

LOAD CONTROL DEVICE

Field of the Invention

5 The present invention relates to a two-wire load control device connected in series between an AC power source and a load such as an illumination device or the like.

Background of the Invention

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Conventionally, load control devices for use in illumination devices employing a non-contact switch element such as triac, thyristor or the like, have been used practically. Such a load control device is generally of a two-wire type for the sake of simple wire connection and is connected in series between an AC power source and a load. In such a load control device coupled in series between an AC power source and a load, securing its own circuit power becomes an important issue to be solved.

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20 A load control device 50 in accordance with a first conventional example shown in Fig. 44 is connected in series between an AC power source 2 and a load 3, and includes a main opening/closing unit 51, a rectifying circuit 52, a control unit 53, a first power source 54 for supplying a stable electric power to the control unit 53, a second power source 55 for supplying an electric power to the first power

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source 54 when the load 3 is not powered, a third power source 56 for supplying an electric power to the first power source 54 when the load 3 is powered, an auxiliary opening/closing unit 57 for conducting a minute current to the load 3. The main opening/closing unit 51 includes a triac as a switch element 51a.

In an OFF state of the load control device 50 where the load 3 is not powered, a voltage applied from the AC power source 2 to the load control device 50 is supplied to the second power source 55 through the rectifying circuit 52. The second power source 55 is a constant voltage circuit including a resistor and a zener diode. In the OFF state, a current flowing through the load 3 is such a minute current that there is no possibility for the load 3 to malfunction. A current consumed in the control unit 53 is set to remain small, while an impedance of the second power source 55 is set to remain high.

On the other hand, in an ON state of the load control device 50 where the load 3 is powered, the third power source 56 is turned on by a control signal from the control unit 53 and an impedance of the load control device 50 is lowered such that an amount of current flowing through the load 3 is increased. At this point, a current flowing into the third power source 56 also flows into the first power source 54, thereby starting to charge a buffer capacitor 54a.

When a charged voltage of the buffer capacitor 54a becomes higher than a predetermined threshold, a zener diode 56a included in the third power source 56 breaks down. Accordingly, a current begins to flow into a gate of the auxiliary opening/closing unit 57, so that the auxiliary opening/closing unit 57 becomes a conduction state (closed state). As a result, a current through the rectifying circuit 52 is transferred to the auxiliary opening/closing unit 57 instead of flowing to the third power source 56 and also flows to a gate of the switch element 51a of the main opening/closing unit 51, so that the main opening/closing unit 51 becomes a conduction state (closed state). Thus, almost all of power is supplied to the load 3.

Once the main opening/closing unit 51 becomes a conduction state, the current continues to flow. However, when an alternating current (AC) reaches a zero-cross point, the switch element 51a is self-grounded or extinguished (i.e., turned off by itself) and the main opening/closing unit 51 becomes non-conductive (open state). When the main opening/closing unit 51 becomes non-conductive, a current again flows from the rectifying circuit 52 to the first power source 54 via the third power source 56 and the load control device 50 performs an operation to secure its own circuit power. That is, an operation of the load control device 50 to secure its own circuit power, and operations to make the auxiliary opening/closing unit 57 and the main

opening/closing unit 51 conductive are repeated every half period of AC.

A load control device 60 in accordance with a second conventional example shown in Fig. 45 is connected in series
5 between an AC power source 2 and a load 3, and includes a main opening/closing unit 61, a rectifying circuit 62, a control unit 63, a first power source 64 for supplying a stable power to the control unit 63, a second power source
10 65 for supplying an electric power to the first power source 64 when the load 3 is not powered, a third power source 66 for supplying an electric power to the first power source 64 when the load 3 is powered, a zero cross detector 67 for detecting a zero-cross point of a load current. The main opening/closing unit 61 includes MOSFETs as a switch element
15 61a thereof and an incandescent lamp is employed as a load to be controlled.

When the load 3 is powered, the switch element 61a of the main opening/closing unit 61 becomes conductive for a period of time determined based on a dimming level inputted
20 from the outside. To be specific, the switch element 61a becomes a conduction state (closed state) at the moment when the zero-cross detector 67 detects a zero-cross point of a voltage, and, after a lapse of the above-described period of time, the switch element 61a becomes a non-conduction state
25 (opened state). While the main opening/closing unit 61 is non-conductive (opened state), the load control device 60

secures its own circuit power as in the first conventional example. When the main opening/closing unit 61 becomes non-conductive, the zero-cross detector 67 again detects a zero cross point and an operation to make the switch element 61a
5 conductive (closed state) is performed. That is, an operation of the load control device 60 to secure its own circuit power while the main opening/closing unit 61 is in the non-conductive state, and, when the main opening/closing unit 61 becomes non-conductive, an operation of the zero-
10 cross detector 67 to detect the zero-cross point so that the switch element 61a becomes conductive are repeated every half period of AC.

In the load control devices 50 and 60 in accordance with the above conventional examples, it is necessary to
15 provide the second power sources 55, 65 to continue to feed powers to the respective first power sources 54, 64, so that the control units 53, 63 can operate even when the load 3 is not powered. Therefore, a current, though minute, keeps flowing into the load 3 and, accordingly, there are
20 restrictions on specification of the connectable load thereto.

Meanwhile, in case where the switch element of the main opening/closing unit 51 is a triac or thyrister as in the load control device 50 in accordance with the first
25 conventional example, a filter is required to reduce noise that is generated when a power is supplied to the load 3 and

to avoid a malfunction due to the noise that propagates from the power source 2 when the supply of the power to the load 3 is stopped. However, because of a size of a coil 58 included in the filter and heat generated by the coil 58, it is difficult to achieve scaling down of the load control device.

There is disclosed a load control device (referred to as a "third conventional example" hereinafter) reducing noise caused by the load control device without using a filter in, e.g., Japanese Patent Application Publication No. 2006-92859. The load control device of the third conventional example, in addition to a switch element of a main opening/closing unit, includes a second switching unit having a turn-on resistance larger than that of the switch element (first switching unit), wherein the first switching unit is turned on after the second switching unit is turned on. However, in such third conventional example, control of switch-on timings of the switch elements and a circuit configuration become complicated due to the increased number of switch elements.

In recent years, electric bulb type fluorescent lamps are widely employed to achieve energy-saving. However, when the switch element 61a of the main opening/closing unit 61 is a transistor as in the load control device 60 in accordance with the first conventional example, there is a restriction that a load, e.g., an incandescent lamp, in

which a load current is in phase with a load voltage (power factor = 1) needs to be used. Therefore, two-wire load control devices adaptable regardless of a type of a load to be connected, such as a fluorescent lamp, an incandescent lamp, or the like, are needed.

In addition, it is common that the triac or transistor used as the switch element of the main opening/closing unit is made of Si and is of a vertical type in which a current flows in a vertical direction of the element. In the case of the triac, a p-n junction exists in a conduction path, and thus a loss occurs in overcoming a barrier of the p-n junction during an electrical conduction. In the case of the transistor, since two elements need to be connected in an inverse direction to each other and resistance of a low carrier density layer serving as a withstanding voltage holding layer is high, a loss occurs in the electrical conduction. Such loss causes large heat dissipation by the switch element itself, which in turn requires a large sized heat sink. As a result, it is difficult to achieve large capacity and scaling down of load control devices.

Further, such load control devices are generally accommodated in a metallic box or the like provided on a wall to be then used. Since conventional load control devices have a limitation in its scaling down, it is difficult to install the load control devices in combination with other sensors, switches and the like in a box generally

used. Accordingly, there is a need for more scaled down load control device in order to use the load control device in combination with other sensors, switches and the like, in a general-sized box.

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Summary of the Invention

In view of the above, the present invention provides a load control device capable of realizing a scaling down and a large capacity of the load control device by reducing a quantity of heat dissipated during electrical conducting to a load, without a limitation on the power factor for a load such as a fluorescent lamp, an incandescent lamp or the like.

Further, the present invention provides a load control device wherein switch elements can be accurately controlled in opening and closing timings while reducing a number of components of the switch elements.

Additionally, the present invention provides a load control device capable of preventing a minute current from flowing into a load while the load is not powered, by omitting a constituent corresponding to the second power source in the conventional example.

In accordance with a first aspect of the present invention, there is provided a load control device connected in series between an AC power source and a load, including a main opening/closing unit connected in series between the

power source and the load for controlling supply of power to the load and including a switch element, wherein the switch element has a lateral dual gate transistor structure having a withstanding voltage portion and having a dual gate to which a control voltage is applied; an auxiliary opening/closing unit having an auxiliary switch device of a thyristor structure for controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state; and a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit.

The load control device further includes a first power source unit for receiving an electric power from both ends of the main opening/closing unit via a rectifying circuit and supplying a stable power to the control unit; a second power source unit for receiving an electric power from both ends of the main opening/closing unit via the rectifying circuit, and supplying a power to the first power source unit when the load is not powered; a drive circuit for driving the main opening/closing unit; a third power source unit for supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state; and a voltage detector for detecting a voltage inputted to the third power source unit.

While the load is powered, the control unit makes the

main opening/closing unit conductive for a first predetermined period of time when the voltage detector detects that the voltage inputted to the third power source unit reaches a predetermined threshold and makes the auxiliary opening/closing unit conductive for a second predetermined period of time when the main opening/closing unit is in non-conductive state.,

With the above configuration, the main opening/closing unit includes a dual-gate transistor as a switch element, which is one of semiconductor chips with a high efficiency from a viewpoint of a low loss (low resistance), thereby achieving a large capacity and a scaling down of the load control device.

In accordance with a second aspect of the present invention, there is provided a load control device connected in series between an AC power source and a load, including a main opening/closing unit controlling a supply of power to the load and having a switch element of a transistor structure; an auxiliary opening/closing unit having a switch device of a thyrister structure and controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state; and a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit.

The load control device further includes a first power source unit receiving an electric power from both ends of

the main opening/closing unit via a rectifying circuit and supplying a stable power to the control unit; a second power source unit receiving an electric power from both ends of the main opening/closing unit via the rectifying circuit and
5 supplying a power to the first power source unit when the load is not powered; and a third power source unit supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state.

10 In the load control device, the third power source unit includes a voltage detector for detecting a voltage inputted thereto, and a zero cross detector for detecting a zero cross point of a load current, and, when the load is powered, the control unit makes the main opening/closing
15 unit conductive while a first predetermined period of time counted from when the voltage detector detects that the voltage inputted to the third power source unit reaches a predetermined threshold falls on a third predetermined period of time counted from when the zero cross detector
20 detects a zero cross point of the load current, the third predetermined period of time being shorter than a half cycle of the load current.

With this configuration, since the control unit makes the main opening/closing unit conductive (closed state) for
25 a first predetermined period of time when the voltage detection unit detects that a voltage inputted to the third

power source reaches a predetermined threshold, the power is supplied from the main opening/closing unit to the load for most of the time of a half cycle of a power source. Further, the control unit makes the main opening/closing unit non-conductive when the third predetermined period of time is lapsed even while in the first predetermined period of time, it can be secured that the main opening/closing unit becomes non-conductive before a load current reaches a zero-cross point, even when there is a delay in the timing at which the first predetermined period of time begins, e.g., for a low load.

In accordance with a third aspect of the present invention, there is provided a load control device connected in series between an AC power source and a load, including a main opening/closing unit controlling a supply of power to the load and having a switch element of a transistor structure; an auxiliary opening/closing unit having a switch device of a thyrister structure and controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state; and a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit.

The load control device further includes a first power source unit receiving an electric power from both ends of the main opening/closing unit via a rectifying circuit and supplying a stable power to the control unit; a third power

source unit supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state; a receiving unit receiving a control signal inputted externally; and a independent power source unit rectifying the control signal received by the receiving unit and supplying an electric power to the first power source.

With the above configuration, since the independent power source rectifies the control signal received by the receiving unit and supplies the first power source with a power, there can be omitted a constituent corresponding to the second power source in the conventional examples. Further, since the independent power source supplies power independently and separately to the first power source and the load, a range of usable load can be widened.

Brief Description of the Drawings

The objects and features of the present invention will become apparent from the following description of embodiments, given in conjunction with the accompanying drawings, in which:

Fig. 1A is a circuit diagram of a switch element having a lateral dual gate transistor structure in which there is a single withstanding voltage portion, and Fig. 1B is a circuit diagram of an example in which two MOSFET

transistor elements are inversely coupled;

Fig. 2 is a cross-sectional view of a switch element having a lateral dual gate transistor structure;

Fig. 3 is a circuit diagram for explaining the basic
5 configuration of a load control device 1 in accordance with a first embodiment of the present invention;

Fig. 4 is a timing chart illustrating signal waveforms of parts in the load control device in accordance with the first embodiment;

10 Fig. 5 is a circuit diagram illustrating a first example of driving circuit of the load control device 1A in accordance with the first embodiment of the present invention;

Fig. 6 is an enlarged diagram of the drive circuit of
15 the load control device 1A shown in Fig. 5;

Fig. 7 is a circuit diagram of a modified example of the drive circuit of the load control device 1A;

Fig. 8 is an enlarged diagram of the drive circuit shown in Fig. 7;

20 Fig. 9 is a circuit diagram a second example of the drive circuit of the load control device 1A;

Fig. 10 an enlarged diagram of the drive circuit shown in Fig. 9;

Fig. 11 is a circuit diagram showing a specific
25 example of drive circuit in accordance with the second example shown in Fig. 9;

Fig. 12 is an enlarged diagram of the drive circuit shown in Fig. 11;

Fig. 13 is a circuit diagram illustrating a modified example of the drive circuit in accordance with the second
5 example;

Fig. 14 is an enlarged diagram of the drive circuit shown in Fig. 13;

Fig. 15 is a circuit diagram of another modified example of the drive circuit in accordance with the second
10 example;

Fig. 16 is an enlarged diagram of the drive circuit shown in Fig. 15;

Fig. 17 is a circuit diagram of a drive circuit in accordance with a third example;

15 Fig. 18 is an enlarged diagram of the drive circuit shown in Fig. 17;

Fig. 19 is a circuit diagram of a first modified example of the load control device in accordance with the first embodiment;

20 Fig. 20 is a circuit diagram of a second modified example of the load control device in accordance with the first embodiment;

Fig. 21 is a time chart illustrating signal waveforms of the respective units in the load control device shown in
25 Fig. 20;

Fig. 22 is a circuit diagram of a third modified

example of the load control device in accordance with the first embodiment;

Fig. 23 is an enlarged diagram of the drive circuit shown in Fig. 22;

5 Fig. 24 is a time chart illustrating signal waveforms of the respective units in the load control device shown in Fig. 22;

10 Fig. 25 is a circuit diagram of a load control device in accordance with a second embodiment of the present invention;

Fig. 26 is a time chart illustrating signal waveforms of the respective units in case of a high load in the load control device in accordance with the second embodiment;

15 Fig. 27 is a time chart illustrating signal waveforms of the respective units in case of a low load in the load control device in accordance with the second embodiment;

20 Fig. 28 is a time chart illustrating signal waveforms of the respective units in case where a third predetermined period of time is used in controlling of the main opening/closing unit and there is a low load in the load control device in accordance with the second embodiment;

Fig. 29 is a circuit diagram illustrating the configuration of a load control device in accordance with a third embodiment of the present invention;

25 Fig. 30 is a circuit diagram illustrating the configuration of a load control device in accordance with a

fourth embodiment of the present invention;

Fig. 31 is a circuit diagram illustrating the configuration of a modified example of the load control device in accordance with the fourth embodiment;

5 Fig. 32 is a block diagram illustrating a load control system including a load control device in accordance with a fifth embodiment of the present invention;

Fig. 33 is a circuit diagram illustrating the configuration of a first example of the load control device
10 in accordance with the fifth embodiment;

Figs. 34A and 34B show waveforms in operation of the load control device in accordance with the fifth embodiment, Fig. 34A showing a waveform when a power factor is 1 and Fig. 34B showing a waveform when a power factor is not 1;

15 Fig. 35 is a circuit diagram illustrating the configuration of a second example of the load control device in accordance with the fifth embodiment;

Fig. 36 is a view illustrating a waveform in operation of the load control device shown in Fig. 35;

20 Fig. 37 is a circuit diagram illustrating the configuration of a third example of the load control device in accordance with the fifth embodiment;

Fig. 38 is a diagram illustrating a schematic configuration of a switch element included in the main opening/closing unit of the load control device of the third
25 example;

Fig. 39 is a circuit diagram illustrating the configuration of a fourth example of the load control device in accordance with the fifth embodiment;

Fig. 40 is a diagram illustrating a schematic
5 configuration of a switch element included in the main opening/closing unit of the load control device of the fourth example;

Fig. 41 is a cross sectional view taken along a line A-A shown in Fig. 40;

10 Fig. 42 is a circuit diagram illustrating a configuration of a load control device in accordance with a sixth embodiment of the present invention;

Fig. 43 is a time chart illustrating signal waveforms of various parts in case where a third predetermined period
15 of time is used in controlling of the main opening/closing unit and there is a low load in the load control device in accordance with the sixth embodiment;

Fig. 44 is a circuit diagram showing a configuration of a load control device in accordance with a first
20 conventional example; and

Fig. 45 is a circuit diagram showing a configuration of a load control device in accordance with a second conventional example.

25 Detailed Description of the Embodiments

Hereinafter, embodiments of the present invention will be described in more detail with reference to accompanying drawings which form a part hereof.

First, a switch element for use in a load control device in accordance with the present invention to be explained below will be described with reference to the drawings. Fig. 1A shows a circuit diagram of a switch element including a lateral dual gate transistor structure having a single withstanding voltage portion and Fig. 1B shows a circuit diagram of a switch element having a configuration where two MOSFET transistor devices are coupled in an inverse direction like in the second conventional example. Further, Fig. 2 illustrates a cross sectional view of the switch element having a lateral dual gate transistor structure.

In the configuration shown in Fig. 1B, since source electrodes S of two transistor devices are connected to each other and grounded (as a lowest potential unit), a withstanding voltage is unnecessary between the source electrodes S and gate electrodes G1 and G2, but it is necessary between the gate electrodes G1 and G2 and drain electrodes D1 and D2, respectively. That is, there is needed a distance for withstanding voltage in two portions and such a portion in which the distance for withstanding voltage is provided is referred to as 'withstanding voltage portion' hereinafter. Further, since the two transistor

devices are operated by a gate signal on the basis of the source electrode, inputting a same drive signal to the gate electrodes G1 and G2 of the respective transistor devices can drive the transistor devices.

5 On the other hand, the switch element having a lateral dual gate transistor structure, e.g., as shown in Figs. 1A and 2, can be realized as a bi-directional device with a small loss and a single withstanding voltage portion. The switch element of such configuration needs to be controlled
10 on the basis of voltages of the drain electrodes D1 and D2, and, accordingly, different drive signals need to be inputted to the two gate electrodes G1 and G2, respectively (for that reason, it may be called a dual gate transistor).

(First Embodiment)

15 Fig. 3 is a circuit diagram showing a basic configuration of a load control device 1 in accordance with a first embodiment of the present invention, and Fig. 4 is a time chart illustrating signal waveforms of various parts in the load control device 1. Further, a detailed
20 configuration of a drive circuit 10 is not shown in these drawings, but will be described below.

Referring to Fig. 3, the load control device 1 in accordance with the first embodiment of the present invention is coupled in series between an AC power source 2
25 and a load 3 and includes a main opening/closing unit 11 for controlling supply of a power to the load 3, a drive circuit

10 for driving the main opening/closing unit 11, a
rectifying circuit 12, a control unit 13 for controlling the
load control device 1 as a whole, a first power source unit
14 for supplying a stable power to the control unit 13, a
5 second power source unit 15 for supplying an electric power
to the first power source unit 14 when the load 3 is not
powered, a third power source unit 16 for supplying an
electric power to the first power source unit 14 when the
electric power is supplied to the load 3, an auxiliary
10 opening/closing unit 17 for conducting a minute current to
the load, and the like.

In addition, the third power source unit 16 is further
provided with a voltage detector 18 for detecting a voltage
inputted thereto. The main opening/closing unit 11 has a
15 switch element 11a having a lateral dual gate transistor
structure and the auxiliary opening/closing 17 has an
auxiliary switch element having a thyrister structure.

Even in an OFF state of the load control device 1 in
which the electric power is not supplied to the load 3,
20 since a current flows into the second power source unit 15
via the rectifying circuit 12 from the power source 2, a
minute current also flows into the load 3. However, the
minute current flowing through the load 3 is suppressed to a
low level such that it does not cause any malfunction in
25 the load and an impedance of the second power source unit 15
is kept at a high value.

While the load 3 is powered, impedance of the third power source unit 16 is made low and a current is started to flow into the load control device 1, thereby charging a buffer condenser 25 of the first power source unit 14. As described above, the third power source unit 16 is provided with the voltage detector (charging monitoring unit) 18 which detects a voltage inputted. When the voltage detector 18 detects that the voltage inputted to the third power source unit 16 reaches a predetermined threshold, it outputs a predetermined detection signal. When the control unit 13 receives the detection signal from the voltage detector 18, it outputs a first pulse signal (main opening/closing unit drive signal) for making the main opening/closing unit 11 conductive to the drive circuit 10 so that the main opening/closing unit 11 becomes conductive (closed state) for a first predetermined period of time.

Fig. 3 shows a configuration example in which a first pulse output unit 19 (i.e., main opening/closing unit drive signal output unit) is included in the control unit 13, the first pulse output unit 19 being configured by using, e.g., a dedicated IC, in hardware to directly output the first pulse signal in response to the detection signal from the voltage detector 18. Alternatively, without being limited to such configuration, there may be a configuration that a main controller 20 including, e.g., a CPU, receives an output of the voltage detector 18 to output the first pulse

signal in software. The first predetermined period of time during which the main opening/closing unit 11 becomes conductive is preferably set to be slightly shorter than a half cycle of power frequency.

5 Next, when the main opening/closing unit 11 starts to become non-conductive (open state) after a lapse of the first predetermined time, the control unit 13 makes the auxiliary opening/closing unit 17 conductive (closed state) for a second predetermined period of time (e.g., several
10 hundreds μ seconds). That is, when the main opening/closing unit 11 becomes non-conductive and a load current begins to flow into the auxiliary opening/closing unit 17, the load current continues to flow into the auxiliary opening/closing unit 17 until the load current becomes '0'.

15 In this regard, Fig. 3 illustrates a configuration in which a second pulse output unit 21 is provided as a portion of the control unit 13 to output a second pulse signal (auxiliary opening/closing unit drive signal) having a duration of a second predetermined period of time so that a
20 drive signal is inputted to the auxiliary opening/closing unit 17 for the second predetermined period of time after detecting that the main opening/closing unit 11 has become a non-conduction state (open state). Alternatively, the second pulse signal may be outputted by using a software
25 configuration or realized by using a delay circuit including, e.g., a diode, a condenser or the like.

Referring to Fig. 4, with the above operations, an electric power is supplied from the main opening/closing unit 11 to the load 3 for most of the time of a half cycle of a standard power source after the buffer condenser 25 is completely charged. After that, an amount of conduction current is reduced and then the electric power is supplied from the auxiliary opening/closing unit 17 to the load 3. Since the auxiliary opening/closing unit 17 includes an auxiliary switch device 17a having a thyrister structure, it becomes a non-conduction state at a time point (i.e., zero cross point) when a current value becomes '0'. Further, when the auxiliary opening/closing unit 17 becomes a non-conduction state, a current starts to flow again into the third power source unit 16.

The above operations are repeated every half cycle of the power source. Since such operations are performed based on a load current, even when the main opening/closing unit 11 includes the switch element 11a having a transistor structure, the load 3 is not requested to have a power factor of 1. That is, a two-wire load control device in accordance with the present invention is adaptable to any of fluorescent lamps and glow lamps. Further, in the present embodiment, since the main opening/closing unit 11 includes the switch element 11a containing a lateral dual gate transistor structure, requiring only one single withstanding voltage portion, upon supplying power to a load, an amount

of heat emitted from the switch element itself is reduced, thereby achieving a scaling down and a large-capacity of the load control device at the same time.

In the embodiment shown in Fig. 3, a current detector 22 for detecting a current flowing through the auxiliary opening/closing unit 17 is provided. With this configuration, in the event of a frequency deviation or overload, a load current path is changed again from the auxiliary opening/closing unit 17 to the main opening/closing unit 11, thereby protecting the auxiliary opening/closing unit 17 from being broken. The current detector 22 is not necessarily required, but may be provided if necessary.

(First Example)

Next, there will be described a load control device 1A including a drive circuit 10 in accordance with a first example in the first embodiment of the present invention with reference to Figs. 5 and 6. Fig. 5 is a circuit diagram of the load control device 1A including the drive circuit 10 in accordance with the first example and Fig. 6 is an enlarged diagram of the drive circuit 10 shown in Fig. 5.

As shown in Figs. 5 and 6, the drive circuit 10 for driving the main opening/closing unit 11 includes two sets of opto-insulating semiconductor switch devices 101 and 102, e.g., photocouplers, or the like, corresponding to the dual

gate of the switch element 11a. A drive signal from the control unit 13 is inputted respectively to light-emitting units 101a and 102a of the opto-insulating semiconductor switch devices 101 and 102. Upon receiving the drive signal,
5 each of the light-emitting units 101a and 102a converts an electric power thereof into a light energy and outputs it.

When lights from the light-emitting units 101a and 102a are incident into light receiving units 101b and 102b of the opto-insulating semiconductor switch devices 101 and
10 102, respectively, photoelectric conversion is performed by each of the light-receiving units 101b and 102b, thereby converting the light energy into an electric energy (i.e., generating electricity). The light-receiving units 101b and 102b are connected to the switch device 11a of the main
15 opening/closing unit 11, such that the electric power generated by each of the light-receiving units 101b and 102b is applied as a positive potential to the dual gate of the switch device 11a on the basis of each of connection points at which the light-receiving units 101b and 102b are
20 connected to the AC power source 2 (e.g., a commercial power source) and the load 3 (see Fig. 5).

As the drive signal is outputted from the control unit 13, each of the light-emitting units 101a and 102a of the opto-insulating semiconductor switch devices 101 and 102
25 emits light in response thereto and the light is inputted to a corresponding one of the light-receiving units 101b and

102b connected to the gate of the switch element 11a of the main opening/closing unit 11. Thus, the drive signal can be easily inputted to the gate electrode of the switch element 11a whose reference potential is different and, accordingly,
5 the switch element 11a of the main opening/closing unit 11 can become a conduction state (closed state).

Further, since the light-emitting units 101a and 102a and the light-receiving units 101b and 102b of the opto-insulating semiconductor switch devices 101 and 102 are
10 electrically insulated from each other, the drive signal is not inputted to the gate electrode of the switch element 11a as long as no light is outputted from any of the light-emitting units 101a and 102a. That is, supplied to the gate electrode of the switch element 11a is an electric power
15 electrically insulated from the control unit 13 (or the first power source unit 14), which is different from the drive signal outputted from the control unit 13. Also, the opto-insulating semiconductor switch devices 101 and 102 connected to the gate electrode of the switch element 11a
20 can be turned on and off easily and definitely while keeping an insulation state, based on the drive signal from the control unit 13.

Figs. 7 and 8 illustrate a modified example of the drive circuit 10 depicted in Figs. 5 and 6. In this
25 modified example, the light-emitting units 101a and 102a of the opto-insulating semiconductor switch devices 101 and 102,

e.g., photocoupler, are connected in series to each other. With this configuration, a value of current flowing through the drive circuit 10 can be reduced to approximately 1/2, and an electric power consumption in the drive circuit 10
5 can be reduced.

(Second Example)

A load control device 1B will be explained which includes a drive circuit 10 in accordance with a second example with reference to Figs. 9 and 10. Fig. 9 shows a
10 circuit diagram of the load control device 1B and Fig. 10 is an enlarged diagram of the drive circuit 10 shown in Fig. 9.

As shown in Figs. 9 and 10, the drive circuit 10 for driving the main opening/closing unit 11 includes diodes 101a and 101b whose anodes are connected to the first power
15 source unit 14; condensers 102a and 102b whose respective one ends are connected to a power line and whose the other respective ends are connected to corresponding cathodes of the diodes 101a and 101b; and drive switch devices 103a and 103b connected between a connection point of the diodes 101a
20 and 101b and the condensers 102a and 102b, and the gate terminal of the switch element 11a, each elements being two sets corresponding to the dual gate of the switch element 11a.

The drive switch devices 103a and 103b are switched on
25 and off in response to a signal from the control unit 13. Further, each of the drive switch devices 103a and 103b has

a configuration where a switch unit and an operation unit are isolated from each other. The drive switch devices 103a and 103b are not limited thereto and may have various configurations as will be described hereinafter.

5 With this configuration, since the first power source unit 14 is connected via the diodes 101a and 101b to the one respective ends of the condensers 102a and 102b whose the other respective ends are connected to the power line, a temporary power source is formed by the condensers 102a and
10 102b on the basis of a potential of the power line. More specifically, a current flowing from a high voltage side of the power line via power source units in the load control device 1B to a low voltage side of the power line charges one of the condensers 102a and 102b which is connected to
15 the low voltage side. Meanwhile, the other which is connected to the high voltage side is not charged and, accordingly, charging to each of the condensers is alternately repeated every one cycle of power frequency.

 When the switch element 11a having a lateral dual gate
20 transistor structure is switched on, a voltage based on a point connected to the power line needs to be applied to the gate of the switch element 11a. More specifically, when a signal from the control unit 13 connects either the drive switch device 103a or 103b to the gate of the switch element
25 11a, a voltage charged in the corresponding condenser on the basis of the power line is applied to the gate of the switch

element 11a and, accordingly, the switch element 11a becomes
conductive. Once the switch element 11a becomes conductive,
a voltage across the switch element 11a becomes extremely
small and the switch element 11a can remain conductive even
5 only by a voltage applied via diodes 101a and 101b and the
drive switch devices 103a and 103b from the first power
source unit 14.

In the present embodiment, since the drive circuit 10
is connected to the first power source unit 14, it is
10 possible to effectively supply a power for drive. The
condensers 102a and 102b serve to temporarily establish a
potential of the gate electrode when the switch element 11a
is switched from OFF to ON and, accordingly, may have a
small size and capacity. Although a power is supplied from
15 an output terminal of the first power source unit 14 to the
drive circuit 10 in the embodiment shown in Fig. 9, it may
be supplied from a relatively stable power source unit, e.g.,
an input terminal of the first power source unit 14.

Figs. 11 and 12 show a specific configuration example
20 of the drive switch devices 103a and 103b of the drive
circuit 10 of the second example. Each of the drive switch
devices 103a and 103b employs an opto-insulation
semiconductor switch element, e.g., a photocoupler, a
photorelay or the like. When the drive signal is inputted
25 from the control unit 13 to the drive circuit 10, an optical
signal is outputted from a light-emitting unit and inputted

to a light-receiving unit in the opto-insulation semiconductor switch element. Accordingly, the light-receiving unit becomes conductive and a current (drive signal) flows from the first power source unit 14 to the
5 gate of the switch element 11a.

Since the light-emitting unit and the light-receiving unit in the drive switch device are electrically isolated from each other, the drive signal is not inputted to the gate of the switch element 11a unless a light is outputted
10 from the light-emitting unit. Therefore, it is possible to easily and definitely switch on and off the drive switch devices 103a and 103b connected to the gate electrode of the switch element 11a while keeping electrical isolation thereof, based on the drive signal from the control unit 13.

15 Figs. 13 and 14 present a modified example of the drive circuit 10 shown in Figs. 11 and 12. In this modified example, the light-emitting units of the drive switch devices 103a and 103b, each employing an opto-insulation semiconductor switch element, e.g., a photocoupler, a
20 photorelay or the like, are connected in series. Accordingly, an amount of the current flowing through the drive circuit 10 can be reduced by 1/2 and, as a result, the power consumption in the drive circuit 10 can be reduced.

25 Figs. 15 and 16 show another modified example of the drive circuit 10 shown in Figs. 11 and 12. In the present modified example, the light-emitting units of the drive

switch devices 103a and 103b, each employing an opto-insulation semiconductor switch element, e.g., a photocoupler, a photorelay or the like, are connected in series. Further, condensers 104a and 104b are connected
5 between a power line serving as a basis of the gate electrode and a connection point of the gate electrode of the switch element 11a and the drive switch devices 103a and 103b. In addition to the configuration of the drive circuit 10 shown in Figs. 11 and 12, condensers 104a and 104b may be
10 added thereto.

With this configuration, since the condensers 104a and 104b are provided, a sharp change of a voltage applied to the gate electrode of the switch element 11a can be alleviated by the condensers 104a and 104b when the drive
15 switch devices 103a and 103b are switched on or off, and the switch element 11a can be prevented from being sharply turned on or off. As a result, since noise generated due to switching on or off of the switch element 11a can be reduced, a noise filter can be made smaller or omitted. That is, as
20 compared to the conventional examples shown in Figs. 44 and 45, a coil or condenser serving as a noise filter can be omitted.

In case that the noise filter includes a coil, the coil becomes large as a rated current of a load control
25 device becomes large and, accordingly, the load control device can be made small by, if possible, omitting the coil.

In case that the noise filter includes a condenser, although there is less restrictions on the size of the load control device as compared to the coil, an impedance of the load control device is lowered by the condenser in an off state
5 when the load control device is not powered. This is not preferable in the off state of the load control device because a current flows via the condenser even in the off state, which may result in malfunction of the load. Therefore, it is preferred to omit a condenser for the noise
10 filter from the load control device in the two-wire load control device, if possible.

(Third Example)

Next, a load control device 1B including a drive circuit 10 in accordance with a third example in the first
15 embodiment of the present invention will be described with reference to Figs. 17 and 18. Fig. 17 is a circuit diagram of the load control device 1B including a drive circuit 10 in accordance with a third example and Fig. 18 is an enlarged diagram of the drive circuit 10 shown in Fig. 17.

20 In the third example, the drive circuit 10 includes a transformer (electromagnetic coupled device) 103 for transferring an electric power by electromagnetic coupling, e.g., a high frequency insulation transformer or the like, rectifying circuits 104a and 104b, an oscillator 105, and
25 the like.

A primary coil 103a of the transformer 103 is coupled

to the oscillator 105, which in turn is coupled to the control unit 13. When a drive signal from the control unit 13 is inputted to the oscillator 105, the oscillator 105 performs an oscillation while the drive signal is applied thereto, thereby generating an AC current. When the AC current generated by the oscillator 105 flows through the primary coil 103a of the transformer 103, a current caused by an induced electromotive force flows in secondary coils 103b and 103c. The current flowing in the secondary coils 103b and 103c of the transformer 103 is an alternative current (AC), and is rectified by the rectifying circuits 104a and 104b and inputted to the gate electrode of the switch element 11a of the main opening/closing unit 11.

Further, the rectifying circuits 104a and 104b are connected to the gate electrode of the switch element 11a so that a positive potential is applied on the basis of connection points at which the power source and the load are respectively connected to the power line. Herein, since the primary coil 103a and the secondary coils 103b and 103c of the transformer 103 are electrically insulated from each other, the drive signal is not inputted to the gate electrode of the switch element 11a as long as a current does not flow into the primary coil 103a of the transformer 103. That is, an electric power electrically insulated from control unit 13, which is different from the drive signal outputted from the control unit 13, is supplied to the gate

electrode of the switch element 11a.

In the drive circuit 10 of the present example, the oscillator 105 is triggered by the drive signal outputted from the control unit 13 and generates an AC electric power. Accordingly, by appropriately setting an oscillating frequency and an amplitude of an oscillating signal of the oscillator 105, and the number of coil turn of the primary coil 103a, and the secondary coils 103b and 103c of the transformer 103, there can be generated a desired electric power in the secondary coils 103b and 103c of the transformer 103. Therefore, even though the gate of the switch element 11a of the main opening/closing unit 11 is a current-type switch element requiring a current value of a certain level or more, it can be driven stably. Furthermore, it is needless to say that a drive electric power of the oscillator 105 is supplied from any one of power source units of the load control device. Alternatively, although not shown herein, it may be configured to omit the oscillator 105 and to directly output a pulse signal having a given frequency and amplitude from the control unit 13.

(Modified example)

Next, a load control device 1B in accordance with a modified example of the first embodiment of the present invention will be described with reference to Fig. 19. The load control device described above has a circuit configuration where, when the drive signal is applied to the

switch element 11a of the main opening/closing unit 11, a current does not flow in diodes of the rectifying circuit 12. Thus, the switch element 11a needs to be of a voltage type in which the gate (gate terminal) of the switch element 11a does not require a current having a certain level or more value. In the present modified example, even though the switch element 11a of the main opening/closing unit 11 is a current-type switch element requiring a current having a certain level or more value, it can be stably driven.

As shown in Fig. 19, in the load control device 1B in accordance with the modified example, synchro-switch devices 120a and 120b are connected between an AC power line of the rectifying circuit 12 and a negative output side of the rectifying circuit 12 serving as a reference of the circuit. The synchro-switch devices 120a and 120b turn on in synchronous to an operation of making the main opening/closing unit 11 closed. When the synchro-switch devices 120a and 120b are made to be in closed states in synchronous to the operation of making the main opening/closing unit 11 closed, a path is established through which current flows from the first power source unit 14 into the gate of the switch element 11a of the main opening/closing unit 11.

Therefore, even though the gate of the switch element 11a is a dual gate device requiring a current having a certain level or more value, it can be stably driven.

Further, other configurations or basic operation is the same as the first embodiment, and the configuration of the drive circuit 10 employed herein is also not limited particularly, but may be configurations shown in the above mentioned examples.

Next, another modified example of the load control device in accordance with the first embodiment of the present invention will be described with reference to Figs. 20 and 21. Fig. 20 is a circuit diagram of a load control device 1C in accordance with the modified example, and Fig. 21 is a time chart illustrating signal waveforms of the various parts in the load control device 1C. The load control device 1C further includes a zero cross detector 23 provided in the third power source unit 16 operating while the load is powered, and a third pulse output unit (drive permission signal output unit) 24, in addition to the configuration of the load control device 1 shown in Fig. 3. Further, a detailed configuration of the drive circuit 10 may be any one of those illustrated in the above mentioned examples.

When the zero cross detector 23 detects a zero cross point of a voltage, the third pulse output unit 24 outputs a third pulse signal (drive permission signal) for a third predetermined period of time. As shown in Fig. 21, the third predetermined period of time corresponds to a period of time slightly shorter than a half cycle of a power source cycle.

The drive signal is inputted to the gate electrode of the switch element 11a of the main opening/closing unit 11 so that the switch element 11a is closed only during a period of time for which the first pulse (main opening/closing unit driving signal) and the third pulse (drive permission signal) are all generated.

In the two-wire load control devices, in case when a load connected thereto is small, a time taken in charging the condenser 25 becomes longer. In case where the load is small, if it is configured to start to drive the main opening/closing unit 11 after the buffer condenser is completely charged in the first power source 14 as described with reference to Fig. 4, the drive signal to the main opening/closing unit 11 may be applied even after passing by a current zero cross point. In this state, when the main opening/closing unit 11 becomes opened and the auxiliary opening/closing unit 17 becomes closed, a load current serving as a main current flows through the auxiliary opening/closing unit 17. Therefore, it is not possible to obtain a stable operation where a charging is performed once every half cycle of the power source cycle as described above.

However, since the load control device 1C uses a combination of the voltage zero cross signal and the charging completion signal, the main opening/closing unit 11 can be controlled such that it will not be driven for a half

cycle or more of the power source cycle based on the voltage zero cross signal. Therefore, an operation of ensuring a power source every half cycle of the power source cycle can be stably executed regardless of a capacity of the load
5 connected to the load control device 1C.

Next, a load control device 1D, still another modified example of the load control device in accordance with the first embodiment of the present invention will be described with reference to Figs. 22 to 24. Fig. 22 is a circuit
10 diagram illustrating a configuration of the load control device 1D in accordance with the still another modified example, Fig. 23 is an enlarged diagram of the drive circuit 10 shown in Fig. 22, and Fig. 24 is a time chart illustrating signal waveforms of various units in the load
15 control device 1D.

In the load control device 1D in accordance with the still another modified example, the drive circuit 10 driving the main opening/closing unit 11 includes diodes 101a and 101b connected to the first power source unit 14, which have
20 high withstanding voltages, respectively; condensers 102a and 102b whose one ends are coupled to power line and whose other ends are coupled to the diodes 101a and 101b, respectively; and drive switch devices 105a and 105b provided between connection points of the diodes 101a and
25 101b and the condensers 102a and 102b, and gate terminals of the switch element 11a of the main opening/closing unit 11,

respectively. The drive switch devices 105a and 105b may be self-turn-off type of, e.g., a photo thyristor or photo triac.

When completion of charging is detected by the voltage
5 detector 18 provided in the third power source unit 16, the main opening/closing unit 11 is turned into a closed state. At this time, a signal is inputted to turn the drive switch devices 105a and 105b connected to the gate electrode of the switch element 11a of the main opening/closing unit 11 to be
10 conductive. Since the drive switch devices 105a and 105b have a thyristor or triac structure, the drive switch devices 105a and 105b may be driven only by a trigger signal. Thus, a drive electric power of the drive switch devices 105a and 105b may be made small as compared with the
15 examples described above.

In addition, the drive switch devices 105a and 105b can be made non-conductive simply by opening the synchro-switch devices 120a and 120b provided in the rectifying circuit 12. Thus, it is possible to make the magnitude of
20 the drive electric power needed in opening and closing the main opening/closing unit 11 small. In the two-wire load control devices, it is an important issue how to secure its stabilized power source as well as a control of the load and, therefore, a small magnitude of the drive electric power for
25 the load control device may be preferable for stable operation of the load.

(Second Embodiment)

A load control device 1E in accordance with a second embodiment of the present invention will be explained with reference to Figs. 25 to 28. Fig. 25 is a circuit diagram showing a configuration of the load control device 1E, Figs. 26 to 28 are time charts illustrating signal waveforms of various parts of the load control device 1E.

Referring to Fig. 25, the load control device 1E is serially connected between an AC power source 2 and a load 3 and includes a main opening/closing unit 11 for controlling supply of power to the load 3, a rectifying circuit 12, a control unit 13 for controlling the load control device 1E as a whole, a first power source unit 14 for supplying a stable power to the control unit 13, a second power source unit 15 for supplying an electric power to the first power source unit 14 when the load 3 is not powered, a third power source unit 16 for supplying an electric power to the first power source unit 14 when the electric power is supplied to the load 3, an auxiliary opening/closing unit 17 for conducting a minute current to the load, and the like.

In addition, the third power source unit 16 is further provided with a voltage detector 18 for detecting a voltage inputted thereto and a zero cross detector 23 for detecting a zero cross point of a load current. The main opening/closing unit 11 has a switch element 11a having a transistor structure and the auxiliary opening/closing unit

17 has an auxiliary switch element 17a having a thyrister structure. Further, the control unit 13 includes a main controller 20 including a CPU or the like, a first pulse output unit 19, a second pulse output unit 21, and a third pulse output unit 24.

Upon receiving a charge completion signal indicating charging completion of a buffer condenser 25 from the voltage detector 18, the first pulse output unit 19 outputs a first pulse to conduct the main opening/closing unit 11 for a first predetermined period of time. That is, the first pulse rises when the charging completion signal is inputted from the voltage detector 18, and then descends after a lapse of the first predetermined period of time. When the zero cross detector 23 detects a zero cross point of the load current, the third pulse output unit 21 outputs a third pulse for a third predetermined period of time to limit an opened state of the main opening/closing unit 11. That is, the third pulse rises when the zero cross detecting signal is received from the zero cross detector 23, and then goes down after a lapse of the third predetermined period of time.

Further, the second pulse output unit 21 detects that the main opening/closing unit 11 has become non-conductive, and outputs a second pulse to conduct the auxiliary opening/closing unit 17 for a second predetermined period of time. That is, the second pulse rises when the main

opening/closing unit 11 becomes non-conductive, and then goes down after a lapse of the second predetermined period of time.

With the above configuration, since a current flows
5 into the second power source unit 15 via the rectifying circuit 12 from the power source 2 even in an OFF state of the load control device 1E that the electric power is not supplied to the load 3, a minute current also flows into the load 3. However, the current is suppressed to a low level
10 such that it does not result in a load malfunction and an impedance of the second power source unit 15 is kept at a high value.

While the load 3 is powered, an impedance of the third power source unit 16 is lowered and a current is made to
15 flow into the load control device 1E, thereby charging the buffer condenser 25 of the first power source unit 14. As described above, the third power source unit 16 is provided with the voltage detector (charging monitoring unit) 18 which detects a voltage inputted thereto. When the voltage
20 detector 18 detects that the voltage inputted to the third power source unit 16 reaches a predetermined threshold, it outputs a predetermined detection signal to the control unit 13. When the control unit 13 receives the detection signal from the voltage detector 18, it makes the main
25 opening/closing unit 11 conductive (closed state) for the first predetermined period of time.

Fig. 3 shows a configuration example in which a first pulse output unit 19 is included in the control unit 13, the first pulse output unit 19 being configured by using, e.g., a dedicated IC, in hardware to directly output a first pulse signal in response to the detection signal from the voltage detector 18. Alternatively, without being limited to such configuration, there may be a configuration in which a main controller 20 including, e.g., a CPU, receives an output of the voltage detector 18 to output the first pulse signal in software. The first predetermined period of time for which the main opening/closing unit 11 becomes conductive is preferably set to be a period of time slightly shorter than a half cycle of a power frequency.

Next, when the main opening/closing unit 11 starts to become non-conductive (open state) after a lapse of the first predetermined time, the control unit 13 makes the auxiliary opening/closing unit 17 conductive (closed state) for the second predetermined period of time (e.g., several hundreds μ seconds). This may be achieved by making the auxiliary opening/closing unit 17 non-conductive slightly later than the main opening/closing unit 11. Alternatively, the second pulse signal may be outputted to the auxiliary opening/closing unit 17 which is longer than the first pulse signal outputted to the main opening/closing unit 11 by the second predetermined period of time. Otherwise, the second

pulse signal may be outputted by using a delay circuit including, e.g., a diode, a condenser or the like.

With the above operations, an electric power is supplied from the main opening/closing unit 11 to the load 3 for most of the time of a half cycle of a power source after the buffer condenser 25 is completely charged. After that, an amount of conduction current is reduced and then the electric power is supplied from the auxiliary opening/closing unit 17 to the load 3. Since the auxiliary opening/closing unit 17 includes an auxiliary switch device 17a having a thyrister structure, it becomes a non-conduction state at a time point (i.e., zero cross point) when a current value becomes '0'. Further, when the auxiliary opening/closing unit 17 becomes a non-conduction state, current starts to flow again into the third power source unit 16. The above operations are repeated every half cycle of the power source.

Fig. 26 shows signal waveforms of various parts of the load control device 1E in a high load, and Figs. 27 and 28 depict signal waveforms of various parts of the load control device 1E in a low load. Herein, Fig. 27 shows signal waveforms in a case where only the first pulse is used in controlling the main opening/closing unit 11 and Fig. 28 presents signal waveforms in a case where the first pulse and the third pulse are used.

When the load 3 is a high load, i.e., a large capacity

load, as shown in Fig. 26, the buffer condenser 25 is charged in a short time. Accordingly, after the charging completion, an electric power is supplied from the main opening/closing unit 11 to the load 3 for most of the time of the half cycle of the power source. On the other hand, since the first predetermined period of time is set to make the main opening/closing unit 11 non-conductive before a current becomes zero (zero cross point), it is impossible that the main opening/closing unit 11 remains conductive after the current passes by the zero cross.

Meanwhile, when the load 3 is a low load, i.e., a small capacity load, a load current is small and it takes much longer time to charge in comparison to the case when the load 3 is a high load. More specifically, as shown in Fig. 27, a time period from when the zero cross detector 23 detects a zero cross till when the voltage detector 18 detects a charging completion becomes longer, and, accordingly, rising of the first pulse is delayed. Herein, the first predetermined period of time is set to same as in the high load. For that reason, if the rising of the first pulse is delayed too much, the first pulse descends after the load current passes by the zero cross point. Therefore, if the main opening/closing unit 11 is controlled only by using the first pulse in the low load, it becomes conductive after the load current passes by the zero cross point and, as a result, charging operation cannot be stably performed

every half cycle.

In this regard, in the present embodiment, an amount of time for which the main opening/closing unit 11 remains conductive is limited to the third predetermined period of time by the third pulse outputted from the third pulse output unit 24. Further, the third pulse rises when the zero cross detector 23 detects a zero cross and descends after a lapse of the third predetermined period of time. The third predetermined period of time is set to be shorter than the half cycle of the load current cycle.

Inputted to the control unit 13 are the first pulse outputted from the first pulse output unit 19 and the third pulse outputted from the third pulse output unit 24. The control unit 13 has an AND circuit 25a which performs a logical product of the first pulse and the third pulse and outputs a result to the main opening/closing unit 11. Thus, the main opening/closing unit 11 becomes conductive only during the time while both the first and the third pulse rise, i.e., while the first predetermined period of time overlaps with the third predetermined period of time.

As described above, the third pulse rises when the zero cross detector 23 detects a zero cross point and descends after a lapse of the third predetermined period of time that is shorter than the half cycle of the load current. Therefore, even when a delay occurs in timing when the charging completion of the buffer condenser 25 is detected,

i.e., the first predetermined period of time starts to rise, it is impossible that the main opening/closing unit 11 remains conductive beyond the zero cross point of a power source frequency.

5 Accordingly, a charging can be definitely performed every half cycle, thereby achieving a stable operation of the charging. Since such operations are performed based on a load current, even when the main opening/closing unit 11 includes the switch element 11a having a transistor
10 structure, the load 3 is not requested to have a power factor of 1. That is, a two-wire load control device in accordance with the present invention is adaptable to any of fluorescent lamps and glow lamps. Further, if the main opening/closing unit 11 includes a switch element having a
15 dual gate transistor structure, there can be achieved a scaling down as well as a large capacity of the load control device.

 With the load control device 1E in accordance with the second embodiment of the present invention, when the voltage
20 detector 18 detects that the voltage inputted to the third power source unit 16 becomes a predetermined threshold, the control unit 13 makes the main opening/closing unit 11 conductive for the first predetermined period of time. Accordingly, an electric power is supplied to the load 3
25 from the main opening/closing unit 11 during most of the time of half cycle of the power source cycle.

Further, when the third predetermined period of time elapses even while in the first predetermined period of time, the control unit 13 makes the main opening/closing unit 11 non-conductive (closed state). For example, even when the
5 first predetermined period of time starts to rise late, the main opening/closing unit 11 becomes non-conductive before the load current crosses zero. Thus, the main opening/closing unit 11 cannot remain conductive beyond the zero cross of the load current and, therefore, a charging
10 can be definitely performed within a half cycle of the AC power source.

Further, when the main opening/closing unit 11 becomes non-conductive after a lapse of the first predetermined period of time, the auxiliary opening/closing unit 17
15 becomes conductive for the second predetermined period of time. That is, when an electric power is supplied to the load 3 from the main opening/closing unit 11 during most of the time of half cycle of the power source cycle and then the conduction current is made small, an electric power is
20 supplied from the auxiliary opening/closing unit 17 to the load 3.

Since such operations are performed based on a load current, even when the main opening/closing unit 11 includes the switch element 11a having a transistor structure, the
25 load 3 is not requested to have a power factor of 1. That is, a two-wire load control device in accordance with the

present invention is adaptable to any of fluorescent lamps and glow lamps. Further, if the main opening/closing unit 11 includes a switch element having a dual gate transistor structure, there can be achieved a scaling down as well as a large capacity of the load control device.

(Third Embodiment)

A load control device 1F in accordance with a third embodiment of the present invention will be described with reference to Fig. 29. Fig. 29 is a circuit diagram illustrating a configuration of the load control device 1F. The load control device 1F further includes a current detector 22 for detecting a current flowing in the auxiliary opening/closing unit 17, and an OR circuit 25b operating in response to a signal outputted from the current detector 22, wherein the OR circuit 25b is one additional component distinguishing the load control device 1F from the load control device 1E shown in Fig. 25. The OR circuit 25b is provided at an output terminal side of the AND circuit 25a in the control unit 13.

The main service of the auxiliary opening/closing unit 17 is basically to detect a zero cross point of a current, not to conduct and, accordingly, the auxiliary opening/closing unit 17 may include a small sized switch device. However, in cases that a frequency of the AC power source is shifted, or a load control device is intended to be operated by dual frequency, e.g., 50 Hz and 60 Hz, or the

like, the time period from when the main opening/closing unit 11 becomes non-conductive to when the zero cross point of the current is detected by the current detector 22 becomes longer such that the auxiliary opening/closing unit 17 may become conductive even before the load current is sufficiently reduced. Moreover, in case of an overload, even though the auxiliary opening/closing unit 17 conducts for the same period of time, a conduction loss becomes larger and, accordingly, the switch devices included in the auxiliary opening/closing unit 17 may be damaged.

Therefore, in the present embodiment, an amount of current flowing in the auxiliary opening/closing unit 17 is detected by the current detector 22 and, when the amount of the current exceeds an allowable value, the main opening/closing unit 11 is made to be conductive again for a short period of time (e.g., fourth predetermined period of time). Thereafter, when the main opening/closing unit 11 becomes non-conductive (opened state), the auxiliary opening/closing unit 17 is made conductive again.

More specifically, when the current detector 22 detects that an amount of current flowing in the auxiliary opening/closing unit 17 exceeds an allowable value, it outputs a signal to the OR circuit 25b of the control unit 13. Upon receiving an output signal from the AND circuit 25a or an output signal from the current detector 22, the OR circuit 25b protects the auxiliary opening/closing unit 17

by making the main opening/closing unit 11 conductive for a short period of time. By repeating a switch between the main opening/closing unit 11 and the auxiliary opening/closing unit 17 as such, damaging the auxiliary opening/closing unit 17 can be prevented, thereby improving correspondences to types of the power source and to the overload.

With the load control device 1F in accordance with the third embodiment, when the current detector 22 detects that an amount of current flowing in the auxiliary opening/closing unit 17 exceeds an allowable value, the main opening/closing unit 11 is made to be conductive first and then made to be non-conductive. Accordingly, while the auxiliary opening/closing unit 17 can be prevented from being damaged, the auxiliary opening/closing unit 17 can be built by using a small sized switch device, and, as a result, the load control device can be made smaller. Further, there can be improved correspondences to types of the power source and to the overload.

In addition, the present invention may be realized by various configurations other than the above described configurations. For example, the control unit 13 may be configured to control an operation of the main opening/closing unit 11 based on a logical product of the first pulse outputted from the first pulse output unit 19 when a charging completion signal of the buffer condenser 25

is outputted from the voltage detector 18, and the third pulse outputted from the third pulse output unit 24 when a zero cross detection signal of the load current is outputted from the zero cross detector 23. Further, there may be a configuration that the main controller 20 including, e.g., a CPU or the like, receives the output of the zero cross detector 23 and outputs the third pulse in software.

(Fourth Embodiment)

Next, a load control device 1G in accordance with a fourth embodiment of the present invention will be described with reference to Fig. 30. The basic configuration of the load control device 1G may have any one of the embodiments and their modified examples described above.

The load control device 1G in accordance with the fourth embodiment is used to control lighting fixtures in non-housing districts, e.g., office buildings, commercial facilities or the like. For example, a plurality of the load control devices 1G may be provided in a control board installed at a place that is distant from the lighting fixtures. Herein, the load control device 1G may be configured to receive a remote control signal 27 from a manipulation switch (not shown) distant from the control board and to be turned ON and OFF. To this end, the main controller 20 is connected to the manipulation switch by wiring, and when the main controller 20 recognizes its own

address superposed on the remote control signal 27, it outputs a control signal.

Fig. 31 illustrates a configuration of load control device 1G in accordance with a modified example of the fourth embodiment. In the modified example, the main controller 20 is also connected to a fourth power source unit 26 including a rectifying circuit, which rectifies an electric power obtained from the remote control signal 27 to secure power source of the main controller 20 (or control unit 13). As described above, in the two-wire load control device, even in an OFF state of the load control device, the second power source unit 15 is provided to secure power source of the main controller 20 and thus a minute current always flows into the load 3. With the present modified example, however, the power source of the main controller 20 is secured separately and the second power source unit 15 can be omitted. Accordingly, there is no current flowing into the load 3 in the OFF state of the load control device 1G, thereby preventing degradation or malfunction of the load 3.

(Fifth embodiment)

Next, a load control system 30 in accordance with a fifth embodiment of the present invention will be described. Fig. 32 is a block diagram showing a configuration of a load control system in accordance with the fifth embodiment of the present invention. A load control system 30 of the

fifth embodiment includes a plurality of load control devices 1 and a master control unit 31 for remotely controlling the plurality of load control devices 1. The number of load control devices 1 connected to the master control unit 31 may be properly set.

Each load control device 1 may be connected to the master control unit 31 either by using a wire or by wireless. Each load control device 1 receives a control signal transmitted from the master control unit 31 and controls a load 3 connected to the load control device 1 based on the control signal. The master control unit 31 transmits the control signal to a main controller 20 of each load control device 1. The control signal transmitted from the master control unit 31 includes an address signal corresponding to one of the load control devices 1.

Each load control device 1, upon receiving a control signal including its own address signal, controls the load 3 responsive to the control signal. Although Fig. 32 shows a load control device 1 as an example of the load control device connected to the master control unit 31, without being limited thereto, the load control device may be any one of, e.g., the load control devices 1H to 1L as described below. Furthermore, an appropriate combination of configurations of these load control devices 1H to 1L may be connected to the master control unit 31.

(First Example)

Fig. 33 is a circuit diagram showing a configuration of a load control device 1H in accordance with a first example used in the load control system 30, Figs. 34A and 34B illustrate waveforms of driving signals of the main opening/closing unit and a load current of the load control device 1H in a power factor=1 of the load and a power factor $\neq$ 1 of the load, respectively.

Referring to Fig. 33, the load control device 1H is serially connected between an AC power source 2 and a load 3, and includes a main opening/closing unit 11 for controlling supply of a power to the load 3, a rectifying circuit 12, a control unit 13 for controlling the load control device 1H as a whole, a first power source unit 14 for supplying a stable power source to the control unit 13, a third power source unit 16 for supplying an electric power to the first power source unit 14 when the load 3 is powered, an independent power source unit 26 for supplying an electric power to the first power source unit 14 when the load 3 is not powered, a receiving unit 16a for receiving a control signal transmitted from the master control unit 31, an auxiliary opening/closing unit 17 for conducting a minute current of the load current.

Further, the third power source unit 16 is provided with a voltage detector 18 for detecting a voltage inputted thereto. The main opening/closing unit 11 includes a switch element 11a having a transistor structure and the auxiliary

opening/closing unit 17 employs a switch device 17a having thyrister structure.

The master control unit 31 normally keeps transmitting a control signal (pulse signal) to remotely control one of the load control devices 1H. When the receiving unit 16a receives the control signal, it sends the control signal to the independent power source unit 26. The independent power source unit 26 rectifies a pulse current of which the control signal is made and supplies the electric power to the first power source unit 14 (i.e., the main controller 20). Since the control signal is always being transmitted regardless of whether the load operates or not, the electric power is supplied to the first power source unit 14 from the independent power source unit 26 even when the load 3 is not powered. That is, the independent power source unit 26 supplies the electric power to the first power source unit 14 independently with the AC power source 2 connected to the load 3 in series.

When the load 3 is powered, an impedance of the third power source unit 16 is made low and a current starts to flow into the load control device 1H, thereby charging a buffer condenser 25 of the first power source unit 14. As described above, the third power source unit 16 is provided with the voltage detector (charging monitoring unit) 18 which detects a voltage inputted thereto. When the voltage detector 18 detects that the voltage inputted to the third

power source unit 16 reaches a predetermined threshold, it outputs a predetermined detection signal. When the control unit 13 receives the detection signal from the voltage detector 18, it outputs a first pulse signal (main opening/closing unit drive signal) for making the main opening/closing unit 11 conductive to the drive circuit 10 so that the main opening/closing unit 11 becomes conductive (closed state) for a first predetermined period of time.

Fig. 33 shows a configuration example in which a first pulse output unit 19 (i.e., main opening/closing unit drive signal output unit) is included in the control unit 13, the first pulse output unit 19 being configured by using, e.g., a dedicated IC, in hardware to directly output the first pulse signal in response to the detection signal from the voltage detector 18. Alternatively, without being limited to such configuration, there may be a configuration that a main controller 20 including, e.g., a CPU, receives an output of the voltage detector 18 to output the first pulse signal in software. The first predetermined period of time for which the main opening/closing unit 11 becomes conductive is preferably set to be a period of time slightly shorter than a half cycle of power frequency.

Next, when the main opening/closing unit 11 starts to become non-conductive (open state) after a lapse of the first predetermined time, the control unit 13 makes the auxiliary opening/closing unit 17 conductive (closed state)

for a second predetermined period of time (e.g., several hundreds μ seconds). This may be achieved by making the auxiliary opening/closing unit 17 non-conductive slightly later than the main opening/closing unit 11.

5 Fig. 33 illustrates a configuration in which a second pulse output unit 21 is provided as a portion of the control unit 13 to output a second pulse signal having a duration of a second predetermined period of time so that the auxiliary opening/closing unit 17 becomes conductive for the second
10 predetermined period of time after detecting that the main opening/closing unit 11 has become a non-conduction state (open state).

 Alternatively, the second pulse signal may be outputted to the auxiliary opening/closing unit 17, wherein
15 the second pulse signal is longer than the first pulse signal outputted to the main opening/closing unit 11 by the second predetermined period of time. Otherwise, the second pulse signal may be outputted by using a delay circuit including, e.g., a diode, a condenser or the like.

20 Meanwhile, signal waveforms of various parts in the load control device in accordance with the present embodiment are same as the ones shown in Fig. 4 and, therefore, a full description will be omitted.

(Second Example)

25 A load control device 1I used in the load control system 30 in accordance with the fifth embodiment of the

present invention will be explained. Fig. 35 is a circuit diagram showing a configuration of a load control device 1I in accordance with a second example. In addition to the configuration of the load control device 1H shown in Fig. 33,
5 the load control device 1I further includes a current detector 22 for detecting a current flowing in the auxiliary opening/closing unit 17. The other configurations are the same as the load control device 1H and description thereof will be omitted.

10 As mentioned above, the auxiliary opening/closing unit 17 basically serves to detect a zero cross point of a current, and conducting is not its main service and, accordingly, the auxiliary opening/closing unit 17 may include only a small sized switch device. However, in cases
15 that a frequency of the AC power source is shifted, or it is intended that a load control device is operated by dual frequency, e.g., 50 Hz and 60 Hz, or the like, the time period from the time when the main opening/closing unit 11 becomes non-conductive till the time when the zero cross
20 point of the current is detected by the current detector 22 becomes longer and the auxiliary opening/closing unit 17 may become conductive even before the load current is sufficiently reduced. Moreover, in case of an overload, even though the auxiliary opening/closing unit 17 conducts
25 for the same period of time, a conduction loss becomes larger and, accordingly, the switch devices of the auxiliary

opening/closing unit 17 may be damaged.

Therefore, in the present embodiment, an amount of current flowing in the auxiliary opening/closing unit 17 is detected by the current detector 22 and, when the amount of current exceeds an allowable value, the main opening/closing unit 11 becomes conductive again for a short period of time (e.g., fourth predetermined period of time). Thereafter, when the main opening/closing unit 11 becomes non-conductive (opened state), the auxiliary opening/closing unit 17 is made conductive again. By repeating a switch between the main opening/closing unit 11 and the auxiliary opening/closing unit 17 as such, damaging the auxiliary opening/closing unit 17 can be prevented, thereby improving correspondences to types of the power source and to the overload. Fig. 36 illustrates waveforms in operation of the load control device 1I in accordance with the second example.

(Third Example)

A load control device 1J used in the load control system 30 in accordance with the fifth embodiment of the present invention will be explained. Fig. 37 is a circuit diagram showing a configuration of a load control device 1J in accordance with a third example. The load control device 1J is different from the load control device 1I shown in Fig. 35, in that a bidirectional controllable lateral transistor device is used as a switch element 11a in the main opening/closing unit 11 and the other configuration is same.

Although the other configuration is same as that of the load control device 1I in accordance with the second example in Fig. 37, the other configuration is not limited thereto and may employ configuration in accordance with the first example shown in Fig. 33.

Fig. 38 shows a schematic structure of the bidirectional controllable lateral transistor device. The lateral transistor device is also referred to as HEMT (High Electron Mobility Transistor) and uses a two-dimensional electron gas layer formed at an AlGa_N/Ga_N hetero-interface as a channel layer. More specifically, the lateral transistor device includes electrodes D1 and D2 provided on a surface of a substrate, which are serially connected to the power source 2 and the load 3, respectively, and a control electrode (gate) G for keeping a high withstanding voltage to the electrodes D1 and D2 during non-conduction of the device. There may be used, e.g., a schottky electrode, as the control electrode G.

When the main opening/closing unit 11 is in the non-conductive state, a low level signal is applied to the control electrode G from the control unit 13. However, the potential of the control electrode G remains higher than the lowermost potential by a potential of a single diode. Therefore, if a threshold needed in switching between the conduction and the non-conduction of the main opening/closing unit 11 is made higher than the potential of

the single diode, the non-conduction of the main opening/closing unit 11 can be definitely kept.

Meanwhile, upon conducting, the main opening/closing unit 11 operates as described in the above examples. Accordingly, the control unit 13 driven by a control signal of several volts can directly control the commercial power source of a high voltage. Further, it is possible to realize scaling-down and high capacity of the two-wired load control device 1J by using HEMT having high electron mobility.

(Fourth Example)

A load control device 1K in accordance with a fourth example of the load control device used in the load control system 30 will be described. Fig. 39 shows a circuit diagram of the load control device 1K. A configuration of the load control device 1K is same as the first to third examples, except that the switch element 11a of the main opening/closing unit 11 includes a newly developed bidirectional controllable lateral transistor device. Although the load control device 1K of the fourth example shown in Fig. 39 is based on the load control device 1J shown in Fig. 37, it is not limited thereto, and may be based on the load control device 1H shown in Fig. 33 or the load control device 1I shown in Fig. 35.

Fig. 40 is a plan view showing a configuration of the switch element 11a, and Fig. 41 is a sectional view taken

along the line XI-XI in Fig. 40. As shown in Fig. 41, a substrate 120 of the switch element 11a includes a conductor layer 120a, and a GaN layer 120b and an AlGaN layer 120c formed on the conductor layer 120a in that order. In the
5 switch element 11a, a two-dimensional electron gas layer formed at an AlGaN/GaN hetero-interface is used as a channel layer. As shown in Fig. 40, formed on a surface 120d of the substrate 120 are a first electrode D1 and a second electrode D2 connected in series to the power source 2 and
10 the load 3, respectively, and a middle potential portion S which has a middle potential between a potential of the first electrode D1 and a potential of the second electrode D2.

In addition, a control electrode (gate) G is formed on
15 the middle potential portion S. A Schottky electrode is used as the control electrode G, for example. The first electrode D1 and the second electrode D2 respectively have a first set of a plurality of electrode portions 111, 112, 113, ... and a second set of a plurality of electrode portions 121, 122,
20 123, The electrode portions of each of the first and the second set are arranged in parallel to face one another in the shape of teeth of comb and, the first and second set of electrode portions are arranged oppositely. The middle potential portion S and the control electrode G are
25 positioned between the plurality of electrode portions 111, 112, 113, ... and 121, 122, 123, ... arranged in the shape

of the teeth of comb and have a shape (approximately a fish backbone shape) conformal to a plane shape of a space formed between the electrodes.

Next, a structure of a lateral transistor of the switch element 11a will be described. As shown in Fig. 40, the electrode portion 111 of the first electrode D1 and the electrode portion 121 of the second electrode D2 are arranged such that central lines in their width directions coincide each other, and the electrode portion 111 of the first electrode D1 and the electrode portion 121 of the second electrode D2 are arranged in parallel to corresponding portions of the middle potential portion S and the control electrode G. Distances from the electrode portion 111 of the first electrode D1 and the electrode portion 121 of the second electrode D2 to the corresponding portions of the middle potential portion S and the control electrode G in the width direction is set such that a predetermined withstanding voltage can be maintained therebetween.

This is also equally applied to a direction perpendicular to the width direction, that is, a longitudinal direction of the electrode portion 111 of the first electrode D1 and the electrode portion 121 of the second electrode D2. In addition, these relationships are equally applied to the remaining pairs of electrode portions 112/122, 113/123, That is, the middle potential

portion S and the control electrode G are arranged at a position where the predetermined withstanding voltage can be maintained with respect to the first electrode D1 and the second electrode D2.

5 As described above, the middle potential portion S having the middle potential between the potentials of the first and the second electrode D1 and D2 and the control electrode G connected to the middle potential portion S for performing a control therefor are arranged at a position
10 where the predetermined withstanding voltage can be maintained with respect to the first and the second electrode D1 and D2. Therefore, if the first electrode D1 is at a high potential and the second electrode D2 is at a low potential and the bidirectional switch element 11a is
15 off (i.e., when a signal of 0 volt is applied to the control electrode G), a current is definitely blocked at least between the first electrode D1 and the control electrode G/the middle potential portion S (a current is blocked right below the control electrode (gate) G).

20 On the other hand, when the bidirectional switch element 11a is on, i.e., when a voltage signal exceeding a predetermined threshold is applied to the control electrode G, as indicated by arrows in Fig. 40, a current flows along a path from the first electrode D1 (electrode portions 111,
25 112, 113, ...) to the second electrode D2 (electrode portions 121, 122, 123, ...) through the middle potential

portion S. This can be equally applied to the reversed case as well.

As described above, by forming the middle potential portion S at a position where the predetermined withstanding voltage can be maintained with respect to the first and the second electrode D1 and D2, the switch element 11a can be reliably made on/off and a low ON-resistance can be realized even when a threshold voltage of a signal applied to the control electrode G is lowered down to a lowest required level. In addition, by setting a reference potential (GND) of a control signal to be equal to the potential of the middle potential portion S in constructing the main opening/closing unit 11 by using the novel switch element 11a, a high voltage commercial power source can be directly controlled by the control circuit 13 driven by the control signal of several volts.

In addition, in comparison with the third example, the load control device 1K of the present example is not affected by a voltage drop caused by a diode of the rectifying circuit 12. Therefore, even if the threshold voltage allowing the switching between conduction and non-conduction of the main opening/closing unit 11 is lowered, the non-conduction can be reliably maintained. Moreover, in the lateral transistor element using the two-dimensional electron gas layer formed at the hetero-interface as the channel layer, a threshold voltage to make the element non-

conductive has a relationship with ON-resistance of the electrical conduction. Hence, lowering the threshold voltage can lead to lowering the ON-resistance, which makes it possible to achieve a scaled-down and high capacitive load control device.

(Sixth Embodiment)

A load control device 1L in accordance with a sixth embodiment of the present invention will be explained. Fig. 42 depicts a circuit diagram of the load control device 1L in accordance with the sixth embodiment. The load control device 1L basically has same configuration as one of the fifth embodiment, excepting that the third power source unit 16 includes a zero cross detector 23 and the control unit 13 has a third pulse output unit 24. Although the load control device shown in Fig. 42 is based on the load control device 1I shown in Fig. 35, without being limited thereto, it may be based on the load control device 1H shown in Fig. 33, the load control device 1J shown in Fig. 37, and the load control device 1K shown in Fig. 39.

The zero cross detector 23 detects a zero cross of a load current and outputs a zero cross detection signal to the third pulse output unit 24. The third pulse output unit 24 receives the zero cross detection signal from the zero cross detector 23 and outputs a third pulse. The third pulse rises when the zero cross detection signal is inputted and descends after a lapse of a third predetermined period

of time. The third predetermined period of time is set to be shorter than the half cycle of the load current.

Inputted to the control unit 13 are the first pulse outputted from the first pulse output unit 19 and the third pulse outputted from the third pulse output unit 24. The control unit 13 has an AND circuit 25a which performs a logical product of the first pulse and the third pulse and outputs the result via an OR circuit 25b to the main opening/closing unit 11. When the OR circuit 25b receives any one of an output signal from the AND circuit 25a and an output signal from a current detector 22, it outputs a signal to a gate of the switch element 11a of the main opening/closing unit 11. Thus, the main opening/closing unit 11 becomes conductive again for a short period of time, thereby protecting the auxiliary opening/closing unit 17.

As described above, the main opening/closing unit 11 becomes conductive while the first and the third pulse are raised at the same time, i.e., while the first predetermined period of time overlaps with the third predetermined period of time. Further, the third pulse rises when the zero cross detector 23 detects a zero cross point and descends after a lapse of the third predetermined period of time that is shorter than the half cycle of the load current. Therefore, even though a delay occurs in timing when the charging completion of the buffer condenser 25 is detected, i.e., the first predetermined period of time starts to rise, it is

impossible that the main opening/closing unit 11 remains
conductive beyond the zero cross point of the power source
frequency. Accordingly, charging can be definitely
performed every half cycle of the power source, thereby
5 achieving a stable operation of the charging.

While the invention has been shown and described with
respect to the embodiments, it will be understood by those
skilled in the art that various changes and modifications
may be made without departing from the scope of the
10 invention as defined in the following claims.

What is claimed is:

1. A load control device connected in series between an AC power source and a load, comprising:

5 a main opening/closing unit connected in series between the power source and the load for controlling supply of power to the load and including a switch element, wherein the switch element has a lateral dual gate transistor structure having a withstanding voltage portion and having a
10 dual gate to which a control voltage is applied;

an auxiliary opening/closing unit having an auxiliary switch device of a thyristor structure for controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state;

15 a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit;

a first power source unit for receiving an electric power from both ends of the main opening/closing unit via a
20 rectifying circuit and supplying a stable power to the control unit;

a second power source unit for receiving an electric power from both ends of the main opening/closing unit via the rectifying circuit, and supplying a power to the first
25 power source unit when the load is not powered;

a drive circuit for driving the main opening/closing

unit;

a third power source unit for supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state; and

a voltage detector for detecting a voltage inputted to the third power source unit,

wherein, while the load is powered, the control unit makes the main opening/closing unit conductive for a first predetermined period of time when the voltage detector detects that the voltage inputted to the third power source unit reaches a predetermined threshold and makes the auxiliary opening/closing unit conductive for a second predetermined period of time when the main opening/closing unit is in non-conductive state.

2. The load control device of claim 1, wherein the drive circuit drives the switch element by supplying a power to the gate of the switch element in response to a drive signal of the control unit, the power being on the basis of potentials of points connected to the AC power source and the load, respectively, and being electrically insulated from the control unit.

3. The load control device of claim 2, wherein the drive circuit includes two opto-insulation semiconductor devices

corresponding to the dual gate of the switch element, each having a light emitting unit connected to the control unit for receiving the drive signal and a light receiving unit for receiving a light outputted from the light emitting unit, and the light receiving unit executing a photoelectric transformation and applying a positive potential to the gate of the switch element on the basis of respective points to which the AC power source and the load are connected.

10 4. The load control device of claim 1, wherein the drive circuit includes two diodes, each connected to the first power source unit, two capacitors, one end of each capacitor connected to a power line and the other end connected to the diode, and two drive switch devices, each connected between
15 a connection point of the diode and the capacitor, and the gate of the switch element, and supplies a power for driving the main opening/closing unit by making the drive switch devices conductive by a drive signal from the control unit.

20 5. The load control device of claim 4, wherein the drive switch device in the drive circuit is an opto-insulation semiconductor switch device having a light-emitting unit for outputting a light by the drive signal from the control unit and a light-receiving unit for receiving the light outputted
25 from the light-emitting unit to conduct, and

wherein, when the light-receiving unit electrically conducts, an electric power of the first power source unit

is supplied to the main opening/closing unit as a drive power.

6. The load control device of claim 3 or 5, wherein
5 light-emitting units of the two opto-insulation semiconductor devices in the drive circuit are connected in series to each other.

7. The load control device of claim 2, wherein the drive
10 circuit includes a transformer which includes a primary coil connected to the control unit and two secondary coils connected to the dual gate of the switch element via rectifying circuit,

wherein, when the driving signal is inputted from the
15 control unit, an AC current flows in the primary coil and, accordingly, an AC current is generated in the secondary coils due to an electromotive force caused by the AC current flowing in the primary coil, thereby applying a positive potential to the dual gate of the switch element on the
20 basis of respective points to which the AC power source and the load are connected.

8. The load control device of claim 4 or 5, wherein the
drive circuit further includes capacitors connected between
25 power lines serving as a basis and connection points of the gate of the switch element and the drive switch device.

9. The load control device of any one of claims 1, 4 and 5, wherein the rectifying circuit includes synchro-switch devices connected between a point to which the power line is coupled and a negative output point, and the synchro-switch devices turn on in synchronous to an operation of making the main opening/closing unit conductive.

10. The load control device of claim 9, wherein the drive switch device has a thyristor or a triac structure and is driven by a signal electrically isolated from the power source units.

11. The load control device of claim 1 or 2, wherein the third power source unit includes a voltage detector for outputting a signal to the control unit when a voltage inputted to the third power source unit reaches a predetermined threshold, a zero cross detector for outputting a signal to the control unit when it detects a zero cross of a voltage inputted to the third power source unit,

the control unit includes a pulse signal output unit for outputting a pulse signal to make the main opening/closing unit conductive for a first predetermined period of time when a signal is inputted from the voltage

detector, and a pulse signal output unit for outputting a pulse signal for a third predetermined period of time when a signal is inputted from the zero cross detector, and

5 the control unit outputs a drive signal to make the main opening/closing unit conductive while the signal from the voltage detector and the signal from the zero cross detector are being outputted together.

12. The load control device of claim 1 or 2, wherein the
10 control unit is operated by a remote control signal.

13. The load control device of claim 12, further comprising a fourth power source unit connected to the first power source unit for rectifying the remote control signal,
15 wherein, when the remote control signal is inputted, an electric power of the remote control signal is supplied to the first power source unit via the fourth power source unit, the control unit is started up and, when the control unit recognizes its own address contained in the remote
20 control signal, the control unit operates the third power source and supplies an electric power to the load by driving the main opening/closing unit.

14. A load control device connected in series between an
25 AC power source and a load, comprising:

a main opening/closing unit controlling a supply of

power to the load and having a switch element of a transistor structure;

an auxiliary opening/closing unit having a switch device of a thyristor structure and controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state;

a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit;

a first power source unit receiving an electric power from both ends of the main opening/closing unit via a rectifying circuit and supplying a stable power to the control unit;

a second power source unit receiving an electric power from both ends of the main opening/closing unit via the rectifying circuit and supplying a power to the first power source unit when the load is not powered; and

a third power source unit supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state,

wherein the third power source unit includes a voltage detector for detecting a voltage inputted thereto, and a zero cross detector for detecting a zero cross point of a load current, and

wherein, when the load is powered, the control unit

makes the main opening/closing unit conductive while a first predetermined period of time counted from when the voltage detector detects that the voltage inputted to the third power source unit reaches a predetermined threshold falls on
5 a third predetermined period of time counted from when the zero cross detector detects a zero cross point of the load current, the third predetermined period of time being shorter than a half cycle of the load current.

10 15. The load control device of claim 14, wherein the control unit makes the auxiliary opening/closing unit conductive for a second predetermined period of time when the main opening/closing unit is in a non-conduction state.

15 16. The load control device of claim 15, further comprising a current detector for detecting a current flowing in the auxiliary opening/closing unit, and

wherein, when a current exceeding a predetermined threshold flows in the auxiliary opening/closing unit, the
20 control unit makes the main opening/closing unit conductive and then, when the main opening/closing unit becomes non-conductive, makes the auxiliary opening/closing unit conductive.

25 17. A load control device connected in series between an AC power source and a load, comprising:

a main opening/closing unit controlling a supply of power to the load and having a switch element of a transistor structure;

5 an auxiliary opening/closing unit having a switch device of a thyristor structure and controlling a supply of power to the load when the main opening/closing unit is in a non-conduction state;

10 a control unit for controlling opening and closing of the main opening/closing unit and the auxiliary opening/closing unit;

a first power source unit receiving an electric power from both ends of the main opening/closing unit via a rectifying circuit and supplying a stable power to the control unit;

15 a third power source unit supplying a power to the first power source unit when the load is powered while the main opening/closing unit or the auxiliary opening/closing unit is in a conduction state;

20 a receiving unit receiving a control signal inputted externally; and

a independent power source unit rectifying the control signal received by the receiving unit and supplying an electric power to the first power source.

25 18. The load control device of claim 17, wherein the third power source unit further includes a voltage detector

detecting a voltage inputted thereto, and

wherein, while the load is powered, the control unit makes the main opening/closing unit conductive for a predetermined period of time when the voltage detects that the voltage inputted to the third power source unit reaches
5 a predetermined threshold, and then, when the main opening/closing unit becomes non-conductive, makes the auxiliary opening/closing unit conductive for a second predetermined period of time.

10

19. The load control device of claim 18, further comprising a current detector for detecting a current flowing in the auxiliary opening/closing unit,

wherein, when a current exceeding a predetermined
15 threshold flows in the auxiliary opening/closing unit, the control unit makes the main opening/closing unit conductive and then, when the main opening/closing unit becomes non-conductive, makes the auxiliary opening/closing unit conductive.

20

20. The load control device of any one of claims 17 to 19, wherein the switch element of the main opening/closing unit includes a bidirectional controllable lateral transistor device, the lateral transistor device including two
25 electrodes respectively connected to the AC power source and the load, and a control electrode is provided on a middle

potential portion between the two electrodes.

21. The load control device of any one of claims 17 to 19,
wherein the switch element of the main opening/closing unit
5 has a lateral transistor structure, the lateral transistor
structure including a first electrode and a second electrode
respectively connected in series to the AC power source and
the load and formed on a surface of a substrate, a middle
potential portion which has a middle potential between a
10 potential of the first electrode and a potential of the
second electrode, and a control electrode at least partially
formed on the middle potential portion for performing a
control for the middle potential portion, and the middle
potential portion and the control electrode being arranged
15 at a position capable of keeping a predetermined
withstanding voltage to the first and the second electrode
during non-conduction of the device.

22. The load control device of claim 18, further comprising
20 a zero cross detector detecting a zero cross point of a load
current,

wherein the control unit makes the main
opening/closing unit conductive while the first
predetermined period of time falls on a third predetermined
25 period of time counted from when the zero cross detector
detects a zero cross point of the load current, the third

predetermined period of time being shorter than a half cycle of the load current.