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# (54) ALTERNATING CURRENT TURNOUT EQUIPMENT, SYSTEM, AND CONTROL METHOD THEREFOR

(57) The present invention provides an alternating current (AC) turnout apparatus, system and control method thereof. The AC turnout apparatus includes a point machine control part and a logic part. The point machine control part includes a drive part and an indication part which are independent of each other. Each of the drive part and the indication part is capable of implementing data connection with the logic part. The drive part is configured to control a point machine to operate a fixed rotation or a reverse rotation according to a control instruction of the logic part. The indication part configured to acquire indication information of the point machine, and send the acquired indication information of the point machine to the logic part. The AC turnout apparatus, system and control method effectively improve the reliability of the AC turnout control and ensure the traveling safety.

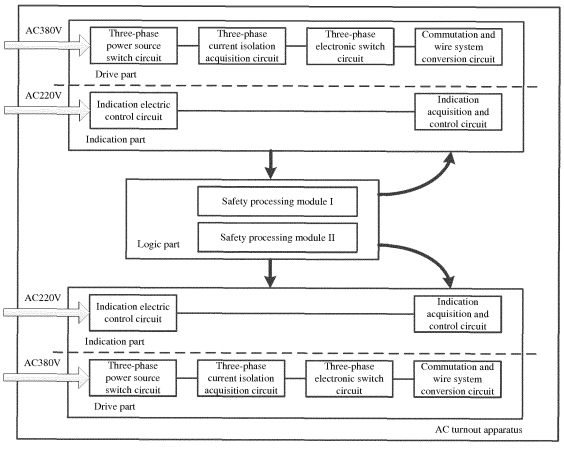


**FIG. 2**

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## Description

**[0001]** This application claims priority to a Chinese patent application No. 201811139273.9 filed on September 28, 2018, the content of which is incorporated herein by reference in its entirety.

## TECHNICAL FIELD

**[0002]** The present invention relates to the technical field of rail transit and, in particular, to an alternating current (AC) turnout apparatus, system and control method thereof.

## BACKGROUND

**[0003]** In a computer interlocking system currently in use, a computer performs interlocking operations, and the driving and indication is completed by a gravitation-type relay circuit performs driving and indication in a driving execution layer. A large number of gravitation-type relays are used in the system. As shown in FIG. 1, an AC turnout control system in the existing art includes a large number of components, e.g., circuit breakers RD, open-phase protectors DBQ, relays DQJ, and has an extremely complex structure. In manufacture, the large number of electric device lead to extremely complex wiring and a large number of welding spots. In actual arrangement, the complex structure requires a large area. In use, the control flow and the current flow directions are complex. In case of a failure, the tracing and locating of the fault is a complex process, and the system requires regular maintenance.

**[0004]** As shown in FIG. 1, a turnout action circuit has following current flow directions:

1) turnout action power source A → circuit breaker RD1 → open-phase protector DBQ-$S_{11\text{-}21}$ → start relay 1DQ$J_{12\text{-}11}$ → coil W of point machine motor;
2) turnout action power source B → circuit breaker RD2 → open-phase protector DBQ-$S_{31\text{-}41}$ → start relay 1DQJ$F_{12\text{-}11}$ → start relay 2DQ$J_{111\text{-}112}$ → point machine connection point 43-44 → off switch K → coil U of point machine motor;
3) turnout action power source C→ circuit breaker RD3 → open-phase protector DBQ-$S_{51\text{-}61}$ → 1DQJ$F_{22\text{-}21}$ → 2DQ$J_{121\text{-}122}$ → point machine connection point 41-42 → coil V of point machine motor;
4) the point machine motor has a phase sequence of W-U-V, and rotates clockwise to drive a switch rail to move towards a normal position.

**[0005]** In a positive half-cycle of a power source, a turnout indication circuit has a following current flow direction: terminal 3 of indication transformer BD → resistor R1 → 2DQ$J_{22\text{-}21}$ → 2DQ$J_{131\text{-}132}$ → 1DQJ$F_{13\text{-}11}$ → 2DQ$J_{111\text{-}112}$ → point machine connection point 33-34 → point machine connection point 15-16 → rectifier diode Z → resistor R → point machine connection point 35-36 → coil U of point machine motor → coil W of point machine motor → 1DQ$J_{11\text{-}13}$ → terminal 4 of indication transformer BD.

**[0006]** In a negative half-cycle of the power source, the turnout indication circuit has a following current flow direction:
terminal 3 of indication transformer BD → resistor R1 → 1DQ$J_{22\text{-}21}$ → 2DQ$J_{131\text{-}132}$ → DB$J_{4\text{-}1}$ → point machine connection point 11-12 → coil V of point machine motor → coil W of point machine motor → 1DQ$J_{11\text{-}13}$ → terminal 4 of indication transformer BD.

**[0007]** The existing turnout control system generally does not have the drive circuit and the indication circuit separated from each other, and thus has low adaptability and safety, which affects the traveling safety and operation efficiency.

## SUMMARY

**[0008]** In terms of the above problem in the existing art, the present invention provides an AC turnout apparatus.

**[0009]** An AC turnout apparatus, including a point machine control part and a logic part, the point machine control part includes a drive part and an indication part which are independent of each other, each of the drive part and the indication part is capable of implementing data connection with the logic part.

**[0010]** The drive part is configured to control a point machine to operate a fixed rotation or a reverse rotation according to a control instruction of the logic part.

**[0011]** The indication part is configured to acquire indication information of the point machine, and send the acquired indication information of the point machine to the logic part.

**[0012]** Further, the drive part includes a three-phase power source switch circuit, a three-phase current isolation acquisition circuit, a three-phase electronic switch circuit and a commutation and wire system conversion circuit.

**[0013]** The three-phase power source switch circuit is configured to implement on-off control for a three-phase alternating current.

**[0014]** The three-phase current isolation acquisition circuit is configured to acquire currents in respective phases of the three-phase current, and determine whether the three-phase current is complete and whether the point machine has been driven in place.

**[0015]** The three-phase electronic switch circuit is configured to increase reliability of the three-phase power source switch circuit and the commutation and wire conversion circuit.

**[0016]** The commutation and wire system conversion circuit is configured to implement commutation of the three-phase current, perform multi-wire system conversion, and control a point machine having a multi-wire system.

**[0017]** Further, the three-phase power source switch

circuit includes a switch circuit and a safety acquisition unit.

**[0018]** The switch circuit is configured to perform an on-off action according to a control signal to implement the on-off control for the three-phase alternating current.

**[0019]** The safety acquisition unit is configured to acquire an on-off state of the switch circuit.

**[0020]** Further, the commutation and wire conversion circuit includes multiple switch circuits.

**[0021]** Each of the switch circuits is connected in parallel to two phase lines of the three-phase alternating current.

**[0022]** Further, the switch circuit includes a switch unit, a control unit and a safety acquisition unit. The switch unit is capable of performing an on-off action according to a control instruction of the control unit.

**[0023]** The safety acquisition unit is configured to acquire an on-off state of the switch unit.

**[0024]** Further, the drive part also includes a three-phase current isolation acquisition circuit and a three-phase electronic switch circuit.

**[0025]** The three-phase current isolation acquisition circuit is configured to determine whether each of three phase lines of the three-phase alternating current is abnormal, and whether the point machine has been driven in place.

**[0026]** The three-phase electronic switch circuit is configured to perform the on-off control on the three phase lines.

**[0027]** Further, the indication part includes an indication electric control circuit, and an indication acquisition and control circuit.

**[0028]** The indication electric control circuit is configured to convert a two-phase high-voltage alternating current into a two-phase low-voltage alternating current.

**[0029]** The indication acquisition and control circuit is connected to an internal shutter of the point machine and is configured to acquire indication state information of the point machine.

**[0030]** Further, the point machine control part includes a first point machine control part and a second point machine control part, the logic part includes a first safety processing module and a second safety processing module.

**[0031]** Each of the drive part and the indication part in the first point machine control part is capable of implementing data connection with the first and second safety processing modules.

**[0032]** Each of the drive part and the indication part in the second point machine control part is capable of implementing data connection with the first and second safety processing modules.

**[0033]** A dual-system hot standby AC turnout system includes a first AC turnout apparatus and a second AC turnout apparatus, each of the first AC turnout apparatus and the second AC turnout apparatus includes a logic part, a first point machine control part and a second point machine control part.

**[0034]** The first point machine control part in the first AC turnout apparatus and the first point machine control part in the second AC turnout apparatus form a double structure.

**[0035]** The second point machine control portion in the first AC turnout apparatus and the second point machine control portion in the second AC turnout apparatus form a double structure.

**[0036]** The logic part in the first AC turnout apparatus communicates with the logic part in the second AC turnout apparatus through an inter-system bus.

**[0037]** Each of the first point machine control part and the second point machine control part includes a drive part and an indication part which are independent of each other, each of the drive part and the indication part is capable of implementing data connection with the logic part.

**[0038]** The drive part is configured to control a point machine to operate a fixed rotation or a reverse rotation according to a control instruction of the logic part.

**[0039]** The indication part is configured to acquire indication information of the point machine, and send the acquired indication information of the point machine to the logic part.

**[0040]** A turnout control method for the AC turnout apparatus includes the steps described below.

**[0041]** A logic part sends a drive control instruction to a drive part, and the drive part controls a point machine to operate a fixed rotation or a reverse rotation according to the drive control instruction.

**[0042]** The indication part acquires indication information of the point machine, and sends the indication information to the logic part.

**[0043]** Further, a three-phase current isolation acquisition circuit in the drive part detects a state of each phase of three phases of a three-phase current, and sends the states of the three phases to the logic part; the logic part determines whether to send an instruction of safety side guiding to the drive part after receiving the states of the three phases.

**[0044]** Further, an AC turnout module sends an AC sinusoidal signal to an outdoor point machine through a normal position circuit and a reverse position circuit separately, and determines an indication state of the point machine by detecting a return current;

in a case where the AC turnout module controls a five-wire system point machine, and the point machine is in a normal position, an internal shutter of the point machine connects the normal position circuit in the indication part to an indication diode of the point machine in the indication part, and the reverse position circuit is in a short-circuit state in the indication part; if a normal position acquisition circuit in the indication part acquires a negative half-cycle sinusoidal current and a reverse position acquisition circuit in the indication part acquires a sinusoidal current, the point machine is determined to be in a normal position state; if the reverse position acquisition circuit acquires a positive half-cycle sinusoidal current

and the normal position acquisition circuit acquires the sinusoidal current, the point machine is determined to be in a reverse position state; otherwise, the point machine is determined to be in a four-open state.

**[0045]** Further, the AC turnout module sends an AC sinusoidal signal to an outdoor point machine through a normal position circuit and a reverse position circuit separately, and determines an indication state of the point machine by detecting a return current;
in a case where the AC turnout module controls a seven-wire system point machine, and the point machine is in a normal position, an internal shutter of the point machine connects the normal position circuit in the indication part with an indication diode of the point machine in the indication part, and the reverse position circuit is in an open-circuit state; if the normal position acquisition circuit in the indication part acquires a positive half-cycle sinusoidal current and a reverse position acquisition circuit in the indication part acquires no current, the point machine is determined to be in a normal position state; if the reverse position acquisition circuit acquires the positive half-cycle sinusoidal current and the normal position acquisition circuit acquired no current, the point machine is determined to be in a reverse position state; otherwise, the point machine is determined to be in a four-open state.

**[0046]** Further, the logic part controls conduction or disconnection of a normal position acquisition self-check circuit in the indication part.

**[0047]** When a branch in which the normal position acquisition self-check circuit is located is in conduction, the branch enters a self-check state; if the normal position acquisition self-check circuit acquires a valid half-cycle signal and a valid negative half-cycle signal at the same time, a normal position acquisition circuit is determined to work normally; otherwise, the normal position acquisition circuit is determined to be in a failure.

**[0048]** When the branch in which the normal position acquisition self-check circuit is located is in disconnection, the branch enters a point machine indication acquisition state, and acquires indication information of the point machine.

**[0049]** Through the technical solution of the present invention, reliability of turnout control can be effectively improved, and operation safety of the railway vehicle is ensured. Additional features and advantages of the preset invention will be set forth in the description which follows, and in part will be apparent from the description, or may be understood by implementing the present invention. The objects and other advantages of the present invention may be implemented and obtained through structures set forth in the description, claims and drawings.

## BRIEF DESCRIPTION OF DRAWINGS

**[0050]** To illustrate the technical solutions in the embodiments of the present invention or the technical solutions in the existing art more clearly, drawings used in the description of the embodiments or the existing art will be briefly described below. Apparently, the drawings described below illustrate part of the embodiments of the present invention, and those skilled in the art may obtain other drawings based on the drawings described below without creative work.

FIG. 1 is a schematic diagram of an AC turnout control system in the existing art;
FIG. 2 is a block diagram of an AC turnout module according to an embodiment of the present invention;
FIG. 3 is a block diagram of a logic part in an AC turnout according to an embodiment of the present invention;
FIG. 4 is a block diagram of a drive part in an AC turnout according to an embodiment of the present invention;
FIG. 5 is a block diagram of an indication part in an AC turnout according to an embodiment of the present invention; and
FIG. 6 is a double hot standby AC turnout system according to an embodiment of the present invention.

## DETAILED DESCRIPTION

**[0051]** To illustrate the objects, technical solutions and advantages of embodiments of the present invention more clearly, the technical solutions in the embodiments of the present invention will be described clearly and completely in conjunction with drawings in the embodiments of the present invention. Apparently, the described embodiments are part, not all, of embodiments of the present invention. Based on the embodiments of the present invention, all other embodiments obtained by those skilled in the art without creative work are within the scope of the present invention.

**[0052]** FIG. 2 is a block diagram of an AC turnout module according to an embodiment of the present invention. As shown in FIG. 2, the AC turnout module in the embodiment of the present invention adopts a double 2-out-of-2 structural design, including two point machine control parts and a logic part. Each point machine control part includes a drive part and an indication part. An upper point machine control part and a down point machine control part, each including the drive part and the indication part, is in data connection with a safety processing module in the logic module. The two point machine control parts have the same principles but are physically independent.

**[0053]** In the embodiment of the present invention, the AC turnout module mainly includes a drive part, an indication part and a logic part. The drive part and the indication part are independent of each other. In the embodiment of the present invention, the logic part, the drive part, and the indication part are respectively introduced

below.

**Logic part:**

**[0054]** The logic part implements data interaction with a control network and a maintenance network to implement functions of communication interaction, output control, acquisition and safety operation. The logic part is composed of a 2-out-of-2 main control unit, and cooperates with another logic unit to form a double 2-out-of-2 structure. FIG. 3 is a schematic diagram of a logic part with a double 2-out-of-2 structure according to an embodiment of the present invention. As shown in FIG. 3, two safety processing modules are provided in the logic part: a safety processing module I and a safety processing module II. Each of the two safety processing modules adopts two safety CPU chips: a safety CPU chip 1 and a safety CPU chip 2. In the safety processing module I, the safety CPU chip 1 implements data connection with the safety CPU chip 2, and the safety CPU chip 1 and the safety CPU chip 2 are respectively connected to a control network A and a maintenance network A. The structure of the safety processing module II is the same with that of the safety processing module I, and each safety CPU chip in the safety processing module I and the safety processing module II implements data interconnection.

**Drive part:**

**[0055]** As shown in FIG. 2, the drive part is powered by a three-phase alternating current (AC 380V) and is connected to an internal motor of the point machine. In use, the drive part may control the point machine to operate a fixed rotation or a reverse rotation based on a control instruction of the safety CPU chips in the logic part. The drive part mainly includes a three-phase power source switch circuit, a three-phase current isolation acquisition circuit, a three-phase electronic switch circuit and a commutation and wire system conversion circuit. FIG. 4 shows a further structural diagram of a logic part according to an embodiment of the present invention.

**[0056]** As shown in FIG. 4, the three-phase power source switch circuit includes a safety relay, a safety AND gate and a safety acquisition unit which are respectively connected to the safety relay. The safety AND gate in the three-phase power source switch circuit controls the safety relay in the three-phase power source switch circuit to implement the on-off control of the three-phase current. The safety AND gate receives dynamic signals at different frequencies sent by the safety CPU chips in the safety processing module to implement the on-off control of the safety relay.

**[0057]** In the embodiment of the present invention, the safety relay may adopt a switch tube device such as a 3-on-1-off small-scale safety relay. The three-phase electricity of AC 380V is respectively accessed through three normal-open contacts of the 3-on-1-off safety relay. The three normal-open contacts of the 3-on-1-off safety relay are closed when the point machine acts. When a fault occurs, the driving to the relay is ensured to be disconnected. The two safety CPU chips in the logic part is capable of sending dynamic control signals at different frequencies to the safety gate to implement the on-off control of the safety relay and ensure the cut-off of the AC 380V power output in case of any CPU failure. The safety acquisition unit in the three-phase power source switch circuit may be implemented by a dynamic code acquisition unit, which acquires a state of normal-close contacts of the safety relay connected to the dynamic code acquisition unit to ensure safety acquisition for the state of the normal-close contacts, and sends the acquired data to the safety CPU chips in the safety processing module. The safety AND gate in the three-phase power source switch circuit, as a control component, is capable of controlling the on and off of the safety relay to implement the on-off control of the AC 380V current. For example, when a safety fault occurs, the safety AND gate controls the 3-on-1-off safety relay to act to cut off the power supply of the AC 380V power source. The safety acquisition circuit monitors the safety relay, acquires an on-off state of the normal-close contacts of the safety relay, and sends the acquired on-off state data to the logic part. Two safety processing modules in the logic part receive the on-off state data at the same time, so as to learn the current state of the safety relay.

**[0058]** The three-phase current isolation acquisition circuit acquires currents in all phase lines of the three-phase electricity to obtain current data (which includes data such as magnitudes and phases of the currents) of the three-phase electricity so as to determine whether each phase line is in abnormal conditions such as phase loss, powerdown or overcurrent, and sends the obtained current data to the safety CPU chips in the safety processing module I and the safety processing module II.

**[0059]** The outdoor AC point machine is driven by the three-phase electricity (U, V and W) of AC 380V. The abnormal in any phase causes a failure in normally driving the point machine (a case where a motor or a circuit inside the board is burnout may even occur at the time of overcurrent). Therefore, an independent current detection circuit is designed for each phase in the embodiment of the present invention (e.g., a three-phase current isolation acquisition module shown FIG. 4) and is configured to determine whether this phase line has phase loss, powerdown or overcurrent. Once the abnormal is detected, the three-phase electricity of 380V output is stopped (i.e., the switch of the three-phase power resource is turned off), and an alarm instruction is sent to the safety CPU chips to control the drive part to guide into a safety side. The three-phase electronic switch circuit includes three independent electronic switches for performing the on-off control on the three-phase electricity. Exemplarily, three independent solid-state relays may be used to control the on and off of the three-phase electricity in parallel separately. The three-phase elec-

tronic switch circuit is beneficial for improving the reliability and lifetime of the contacts of the safety relays before and after the three-phase electronic switch circuit. When an output is required to drive the point machine to rotate, the three-phase electronic switch circuit is finally closed or opened, so that the safety relays before and after the three-phase electronic switch circuit are turned on and off with no electricity.

**[0060]** As shown in FIG. 4, in the embodiment of the present invention, three electronic switches are provided on the lines of the three-phase electricity respectively. The three-phase electronic switch circuit further includes an electronic switch control part which implements a data connection with the safety CPU chips in the safety processing module. The safety CPU chips are capable of sending the control instruction to the electronic switch control part. The electric switch control part controls the on and off of the electronic switches after receiving the control instruction, thereby controlling the on and off of the three-phase electricity.

**[0061]** The commutation and wire conversion circuit includes one or more switch circuits. The switch circuit includes a safety relay, a safety AND gate and a safety acquisition unit which are respectively connected to the safety relay. As shown in FIG. 4, the commutation and wire conversion circuit takes use of two switch circuits to implement not only conversion from three phase lines to five wires, but also commutation. The two switch circuits are respectively connected to two phase lines, thereby converting two phases of the three-phase electricity into four wires, and finally converting the drive circuit into a five-wire system. The safety acquisition unit in each switch circuit acquires state data of the normal-open contacts and the normal-close contacts in the safety relay. The state data includes the on-off state of the normal-open contacts and the normal-close contacts or a state of whether adhesion occurs. Through the acquisition of the state of the normal-open contacts and the normal-close contacts, and the comparison between the state and a current relay control signal, the state of the relay contacts is determined. At the same time, the acquired state data is sent to the safety CPU chips in the safety processing module. In the embodiment of the present invention, the state data may be sent to both of the safety CPU chip 1 and the safety CPU chip 2. The safety AND gate in the commutation and wire conversion circuit also implements the data connection with the safety CPU chips in the safety processing module, and implements the on-off control of lines based on the control instruction of the safety CPU chips. Specifically, each of the two safety CPU chips in the safety processing module may send the control signal to one or two of two safety AND gates.

**[0062]** The commutation and wire system conversion circuit of the drive part is connected to an internal motor of the point machine through an electromagnetic compatibility protection circuit.

**Indication part:**

**[0063]** As shown in FIG. 2, the indication part is connected to an internal shutter of the point machine. In operation, the indication part acquires indication state information of the point machine, and sends the acquired indication state information of the point machine to the safety CPU chips of the logic part. The indication part mainly includes an indication electric control circuit, and an indication acquisition and control circuit.

**[0064]** FIG. 5 shows a structural diagram of an indication part according to an embodiment of the present invention. The indication electric control circuit of the indication part may be implemented through a transformer. Specifically, an AC 220V voltage may be converted into two AC 48V voltages and output through a power frequency transformer, and the AC 48V voltages are output to the indication acquisition and control circuit. The indication acquisition and control circuit of the indication part includes an indication acquisition circuit, an indication acquisition self-check circuit and a safety relay. The indication acquisition and control circuit is connected to the internal motor of the point machine through the electromagnetic compatibility protection circuit. As shown in FIG. 5, the indication part in the embodiment of the present invention adopts a four-wire system. A first wire and a second wire are respectively connected to a first terminal and a second terminal of a first secondary coil of the transformer, and a third wire and a fourth wire are respectively connected to a first terminal and a second terminal of a second secondary coil of the transformer. The four wires are connected to switch branches of the safety relay separately.

**[0065]** The indication acquisition and control circuit is connected to the internal shutter of the point machine and may acquire the indication state information of the point machine in operation. As shown in FIG. 5, a circuit in which the first secondary coil of the transformer is located forms a first loop and a circuit in which the second secondary coil of the transformer is located forms a second loop. The first loop includes a normal position circuit, and the second loop includes a reverse position circuit.

**[0066]** The normal position circuit includes a normal position acquisition circuit and a normal position acquisition self-check circuit. The reverse position circuit includes a reverse position acquisition circuit and a reverse position acquisition self-check circuit. The normal position circuit and the reverse position circuit are configured to determine indication information of the turnout, i.e., obtaining state information of the turnout such as a normal position, a reverse position or a four-open position. The normal position acquisition circuit is connected to the second wire. The normal position acquisition self-check circuit is connected between the first wire and the second wire. The reverse position acquisition circuit is connected to the third wire, and the reverse position acquisition self-check circuit is connected between the third wire and the fourth wire. The normal position circuit and

the reverse position circuit determine whether the turnout is in a normal position, a reverse position or a four-open state through the normal position acquisition circuit and the reverse position acquisition circuit. When the AC turnout controls a five-wire system point machine and the point machine is in a normal position, the internal shutter of the point machine connects the normal position circuit to an indication diode of the point machine, and the reverse position circuit is in a short-circuit state. The AC turnout module sends an AC sinusoidal signal to an outdoor point machine through the normal position circuit and the reverse position circuit separately. The AC sinusoidal signal of the normal position circuit returns a negative half-cycle sinusoidal current after passing through the indication diode, and the reverse position circuit returns a sinusoidal current due to the short circuit of the point machine. In this case, when the normal position acquisition circuit acquires the negative half-cycle sinusoidal current and the reverse position acquisition circuit acquires the sinusoidal current, the point machine is determined to be in a normal position state. Similar to the principle of the normal position acquisition, when the reverse position acquisition circuit acquires a positive half-cycle sinusoidal current and the normal position acquisition circuit acquires the sinusoidal current, the point machine is determined to be in a reverse position state. When other combinations or an abnormal current is acquired, the point machine is determined to be in a four-open state. When the AC turnout controls a seven-wire system point machine, and the point machine is in a normal position, the internal shutter of the point machine connects the normal position circuit to the indication diode of the point machine, and the reverse position circuit is in a short-circuit state. The AC turnout module sends the AC sinusoidal signal to the outdoor point machine through the normal position circuit and the reverse position circuit separately. The AC sinusoidal signal of the normal position circuit returns the positive half-cycle sinusoidal current after passing through the indication diode, and the reverse position circuit returns no current due to the short circuit of the point machine. In this case, when the normal position acquisition circuit acquires the positive half-cycle sinusoidal current and the reverse position acquisition circuit acquires no current, the point machine is determined to be in a normal position state. Similar to the principle of the normal position acquisition, when the reverse position acquisition circuit acquires the positive half-cycle sinusoidal current and the normal position acquisition circuit acquires no current, the point machine is determined to be in a reverse position state. When other combinations or acquiring an abnormal current is acquired, the point machine is determined to be in a four-open state. The acquisition and self-check circuits are in a working state in real time, and periodically submits the indication state information to the logic part. The normal/reverse position acquisition self-check circuit is configured to determine whether the normal/reverse position circuit works normally. When the normal/reverse position acquisition self-check circuit determines that the normal/reverse position circuit works abnormally, the turnout module guides to a safety side. That is, when it is determined to be abnormal in the indication part, the normal position acquisition self-check circuit sends an instruction to the safety CPU chips, and the safety CPU chips control the drive circuit to guide the turnout to the safety side. The normal position acquisition self-check circuit and the reverse position acquisition self-check circuit may perform self-check at a certain period to implement a periodic detection for the abnormal work of the indication part.

**[0067]** The normal position acquisition self-check circuit is configured to determine whether the normal position acquisition circuit works normally. Based on the control instruction sent by the safety CPU chips, the normal position acquisition self-check circuit controls conduction or disconnection of a branch in which the normal position acquisition self-check circuit is located. When the branch in which the normal position acquisition self-check circuit is located is in conduction, the branch shorts an external circuit and enters a self-check state.in a normal condition, the normal position acquisition self-check circuit acquires a valid positive half-cycle signal and a valid negative half-cycle signal at the same time; otherwise, the normal position acquisition circuit is determined to be in failure. When the branch in which the normal position acquisition self-check circuit is located is in disconnection, the branch enters a point machine indication acquisition state, and a signal acquired by the normal position acquisition circuit is a real indication of the external point machine. The work principles of the reverse position acquisition self-check circuit and the normal position acquisition self-check circuit are the same. The normal position circuit and the reverse position circuit are connected to the safety relay. Specifically, the first wire, the second wire, the third wire and the fourth wire are respectively connected to contacts of four switch branches of the safety relay to connect the normal position circuit and the reverse position circuit to the safety relay. The safety relay is controlled by a control circuit to implement the on-off control of each wire. The safety CPU chips in the safety processing module sends the control instruction to the control circuit, so that the control circuit controls the on and off of the contacts of the safety relay. An acquisition circuit is connected to the safety relay, so as to acquire the state of the normal-open contacts and the normal-close contacts in each branch of the safety relay, and determine whether each branch of the safety relay works normally (mainly determining problems of whether the coil is open or the contacts are adhered), and send the acquired state data (including the on or off state of the normal-open contacts and the normal-close contacts) to the safety CPU chips in the safety processing module. The normal position acquisition circuit is connected in parallel. A first end of the paralleled circuit is connected to the first terminal of the first secondary coil. The normal position acquisition circuit is configured to acquire the

turnout indication state. The normal position acquisition self-check circuit is connected between the first wire and the second wire, and is connected to the normal position acquisition circuit. Corresponding to the normal position circuit, the reverse position acquisition circuit in the reverse position circuit is connected between the third wire and the fourth wire, and is connected to the reverse position circuit. The safety relay is connected to the internal shutter of the point machine through a rear plate protection circuit.

**[0068]** The normal position acquisition self-check circuit and the reverse position acquisition self-check circuit receive the control instruction of the safety CPU chips in the safety processing module. According to the control instruction, the normal position acquisition circuit and the reverse position acquisition circuit operate the acquisition and self-check to perform control. Based on the AC turnout module described above, the present invention provides a dual-system hot standby AC turnout system. As shown in FIG. 6, the dual-system hot standby AC turnout system includes two AC turnout modules: an AC turnout module I and an AC turnout module II. Each AC turnout module includes a logic part as described above and two point machine control parts as described above.

**[0069]** A first point machine control part in the AC turnout module I and a first point machine control part in the AC turnout module II form a double structure to cooperatively control the point machine through the electromagnetic compatibility protection circuit and an outdoor distribution board. A second point machine control part in the AC turnout module I and a second point machine control part in the AC turnout module II also form a double structure to cooperatively control the another point machine through the electromagnetic compatibility protection circuit and the outdoor distribution board.

**[0070]** The safety CPU chips in the logic parts of the two AC turnout modules implements data communication through inter-system communication wires. This dual-system hot standby AC turnout system further effectively improves the safety, reliability and availability in the control of the turnout.

**[0071]** Although the present invention has been described in detail with reference to the above-mentioned embodiments, it should be understood by those skilled in the art that the technical solutions described in the above-mentioned embodiments may still be modified, or part of the technical features therein may be equivalently substituted. Such modifications or substitutions do not depart from the spirit and scope in nature of the technical solutions in the embodiments of the present invention.

## Claims

1. An alternating current (AC) turnout apparatus, comprising a point machine control part and a logic part,
the point machine control part comprises a drive part and an indication part which are independent of each other, each of the drive part and the indication part is capable of implementing data connection with the logic part,
wherein the drive part is configured to control a point machine to operate a fixed rotation or a reverse rotation according to a control instruction of the logic part;
the indication part is configured to acquire indication information of the point machine, and send the acquired indication information of the point machine to the logic part.

2. The AC turnout apparatus of claim 1, wherein the drive part comprises a three-phase power source switch circuit, a three-phase current isolation acquisition circuit, a three-phase electronic switch circuit, and a commutation and wire system conversion circuit,
wherein the three-phase power source switch circuit is configured to implement on-off control for a three-phase alternating current;
the three-phase current isolation acquisition circuit is configured to acquire currents in respective phases of the three-phase current, and determine whether the three-phase current is complete and whether the point machine has been driven in place;
the three-phase power source switch circuit is configured to increase reliability of the three-phase power source switch circuit and the commutation and wire conversion circuit;
the commutation and wire system conversion circuit is configured to implement commutation of the three-phase current, perform multi-wire system conversion, and control a point machine having a multi-wire system.

3. The AC turnout apparatus of claim 2, the three-phase power source switch circuit comprises a switch circuit and a security acquisition unit,
wherein the switch circuit is configured to perform an on-off action according to a control signal to implement the on-off control for the three-phase alternating current;
the security acquisition unit is configured to acquire an on-off state of the switch circuit.

4. The AC turnout apparatus of claim 2, the commutation and wire conversion circuit comprises a plurality of switch circuits,
wherein each of the plurality of switch circuits is connected in parallel to two phase lines of the three-phase alternating current.

5. The AC turnout apparatus of claim 4, each of the plurality of switch circuits comprises a switch unit, a control unit and a security acquisition unit,
wherein the switch unit is capable of performing an on-off action according to a control instruction of the

control unit;
the security acquisition unit is configured to acquire an on-off state of the switch unit.

**6.** The AC turnout apparatus of claim 2, wherein
the three-phase current isolation acquisition circuit is further configured to determine whether each of three phase lines of the three-phase alternating current is abnormal, and whether the point machine has been driven in place;
the three-phase electronic switch circuit is further configured to perform the on-off control on the three phase lines;

**7.** The AC turnout apparatus of claim 1, the indication part comprises an indication electric control circuit and an indication acquisition and control circuit, wherein
the indication electric control circuit is configured to convert a two-phase high-voltage alternating current into a two-phase low-voltage alternating current;
the indication acquisition and control circuit is connected to an internal shutter of the point machine and is configured to acquire indication state information of the point machine.

**8.** The AC turnout apparatus of claim 1, the point machine control part comprises a first point machine control part and a second point machine control part, the logic part comprises a first security processing module and a second security processing module,
wherein each of the drive part and the indication part in the first point machine control portion is capable of implementing data connection with the first and second security processing modules;
the drive part and the indication portion in the second point machine control part is capable of implementing data connection with the first and second security processing modules.

**9.** A dual-system hot standby alternating current (AC) turnout system, comprising a first AC turnout apparatus and a second AC turnout apparatus, each of the first AC turnout apparatus and the second AC turnout apparatus comprises a logic part, a first point machine control part and a second point machine control part,
wherein the first point machine control part in the first AC turnout apparatus and the first point machine control part in the second AC turnout apparatus form a double structure;
the second point machine control part in the first AC turnout apparatus and the second point machine control part in the second AC turnout apparatus form a double structure;
the logic part in the first AC turnout apparatus communicates with the logic part in the second AC turnout apparatus through an inter-system bus;
each of the first point machine control part and the second point machine control part comprises a drive part and an indication part which are independent of each other, each of the drive part and the indication part is capable of implementing data connection with the logic part,
wherein the drive part is configured to control a point machine to operate a fixed rotation or an reverse rotation according to a control instruction of the logic part;
the indication part is configured to acquire indication information of the point machine, and send the acquired indication information of the point machine to the logic part.

**10.** A turnout control method for the AC turnout apparatus of any one of claims 1 to 8, comprising:

sending, by a logic part, a drive control instruction to a drive part, and controlling, by the drive part, a point machine to operate a fixed rotation or an reverse rotation according to the drive control instruction; and
acquiring, by the indication part, indication information of the point machine, and sending the indication information to the logic part.

**11.** The turnout control method of claim 10, wherein
a three-phase current isolation acquisition circuit in the drive part detects a state of each phase of three phases of a three-phase current, and sends the states of the three phases to the logic part, the logic part determines whether to send an instruction of safety side guiding to the drive part after receiving the states of the three phases.

**12.** The turnout control method of claim 10, wherein
the AC turnout apparatus sends an AC sinusoidal signal to an outdoor point machine through a normal position circuit and a reverse position circuit separately, and determines an indication state of the point machine by detecting a return current;
in a case where the AC turnout apparatus controls a five-wire system point machine and the point machine is in a normal position, an internal shutter of the point machine connects the normal position circuit to an indication diode of the point machine in the indication part, and the reverse position circuit is in a short-circuit state in the indication part;
in response to determining that a normal position acquisition circuit in the indication part acquires a negative half-cycle sinusoidal current and a reverse position acquisition circuit in the indication part acquires a sinusoidal current, the point machine is determined to be in a normal position state; in response to determining that the reverse position acquisition circuit acquires a positive half-cycle sinusoidal current and the normal position acquisition circuit ac-

quires the sinusoidal current, the point machine is determined to be in a reverse position state; otherwise, the point machine is determined to be in a four-open state.

**13.** The turnout control method of claim 10, wherein
the AC turnout apparatus sends an AC sinusoidal signal to an outdoor point machine through a normal position circuit and a reverse position circuit separately, and determines an indication state of the point machine by detecting a return current;
in a case where the AC turnout apparatus controls a seven-wire system point machine and the point machine is in a normal position, an internal shutter of the point machine connects the normal position circuit in the indication part an indication diode of the point machine in the indication part, and the reverse position circuit is in an open-circuit state;
in response to determining that a normal position acquisition circuit in the indication part acquires a positive half-cycle sinusoidal current and a reverse position acquisition circuit in the indication part acquires no current, the point machine is determined to be in a normal position state; in response to determining that the reverse position acquisition circuit acquires the positive half-cycle sinusoidal current and the normal position acquisition circuit acquires no current, the point machine is determined to be in a reverse position state; otherwise, the point machine is determined to be in a four-open state.

**14.** The turnout control method of any one of claims 10 to 13, wherein
the logic part controls conduction or disconnection of a normal position acquisition self-check circuit in the indication part;
in response to determining that a branch in which the normal position acquisition self-check circuit is located is in conduction, the branch enters a self-check state; in response to determining that the normal position acquisition self-check circuit acquires a valid positive half-cycle signal and a valid negative half-cycle signal at the same time, a normal position acquisition circuit is determined to work normally; otherwise, the position acquisition circuit is determined to be in a failure; and
in response to determining that the branch in which the normal position acquisition self-check circuit is located is in disconnection, the branch enters a point machine indication acquisition state and acquires indication information of the point machine.

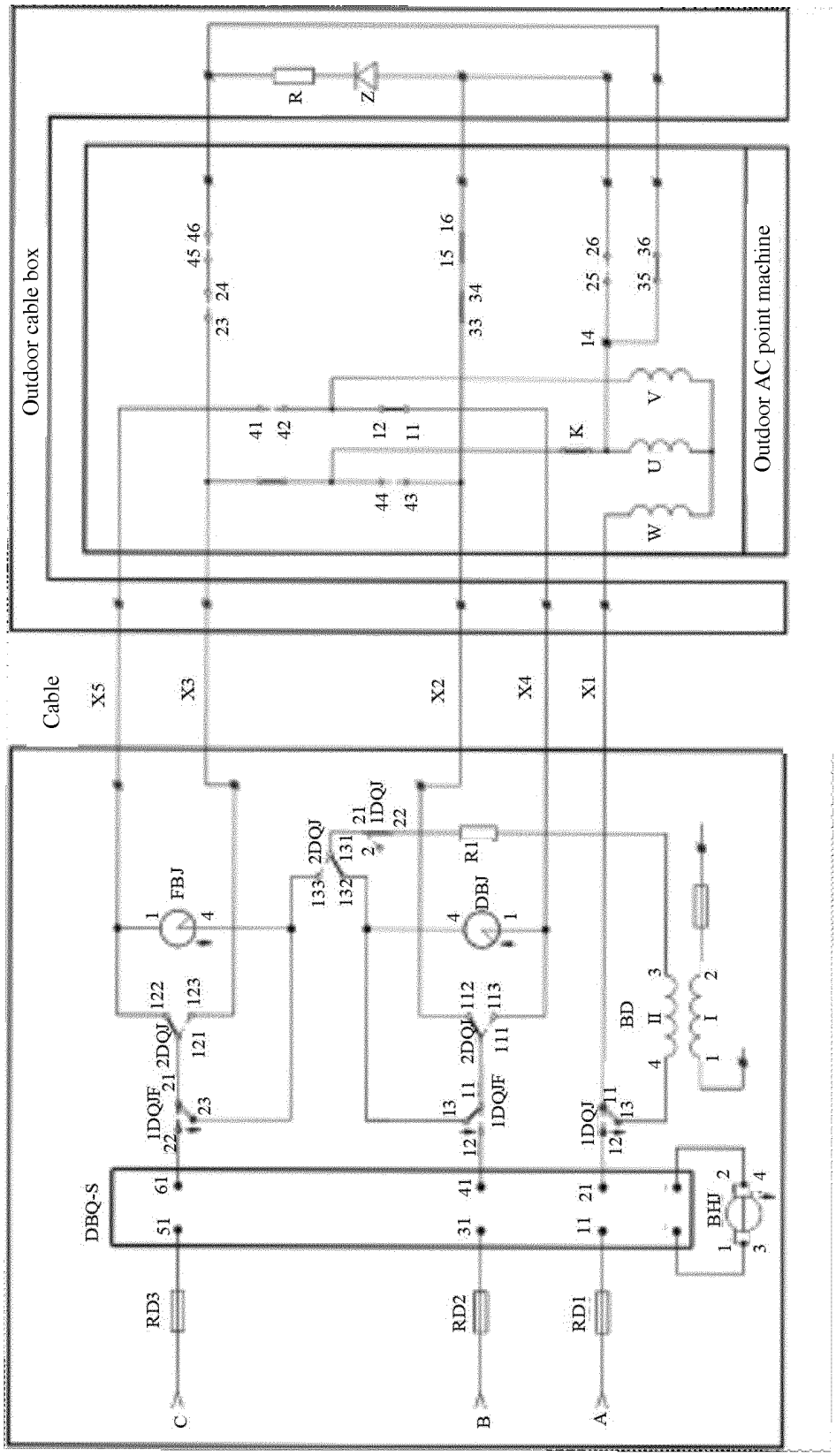
Outdoor cable box
Outdoor AC point machine
Cable
X5
X3
X2
X4
X1
R
Z
K
V
U
W
FBJ
DBJ
R1
2DQJ
1DQJ
1DQJF
BD
BHJ
DBQ-S
RD3
RD2
RD1
C
B
A

FIG. 1

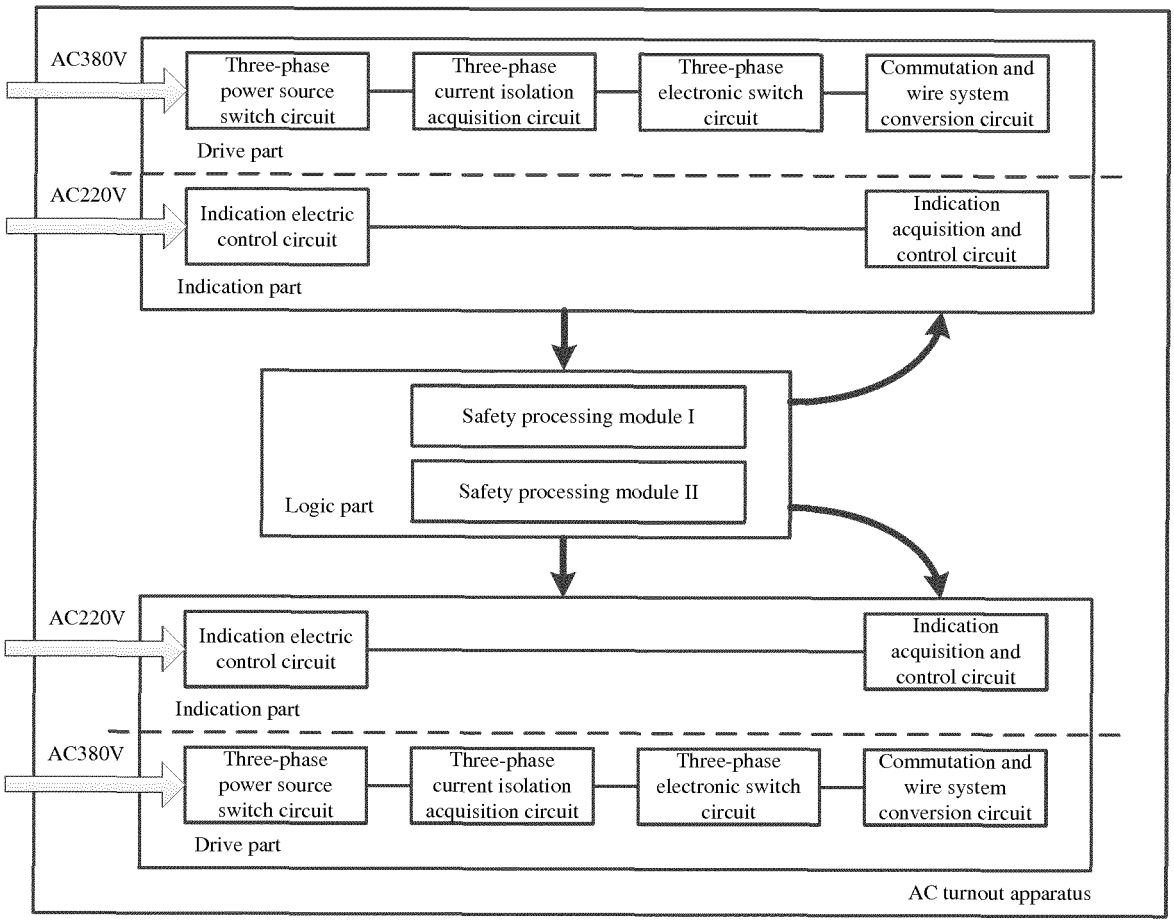
AC380V
Three-phase power source switch circuit
Three-phase current isolation acquisition circuit
Three-phase electronic switch circuit
Commutation and wire system conversion circuit
Drive part
AC220V
Indication electric control circuit
Indication acquisition and control circuit
Indication part
Safety processing module I
Safety processing module II
Logic part
AC220V
Indication electric control circuit
Indication acquisition and control circuit
Indication part
AC380V
Three-phase power source switch circuit
Three-phase current isolation acquisition circuit
Three-phase electronic switch circuit
Commutation and wire system conversion circuit
Drive part
AC turnout apparatus

FIG. 2

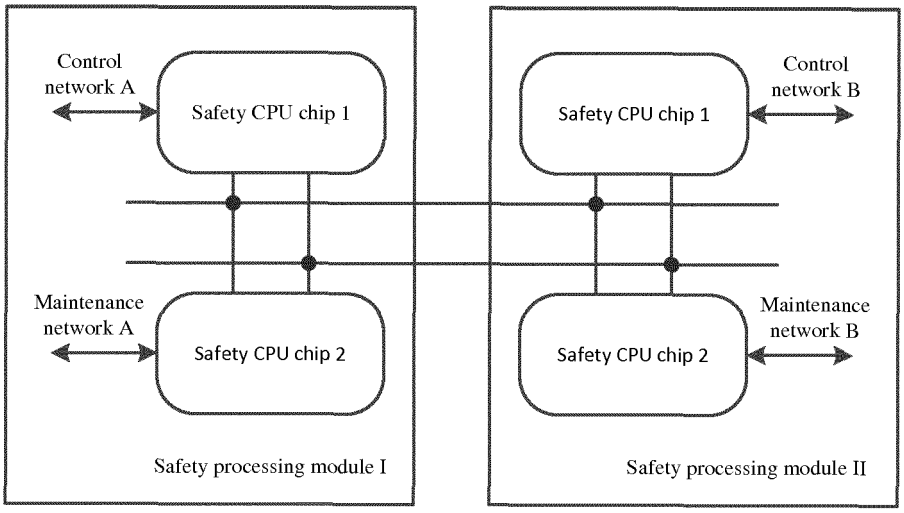
Control network A
Safety CPU chip 1
Maintenance network A
Safety CPU chip 2
Safety processing module I
Safety CPU chip 1
Control network B
Maintenance network B
Safety CPU chip 2
Safety processing module II

FIG. 3

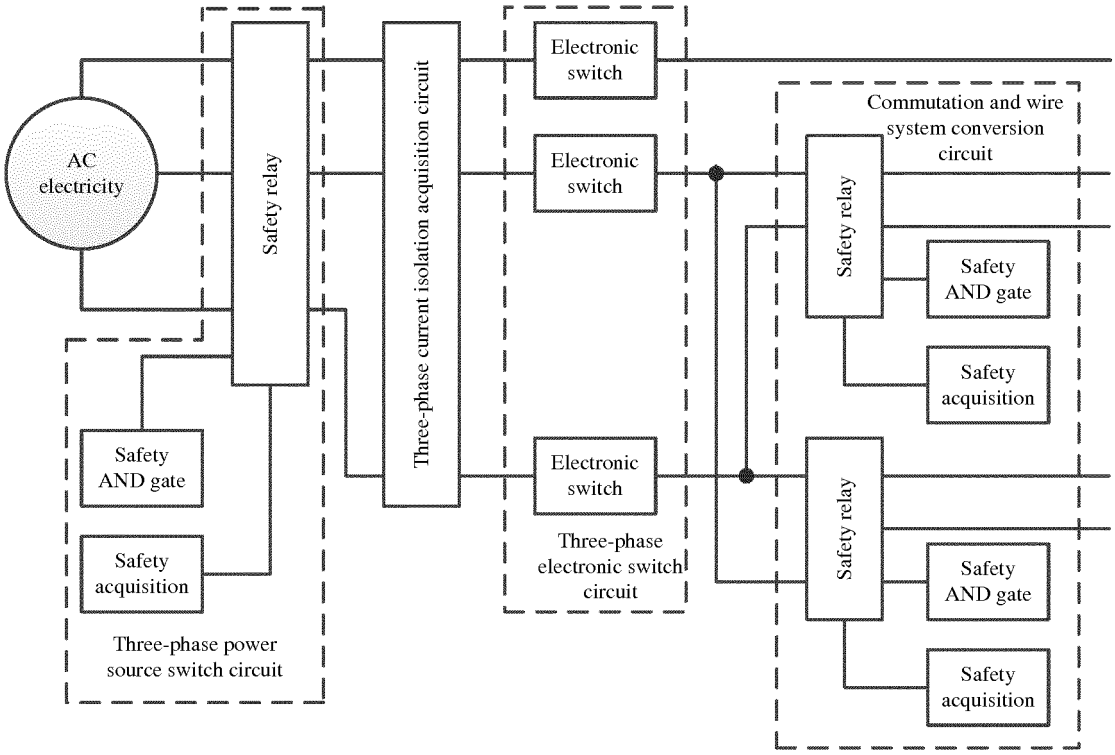
AC electricity
Safety relay
Three-phase current isolation acquisition circuit
Electronic switch
Electronic switch
Electronic switch
Three-phase electronic switch circuit
Commutation and wire system conversion circuit
Safety relay
Safety AND gate
Safety acquisition
Safety relay
Safety AND gate
Safety acquisition
Safety AND gate
Safety acquisition
Three-phase power source switch circuit

FIG. 4

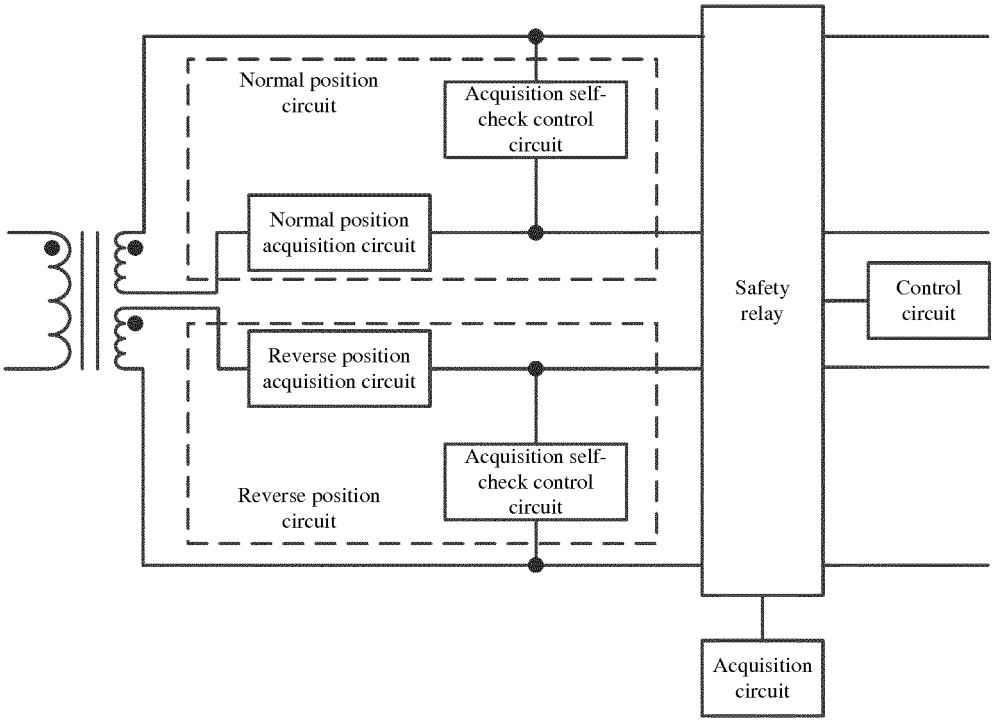
Normal position circuit
Acquisition self-check control circuit
Normal position acquisition circuit
Reverse position acquisition circuit
Acquisition self-check control circuit
Reverse position circuit
Safety relay
Control circuit
Acquisition circuit

FIG. 5

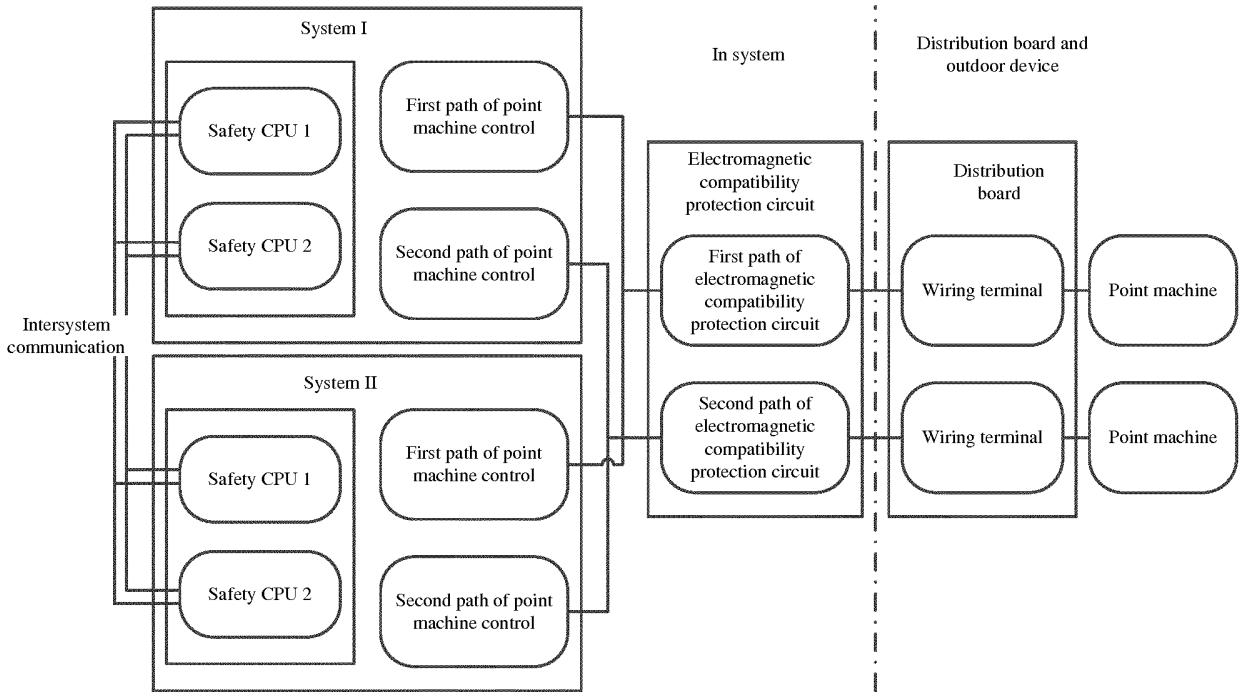
System I
Safety CPU 1
Safety CPU 2
First path of point machine control
Second path of point machine control
Intersystem communication
System II
Safety CPU 1
Safety CPU 2
First path of point machine control
Second path of point machine control
In system
Distribution board and outdoor device
Electromagnetic compatibility protection circuit
First path of electromagnetic compatibility protection circuit
Second path of electromagnetic compatibility protection circuit
Distribution board
Wiring terminal
Wiring terminal
Point machine
Point machine

FIG. 6

TRANSLATION

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2019/104326**

**A. CLASSIFICATION OF SUBJECT MATTER**

B61L 5/06(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)

B61L

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)

CNKI, CNPAT, WPI, EPODOC: 道岔, 转辙机, 驱动, 控制, 表示, 采集, 逻辑; turnout, switch machine, driv+, display+, logic

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | 陈东 (CHEN, Dong). "新型道岔控制电路研究及其可靠性安全性分析 (Research on New Switch Control Circuit and Its Reliability and Safety Analysis)" *中国优秀硕士学位论文全文数据库 工程科技II辑 (Chinese Master's Theses Full-Text Database, Engineering Science &Technology II),* No. 03, 15 March 2015 (2015-03-15), ISSN: 1674-0246, text, pp. 20-40 | 1-14 |
| X | CN 101439725 A (LANZHOU DECHENG AUTOMATIC CONTROL SYSTEM CO., LTD.) 27 May 2009 (2009-05-27) description page 3, the second paragraph from the bottom to page 5, paragraph 2, and figures 1-3 | 1-14 |
| PX | CN 109278802 A (CRSC RESEARCH & DESIGN INSTITUTE GROUP CO., LTD.) 29 January 2019 (2019-01-29) claims 1-14 | 1-14 |
| PX | CN 109278801 A (CRSC RESEARCH & DESIGN INSTITUTE GROUP CO., LTD.) 29 January 2019 (2019-01-29) description, paragraphs [0048]-[0075], and figures 2-6 | 1-14 |

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

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

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **05 November 2019** | **27 November 2019** |
| Name and mailing address of the ISA/CN<br>**China National Intellectual Property Administration (ISA/CN)**<br>**No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**<br>**China** | Authorized officer |
| Facsimile No. **(86-10)62019451** | Telephone No. |

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

TRANSLATION

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/104326

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP 2620347 A1 (ALSTOM FERROVIARIA S.P.A.) 31 July 2013 (2013-07-31)<br>entire document | 1-14 |

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

TRANSLATION

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/104326

| Patent document cited in search report | Publication date (day/month/year) | Patent family member(s) | Publication date (day/month/year) |
|---|---|---|---|
| CN 101439725 A | 27 May 2009 | CN 101439725 B | 05 January 2011 |
| CN 109278802 A | 29 January 2019 | None | |
| CN 109278801 A | 29 January 2019 | None | |
| EP 2620347 A1 | 31 July 2013 | EP 2620347 B1 | 08 October 2014 |
| | | ES 2527964 T3 | 02 February 2015 |

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

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- CN 201811139273 **[0001]**