is not used to limit the present disclosure. Although the present disclosure has been described in detail with reference to the foregoing embodiments, it is still possible for a person skilled in the art to modify the technical solution described in the foregoing embodiments or to replace some technical features by equivalents. Any modification, equivalent replacement, improvement, etc. made within the spirit and principle of the present disclosure should be included in the scope of protection of the present disclosure.

Claims

1. An energy-saving control method for a contactor, comprising the following steps:

connecting the contactor: after a control power supply is turned on, enabling an energy storage circuit to work to charge an energy storage capacitor, and meanwhile, enabling a coil (4) of a contactor KM to generate an attractive magnetic force after receiving a pulse voltage signal, making an action mechanism (2) of the contactor KM act, wherein a main loop contact (1) of the contactor KM is connected, a control line of the coil (4) of the contactor KM loses power within set millisecond-scale delay time, and the main loop contact (1) of the contactor KM is continuously kept in a connected state under the action of a pull-in permanent magnet (5);
disconnecting the contactor: when the control power supply is turned off, discharging the energy storage capacitor of the energy storage circuit to provide released electric energy to the coil (4) of the contactor KM, where the released electric energy outputs a pulse with opposite po-

larity to a pull-in voltage of the coil (4) of the contactor KM via a full-bridge drive control circuit, the coil (4) of the contactor KM generates a reverse magnetic force, a direction of a magnetic force of a magnetic field is reversed, making the action mechanism (2) of the contactor KM act towards a direction opposite to the direction when pulling in, the main loop contact (1) of the contactor KM is disconnected, and after the coil (4) of the contactor KM loses power, the main loop contact (1) of the contactor KM is kept in a disconnected state under the action of a release permanent magnet (3).

2. The energy-saving control method for a contactor according to claim 1, wherein the energy-saving control method further comprises an energy-saving control circuit; the energy-saving control circuit comprises a full-bridge driver chip U1 for controlling the function of the contactor KM, the energy storage circuit connected to the control power supply, a voltage-stabilizing circuit connected to the energy storage circuit and configured to send an input voltage to the full-bridge driver chip U1 after voltage stabilization, a voltage signal detection and regulation circuit, a three-stage inverter connected to the voltage signal detection and regulation circuit, a pull-in delay regulation circuit for generating a pull-in voltage and a contactor KM connecting delay, and a release delay regulation circuit (6) for controlling a release voltage and a contactor KM disconnecting delay; the pull-in delay regulation circuit and the release delay regulation circuit (6) are both connected to the three-stage inverter; the voltage signal detection and regulation circuit and the control power supply are connected for the detection and regulation and filter overvoltage protection of an input voltage signal;

the full-bridge driver chip U1 is internally provided with the full-bridge driver control circuit; and the three-stage inverter comprises an inverter U2A, an inverter U2B, and an inverter U2C connected in series.

3. The energy-saving control method for a contactor according to claim 2, wherein when the control power supply is turned on, the energy storage capacitor C1 is charged by the energy storage circuit, and meanwhile, the coil (4) of the contactor KM generates an attractive magnetic force after receiving a pulse voltage signal, making the action mechanism (2) of the contactor KM connected under the combined action of the attractive magnetic force generated by the coil (4) of the contactor KM and the attractive magnetic force of the pull-in permanent magnet (5), and a signal is sent to the full-bridge driver chip U1 through the pull-in delay regulation circuit; the full-bridge driver chip U1, after receiving the signal, controls to turn

off a voltage of the coil (4) of the contactor KM, the coil (4) of the contactor KM loses power, and the main loop contact (1) of the contactor KM is kept in a connected state under the action of the pull-in permanent magnet (5);

when the control power supply is turned off, after the full-bridge driver chip U1 receives a power-off signal of the voltage signal detection and regulation circuit, an electric energy voltage of the energy storage capacitor C1 in the energy storage circuit is sent into the coil (4) of the contactor KM after polarity switching, the coil (4) of the contactor KM generates a magnetic force in an opposite direction of an existing magnetic force, the reverse magnetic force makes the contact KM break away from the attractive magnetic force of the pull-in permanent magnet (5) to be disconnected, the action mechanism (2) of the contactor KM is attached to the release permanent magnet (3), the main loop contact (1) of the contactor KM is disconnected, and then a signal is sent by the release delay regulation circuit (6) to the full-bridge driver chip U1 to make the coil (4) of the contactor KM lose power, and the main loop contact (1) of the contactor KM is kept in a disconnected state under the action of the release permanent magnet (3).

4. The energy-saving control method for a contactor according to claim 3, wherein the pull-in delay regulation circuit comprises a triode V1 connected to an output terminal of the inverter U2B, and a capacitor C2 connected to the triode V1; the output terminal of the inverter U2B is connected to a base electrode of the triode V1 after being connected to a resistor R2 and a resistor R3 in series for voltage division; a collector electrode of the triode V1 is connected to an IN2 pin of the full-bridge driver chip U1 through a resistor R6;

when a charging voltage of the capacitor C2 reaches a switch-on threshold of the triode V1, electrical level of the IN2 pin of the full-bridge driver chip U1 is pulled down, an OUT1 pin and an OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil (4) of the contactor KM loses power; an input terminal of the inverter U2B is connected to an output terminal of the inverter U2A, and an input terminal of the inverter U2A is connected to a positive electrode of the control power supply through a resistor R4 and a resistor R5, and both terminals of the resistor R5 are connected in parallel with a capacitor C3 and a Zener diode DW1.

5. The energy-saving control method for a contactor according to claim 3, wherein the release delay regulation circuit (6) comprises a triode V2 connected to an output terminal of the inverter U2C, and a capacitor C4 connected to the triode V2; the output terminal of the inverter U2C is connected to a base electrode of the triode V2 after being connected to

a resistor R10 and a resistor R11 in series for voltage division, a collector electrode of the triode V2 is connected to an IN1 pin of the full-bridge driver chip U1, and the collector electrode of the triode V2 is further connected to the output terminal of the inverter U2C through a resistor R9; 5

when a charging voltage of the capacitor C4 reaches a switch-on threshold of the triode V2, electrical level of the IN1 pin of the full-bridge driver chip U1 is pulled down, the OUT1 pin and the OUT2 pin of the full-bridge driver chip U1 output high resistance, and the coil (4) of the contactor KM loses power. 10

6. The energy-saving control method for a contactor according to claim 3, wherein the positive electrode of the control power supply is also connected to a diode D1, and the diode D1 is also connected to a VBB pin of the full-bridge driver chip U1; when the control power supply is powered off, the diode D1 is cut off reversely, and the output terminal of the inverter U2C outputs a high electrical level signal to the full-bridge driver chip U1, and the full-bridge driving chip U1 outputs a voltage after polarity switching of the power supply. 15 20 25
7. The energy-saving control method for a contactor according to any one of claims 3 to 6, wherein when the control power supply is turned on, a current generated by the control power supply is connected to a Vref pin of the full-bridge driver chip U1 through a circuit in which a resistor R1 and a Zener diode DW2 are connected in series. 30
8. The energy-saving control method for a contactor according to any one of claims 3 to 6, wherein the energy storage capacitor C1 is connected to the control power supply through a buffer resistor R8. 35
9. The energy-saving control method for a contactor according to claim 8, wherein the resistor R8 is connected to an LSS pin of the full-bridge driver chip U1 through a resistor R7, a freewheeling diode is arranged between the resistor R7 and the resistor R8; and the freewheeling diode comprises a diode D3, a diode D5, a diode D2, and a diode D4, wherein the diode D2 and the diode D4 are connected in series, the diode D3 and the diode D5 are connected in series, and then the diode D2 and the diode D4 are connected in parallel with the diode D3 and the diode D5. 40 45 50

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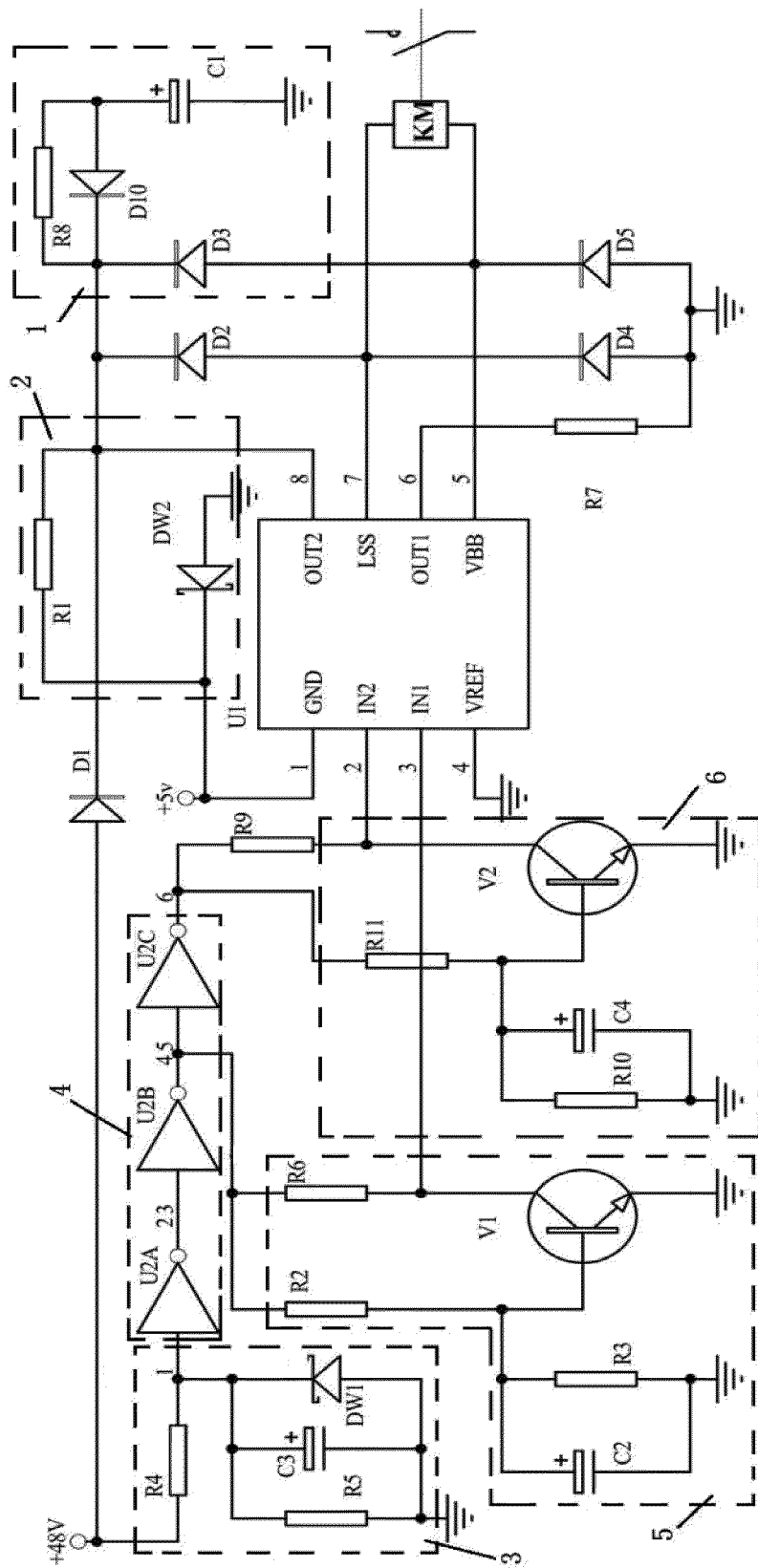


FIG. 1

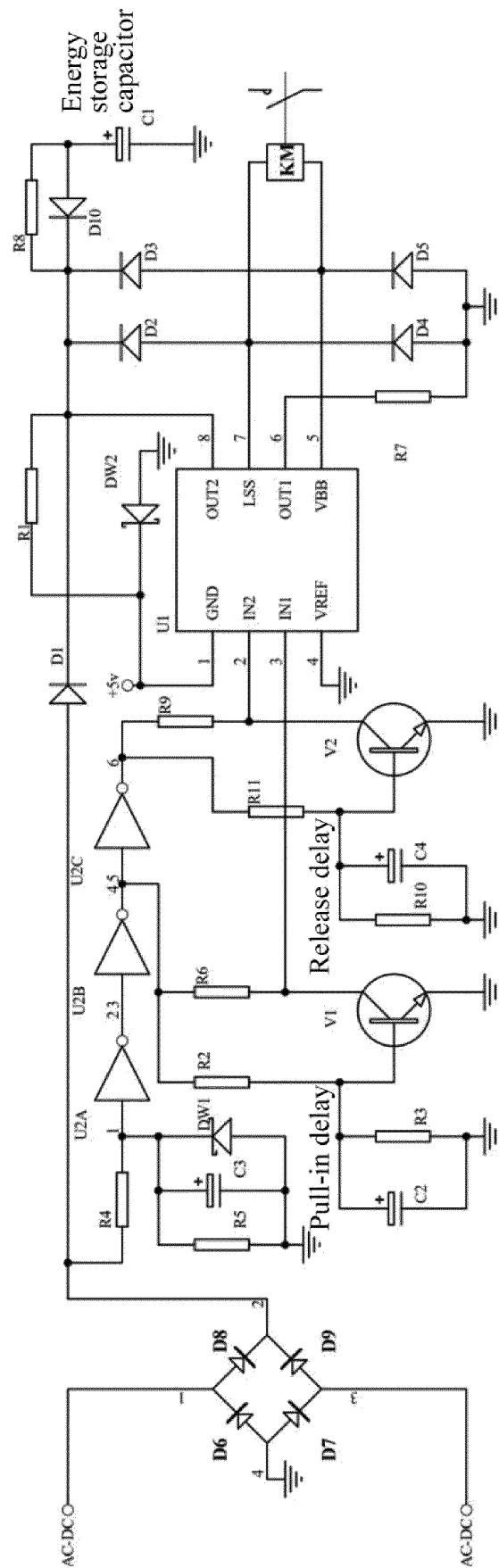


FIG. 2

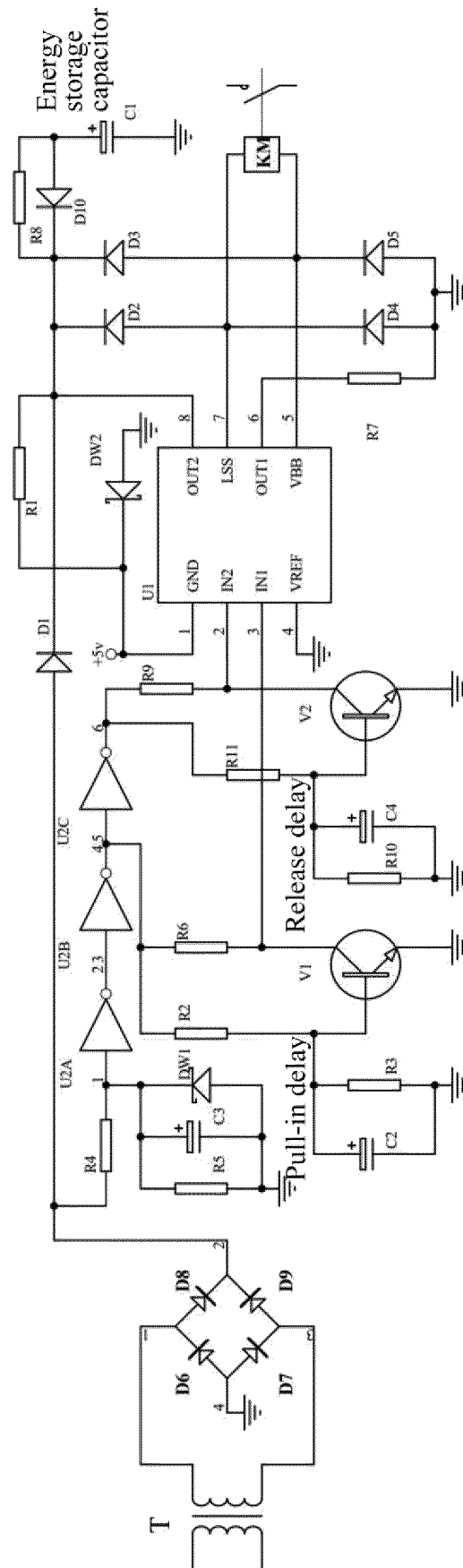


FIG. 3

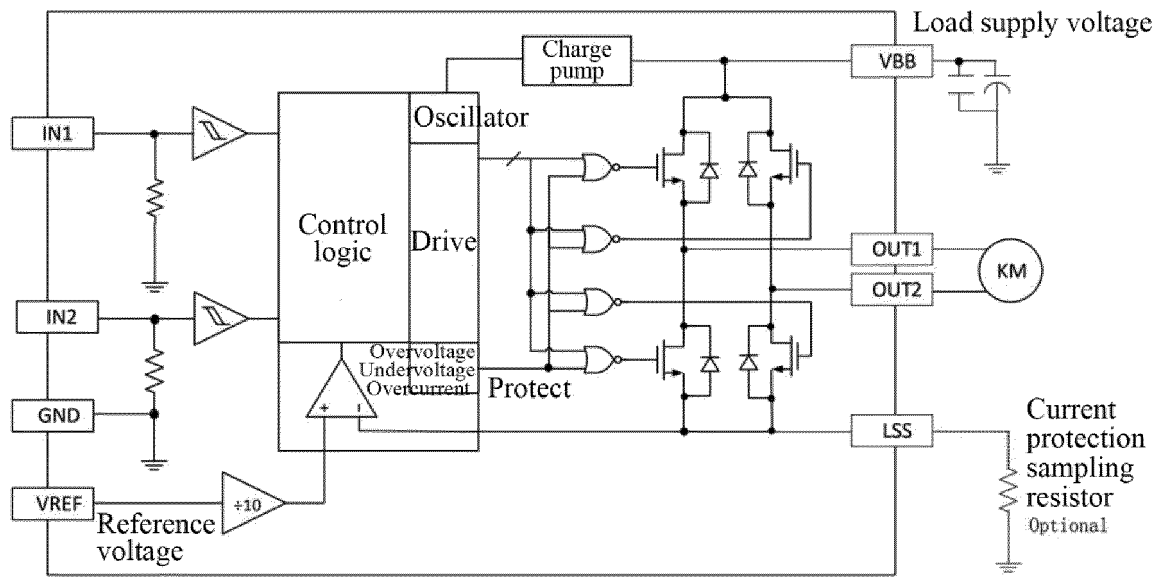


FIG. 4

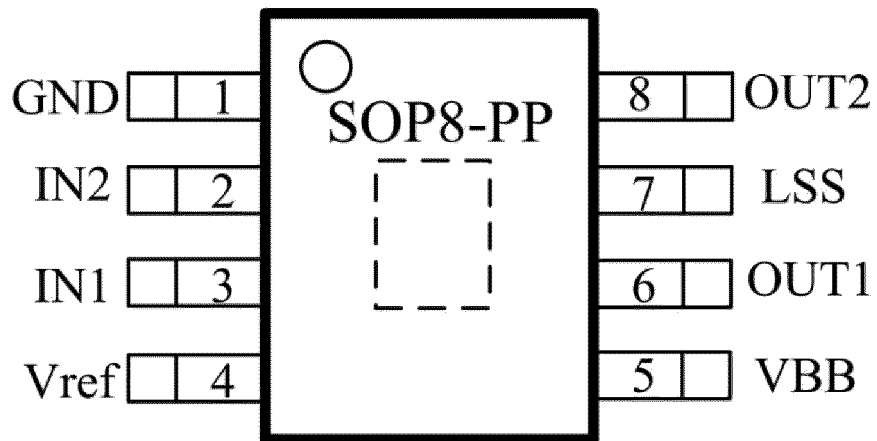


FIG. 5

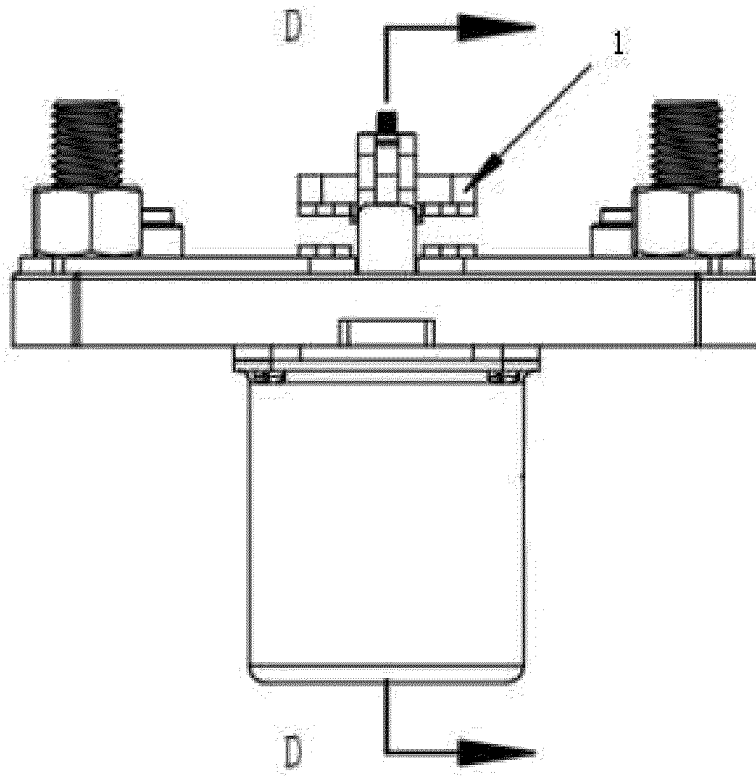


FIG. 6

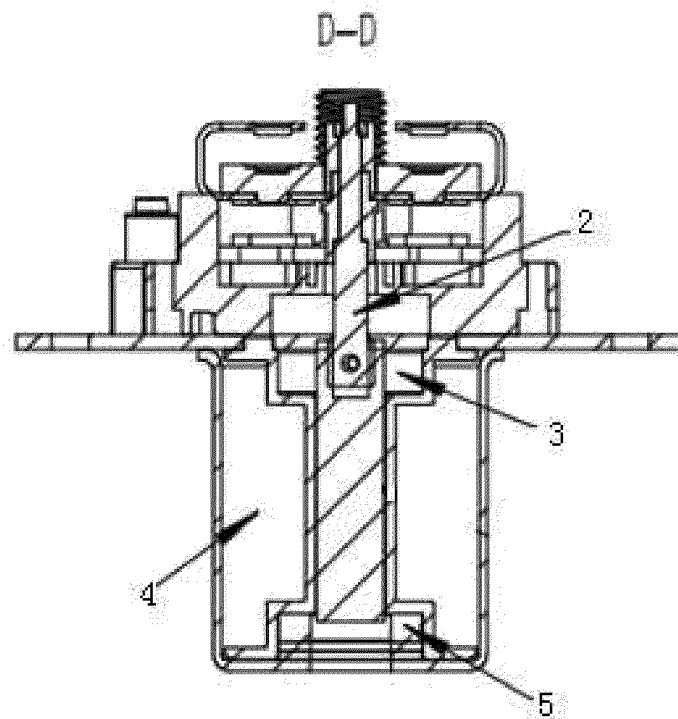


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/110370

A. CLASSIFICATION OF SUBJECT MATTER

H01H 47/04(2006.01)i; H01H 47/18(2006.01)i; H01H 47/32(2006.01)i; H01H 51/01(2006.01)i

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)

H01H

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)

CNTXT, ENTXT, ENTXTC, DWPL, CNKI: 接触器, 继电器, 磁, 电容, 节能, 储能, contact, relay, magnet, capacitance, energy saving, conservation, stored

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 113611572 A (NANJING QUANNING ELECTRIC CO., LTD.) 05 November 2021 (2021-11-05) claims 1-9	1-9
X	CN 102842461 A (FATO MECHANICAL & ELECTRICAL EQUIPMENT GROUP COMPANY LTD.) 26 December 2012 (2012-12-26) description, paragraphs 5-10 and 12-17, and figures 1-2	1
X	CN 2483827 Y (LIN LIJIE) 27 March 2002 (2002-03-27) description, pages 1-2, and figure 1	1
A	DE 102011080226 A1 (BAYERISCHE MOTOREN WERKE AG.) 07 February 2013 (2013-02-07) entire document	1-9
A	DE 19641188 C1 (SIEMENS AKTIENGESELLSCHAFT) 08 January 1998 (1998-01-08) entire document	1-9

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

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Facsimile No. (86-10)62019451

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/110370

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CN 2483827 Y	27 March 2002	None	
DE 102011080226 A1	07 February 2013	US 2013033101 A1	07 February 2013
		US 9283906 B2	15 March 2016
DE 19641188 C1	08 January 1998	WO 9813847 A1	02 April 1998

Form PCT/ISA/210 (patent family annex) (January 2015)