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(54) CONSTANT-CURRENT DRIVE CIRCUIT, CONSTANT-CURRENT DRIVE DEVICE AND LAMP

(57) The present application relates to the field of driving technology, and provides a constant-current drive circuit, a constant-current drive device, and a lamp. The AC power is connected via a rectifier module (10) and rectified by the rectifier module (10) to generate a DC voltage signal. An electrolytic capacitor (C3) is provided at an output end of the rectifier module (10) to improve an efficiency of circuit and to eliminate a stroboscopic phenomenon in the DC voltage signal. The driver module (20) is configured to generate a constant-current driving signal according to the DC voltage signal in the discontinuous conduction mode, and adjust an output duty cycle according to the constant-current driving signal to maintain a constant current of the constant-current driving signal. The electromagnetic suppression module (30) is configured to eliminate a clutter interference signal in the DC voltage signal to improve an electromagnetic performance of the circuit. Such that problems of higher driving cost and larger size of driving space caused by an additional de-stroboscopic circuit in the circuit can be solved.

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Description

TECHNICAL FIELD

[0001] The present application relates to the field of driving technology, and more particularly to a constant-current drive circuit, a constant-current drive device and a lamp.

BACKGROUND

[0002] A Buck/Boost converter, also known as a buck-boost converter, is a single-tube non-isolated DC converter whose output voltage can be lower or higher than its input voltage, but the polarity of the output voltage is opposite to the input voltage. The Buck/Boost converter can be regarded as a series connection of a Buck converter and a Boost converter, combined with switch tubes.

[0003] However, existing Boost circuits usually use film capacitors for filtering after rectification, and their output will be stroboscopic, thus, an additional de-stroboscopic circuit is required, which leads to problems of higher driving cost and larger size of driving space.

SUMMARY

[0004] An object of the present application is to provide a constant-current drive circuit, a constant-current drive device and a lamp, aiming to solve the problems of higher driving cost and larger size of driving space caused by an additional de-stroboscopic circuit required in the existing Boost circuits.

[0005] In accordance with a first aspect of embodiments of the present application, it is provided a constant-current drive circuit, which includes:

a rectifier module, which is configured to receive an AC power and perform a rectification on the AC power to generate a DC voltage signal;

an electrolytic capacitor, which is connected to the rectifier module, and configured to improve an efficiency of circuit and eliminate a stroboscopic phenomenon in the DC voltage signal;

a driver module, which is connected to the rectifier module, and configured to generate a constant-current driving signal according to the DC voltage signal in a discontinuous conduction mode, and adjust an output duty cycle according to the constant-current driving signal to maintain a constant current of the constant-current drive signal; and

an electromagnetic suppression module, which is connected to the driver module, and configured to eliminate a clutter interference signal in the DC voltage signal to improve an electromagnetic performance of the circuit.

[0006] Optionally, the driver module is specifically configured to perform a current sampling on the constant-current driving signal, and adjust a switch duty cycle of the driver module according to a sampling result.

[0007] Optionally, the driver module is configured to control the switch duty cycle according to a preset on-off time relation, and the preset on-off time relation is: t_off=(V_in-1)/(V_o+1)*t_on. In which, t off is a turn-off time, t on is a turn-on time, V_in is an input voltage, and V_o is an output voltage.

[0008] Optionally, the constant-current drive circuit also includes a filter module, which is connected to the driver module and configured to filter the constant-current driving signal.

[0009] Optionally, the electromagnetic suppression module includes a first capacitor, a first diode, and a first resistor. A first end of the first capacitor and an anode of the first diode are connected in common to the rectifier module. A second end of the first capacitor is connected to a first end of the first resistor. A second end of the first resistor and a cathode of the first diode are connected in common to an output end of the driver module.

[0010] Optionally, the filter module includes at least one electrolytic capacitor. A first end of the at least one electrolytic capacitor is connected to the driver module, and a second end of the at least one electrolytic capacitor is grounded.

[0011] Optionally, the driver module includes: a first inductor, a second capacitor, a second resistor, a third resistor, a fourth resistor, a fifth resistor, a second diode, and a constant-current driver chip. A first end of the first inductor is connected to the rectifier module. A second end of the first inductor, a first end of the second capacitor, and an anode of the second diode are connected in common to an output pin of the constant-current driver chip. A second end of the second capacitor and a first end of the second resistor are commonly connected. A cathode of the second diode and a second end of the second resistor are connected in common to an input pin of the constant-current driver chip. A current detection pin of the constant-current driver chip, a first end of the third resistor, and a first end of the fourth resistor are commonly connected. An over-voltage protection pin of the constant-current driver chip is connected to a first end of the fifth resistor. A second end of the third resistor, a second end of the fourth resistor, and a second end of the fifth resistor are connected in common to an output end of a load.

[0012] Optionally, the constant-current driver chip includes: a reference voltage signal source, a first switch tube, a second switch tube, an under-voltage lockout unit, a lockout restart unit, an over-voltage protection unit, a current detection unit, a current control unit, an on-time control unit and a drive unit. A first input end of the over-voltage protection unit constitutes the over-voltage protection pin of the constant-current driver chip. A first end of the first switch tube and the first input end of the over-voltage protection unit are connected in common to form the input pin of the constant-current driver chip. A second end of the first switch tube is connected to the under-voltage lockout unit. A control end of the first switch tube is connected to a substrate of the constant-current driver chip. An input end of the current detection unit constitutes the current detection pin of the constant-current driver chip. A first input end of the lockout restart unit is connected to the under-voltage lockout unit. A second input end of the lockout restart unit is connected to the over-voltage protection unit. A first input end of the current control unit is connected to the reference voltage signal source. A second input end of the current control unit is connected to the current detection unit. An input end of the on-time control unit is connected to the current control unit. A first input end of the drive unit is connected to the on-time control unit. A second input end of the drive unit is connected to the lockout restart unit. A first end of the second switch tube is connected to the output pin of the constant-current driver chip. A second end of the second switch tube is connected to the current detection pin of the constant-current driver chip.

[0013] Optionally, the over-voltage protection unit is configured to sample an output current of the load to generate a reference over-voltage signal, and generate an over-voltage protection signal when the voltage of the constant-current driving signal is greater than that of the reference over-voltage signal. The under-voltage lockout unit is configured to perform a voltage detection on the input constant-current driving signal, and generate an under-voltage protection signal when the voltage of the constant-current driving signal is lower than a preset under-voltage threshold. The lockout restart unit is configured to lock or restart the drive unit according to the over-voltage protection signal and the under-voltage protection signal.

[0014] Optionally, the current detection unit is configured to perform a current detection of the constant-current driving signal and generate a current detection signal.

[0015] The current control unit is configured to compare the current detection signal with the reference voltage signal provided by the reference voltage signal source, and generate a current control signal according to a comparison result to control a current magnitude of the constant-current driving signal.

[0016] Optionally, the on-time control unit is configured to determine a switch duty cycle according to the current control signal, and generate a drive control signal according to the switch duty cycle to control the current magnitude of the constant-current driving signal.

[0017] Optionally, the drive unit is configured to control an on state and an off state of the second switch tube according to the drive control signal.

[0018] Optionally, when the constant-current driver chip operates in the discontinuous conduction mode, when the second switch tube is switched on, an inductor current output from the driver module increases, and when the second switch tube is switched off, the inductor current output from the driver module decreases, and when a turn-off time $t\_off=(V\_in-1)/(V\_o+1)*t\_on$, the second switch tube switches on again. Where, t_off is the off time, T_on is a turn-on time, V_in is an input voltage, and V_o is an output voltage.

[0019] In accordance with a second aspect of the embodiments of the present application, it is provided a constant-current drive device, which includes the constant-current drive circuit described in any one of the above.

[0020] In accordance with a third aspect of the embodiments of the present application, it is provided a lamp, which includes: a light source module and the constant-current drive circuit described in any one of the above, the constant-current drive circuit is connected to the light source module.

[0021] The embodiment of the present application provides a constant-current drive circuit, a constant-current drive device, and a lamp. The AC power is connected via a rectifier module and rectified by the rectifier module to generate a DC voltage signal. An electrolytic capacitor is provided at an output end of the rectifier module to improve an efficiency of circuit and to eliminate a stroboscopic phenomenon in the DC voltage signal. The driver module is configured to generate a constant-current driving signal according to the DC voltage signal in the discontinuous conduction mode, and adjust an output duty cycle according to the constant-current driving signal to maintain a constant current of the constant-current driving signal. The electromagnetic suppression module is configured to eliminate a clutter interference signal in the DC voltage signal to improve the electromagnetic performance of the circuit. Such that the problems of higher driving cost and larger size of driving space caused by the additional de-stroboscopic circuit in the circuit can be solved.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

FIG. 1 is a schematic structural diagram of a constant-current drive circuit in accordance with an embodiment of the present application;

FIG. 2 is a schematic structural diagram of yet another constant-current drive circuit in accordance with an embodiment of the present application;

FIG. 3 is a schematic structural diagram of still another constant-current drive circuit in accordance with an embodiment of the present application; and

FIG. 4 is a schematic structural diagram of a constant-current driver chip in accordance with an embodiment of the present application.

DETAILED DESCRIPTION

[0023] In order to make the technical problems to be solved, technical solutions, and beneficial effects of the present application more comprehensible, the present application is further described in detail with reference to the drawings and embodiments herein and below. It should be understood that specific embodiments described here are intended only to explain the present application, and are not intended to limit the present application.

[0024] It should be noted that when an element is referred to as being "fixed to" or "disposed on" another element, it can be directly or indirectly on the other element. When an element is referred to as being "connected to" another element, it can be directly or indirectly connected to the other element.

[0025] It should be understood that the orientation or positional relationship indicated by terms "length", "width", "upper", "lower", "front", "rear", "left", "right", "vertical", "horizontal", "top" "bottom", "inner", "outer", etc. is based on the orientation or positional relationship shown in the drawings, which is used only for the convenience of describing the present application and simplifying the description, and does not indicate or imply the device or the element referred to must have a specific orientation, or be constructed and operated in a specific orientation, and therefore should not be understood as a limitation to the present application.

[0026] In addition, the terms "first" and "second" are only used for descriptive purposes, and cannot be understood as indicating or implying relative importance or implicitly indicating the number of indicated technical features. Thus, features defined with "first" and "second" may explicitly or implicitly include one or more of these features. In the description of the present application, the term "a/the plurality of" means two or more than two, unless otherwise specifically defined.

[0027] An embodiment of the present application provides a constant-current drive circuit to solve the problems of stroboscopic and low efficiency in the existing drive circuits. As shown in FIG. 1, the constant-current drive circuit in this embodiment includes: a rectifier module 10, an electrolytic capacitor C3, a driver module 20, and an electromagnetic (EM) suppression module 30. Among them, the rectifier module 10 is configured to receive an AC power, and perform a rectification on the AC power to generate a DC voltage signal. The electrolytic capacitor C3 is connected to the rectifier module 10 to improve an efficiency of circuit, and to eliminate a stroboscopic phenomenon in the DC voltage signal. The driver module 20 is connected to the rectifier module 10, and configured to generate a constant-current driving signal according to the DC voltage signal in a discontinuous conduction mode, and to adjust an output duty cycle according to the constant-current driving signal to maintain a constant current of the constant-current driving signal. The electromagnetic suppression module 30 is connected to the driver module 20, and configured to eliminate a clutter interference signal in the DC voltage signal to improve an electromagnetic performance of the circuit.

[0028] In this embodiment, the AC power is connected via the rectifier module 10, and rectified by the rectifier module 10 to generate a DC voltage signal. The electrolytic capacitor C3 is provided at an output end of the rectifier module 10 to improve the efficiency of circuit and to eliminate the stroboscopic phenomenon in the DC voltage signal. The driver module 20 is configured to generate a constant-current driving signal according to the DC voltage signal in the discontinuous conduction mode, and adjust the output duty cycle according to the constant-current driving signal to maintain the constant current of the constant-current driving signal. The electromagnetic suppression module 30 is configured to eliminate the clutter interference signal in the DC voltage signal to improve the electromagnetic performance of the circuit. In this way, the problems of higher driving cost and larger size of driving space caused by the additional de-stroboscopic circuit in the circuit can be solved.

[0029] Specifically, in this embodiment, the rectifier module 10 converts an alternate current into a pulsating direct current, and a larger-capacity electrolytic capacitor C3 is connected after the rectifier circuit. By replacing the traditional small-capacity film capacitor with the electrolytic capacitor C3, the efficiency of circuit can be improved. Moreover, owing to charge and discharge characteristics of the electrolytic capacitor C3, the rectified pulsating DC voltage becomes a relatively stable DC voltage.

[0030] In a practical application embodiment, in order to prevent a supply voltage of each part of the circuit from changing due to a change of a load 00, the output end of the rectifier module 10 and an input end of the load 00 are generally connected with an electrolytic capacitor of tens to hundreds of microfarads (for example, 10-500 uF). Since the large-capacity electrolytic capacitors generally have a certain inductance effect which may not be able to effectively eliminate high-frequency and pulse interference signals, a capacitor having a capacity of 0.001-0.1 pF is connected in parallel at both ends of the electrolytic capacitor to eliminate high-frequency and pulse interference.

[0031] In an embodiment, the driver module 20 is specifically configured to perform a current sampling on the constant-current driving signal, and adjust a switch duty cycle of the driver module 20 according to a sampling result.

[0032] In this embodiment, the driver module 20 determines whether a magnitude of an output current is within a constant preset range based on the result of the current sampling on the constant-current driving signal output from the driver module 20, and then controls the switch duty cycle of the driver module 20 to maintain a constant output current.

[0033] For example, the driver module 20 detects a current flowing out of the load 00 through a current sampling pin of the driver module 20 to obtain a current detection signal, and compares the current detection signal with a reference voltage signal provided by a reference voltage signal source 21. The threshold of the detected current may be corresponding to an average current calculated based on the reference voltage, and then control the duty cycle of turn-on time and turn-off time of the driver module 20 in the discontinuous conduction mode (DCM), so as to maintain the constant output current of the driver module 20.

[0034] In an embodiment, the driver module 20 is configured to control the switch duty cycle according to a preset on-off time relation, and the preset on-off time relation is: t_off=(V_in-1)/(V_o+1)*t_on. Where, t_off is a turn-off time, t_on is a turn-on time, V_in is an input voltage, and V_o is an output voltage.

[0035] In this embodiment, the driver module 20 adjusts its output current by controlling a ratio of turn-on time and turn-off time of a switch tube (such as a MOSFET) in the driver module 20. Specifically, the driver module 20 when operates in the discontinuous conduction mode, the switch tube in the driver module 20 is switched on, an inductor current in the driver module 20 increases, when the switch tube is switched off, the inductor current in the driver module 20 decreases, until t off = (V_in-1)/(V_o+1)*t_on, the switch tube is switched on again. In a specific application embodiment, the turn-on time t_on may be set as a constant through a timer, and the duty cycle can be controlled by changing the turn-off time t off, so that a conduction loss can be reduced and the efficiency can be improved.

[0036] In an embodiment, referring to FIG. 2, the constant-current drive circuit may also include a filter module 40, and the filter module 40 is connected to the driver module 20 and configured to filter the constant-current driving signal.

[0037] In an embodiment, referring to FIG. 3, the electromagnetic suppression module 30 may include a first capacitor C1, a first diode D1, and a first resistor R1. A first end of the first capacitor C1 and an anode of the first diode D1 are connected in common to the rectifier module 10. A second end of the first capacitor C1 is connected to a first end of the first resistor R1. A second end of the first resistor R1 and a cathode of the first diode D1 are connected in common to an output end of the driver module 20.

[0038] In this embodiment, the first capacitor C1, the first diode D1, and the first resistor R1 form a first-stage EMI circuit to eliminate the clutter interference in the DC voltage signal, so as to improve the electromagnetic performance of the circuit.

[0039] In an embodiment, referring to FIG. 3, the rectifier module 10 may be a rectifier bridge.

[0040] In this embodiment, the rectifier bridge converts an input voltage of 50/60HZ sine wave into a voltage of 100/120HZ waveform without a negative half cycle to achieve an effect of full-wave rectification.

[0041] In an embodiment, the filter module 40 includes at least one electrolytic capacitor, a first end of the at least one electrolytic capacitor is connected to the driver module 20, and a second end of the at least one electrolytic capacitor is grounded.

[0042] In a specific application embodiment, referring to FIG. 3, the filter module 40 includes a fourth capacitor C4, a first end of the fourth capacitor C4 is connected to the output end of the driver module 20, and a second end of the fourth capacitor C4 is grounded. In which, the fourth capacitor C4 is an electrolytic capacitor.

[0043] In practical applications, for example, in an application of switch power supply, the filter module 40 may also be used as an output capacitor to store energy, so as to maintain a constant voltage. The selection of capacitor for the Boost circuit is mainly depended on the output ripple whether it can be controlled within a range specified by indexes. For the Boost circuit, the magnitude of the output voltage ripple depends on an impedance of the capacitor and the output current. The impedance of a capacitor consists of three parts, namely, equivalent series inductance (ESL), equivalent series resistance (ESR) and capacitance (C). When the inductor current is in a continuous mode, the capacitance of the capacitor depends on the output current, a switching frequency and an expected output ripple. When the switch tube in the driver module 20 is switched on, the output filter capacitor provides current for the entire load 00.

[0044] In an embodiment, the driver module 20 includes: a first inductor L1, a second capacitor C2, a second resistor R2, a third resistor R3, a fourth resistor R4, a fifth resistor R5, a second diode D2, and a constant-current driver chip U1. A first end of the first inductor L1 is connected to the rectifier module 10. A second end of the first inductor LI, a first end of the second capacitor C2, and an anode of the second diode D2 are connected in common to an output pin Drain of the constant-current driver chip U1. A second end of the second capacitor C2 and a first end of the second resistor R2 are commonly connected. A cathode of the second diode D2 and a second end of the second resistor R2 are connected in common to an input pin Vin of the constant-current driver chip U1. A current detection pin ISP of the constant-current driver chip U1, a first end of the third resistor R3 and a first end of the fourth resistor R4 are commonly connected. An over-voltage protection pin OVP of the constant-current driver chip U1 is connected to a first end of the fifth resistor R5. A second end of the third resistor R3, a second end of the fourth resistor R4 and a second end of the fifth resistor R5 are connected in common to an output end of the load 00.

[0045] In this embodiment, the second capacitor C2, the second resistor R2, and the second diode D2 form a second-stage EMI circuit to eliminate the interference clutter in the constant-current driving signal generated by the constant-current driver chip U1. Since the input of the driver module 20 is a direct current, the current on the first inductor L1 increases linearly at a certain ratio, and this ratio is related to the inductance of the first inductor L1. As the inductor current increases, some energy is stored in the inductor. When the MOS tube in the constant-current driver chip U1 is switched off, due to the current characteristic of the inductor, the current flowing through the inductor will not immediately become zero, but change slowly from a value when the charging is completed to zero. As the original circuit has been disconnected, the inductor can only be discharged through a new circuit, that is, the inductor starts to charge the capacitor, the voltage across the capacitor increases, until the voltage is higher than the input voltage, and the boost is completed. The boost process is a transfer process of inductance energy. The inductor stores energy during a charge process, and releases energy during a discharge process. If the capacitor is large enough, the output end can maintain a continuous current during the discharge process. The on-off process is repeated, so that a voltage higher than the input voltage at both ends of the capacitor can be obtained. At the same time, the output current can be controlled by controlling the turn-on time and turn-off time of the MOS tube of the constant-current driver chip U1. The second diode D2 can prevent the final stage filter capacitor from discharging to the ground.

[0046] In this embodiment, the constant-current driver chip U1 is powered by its output voltage. When the voltage of the input pin Vin is higher than a starting voltage, the constant-current driver chip U1 starts to supply power. When the voltage of the input pin Vin is lower than the starting voltage, the chip activates an under-voltage protection, thereby locking the chip, until the voltage returns to normal, the chip restarts. Furthermore, the chip detects the current through the current detection pin ISP, the detected current is compared with the average current calculated based on the reference voltage, so that the constant output current can be maintained. Specifically, by setting the turn-on time t_{on} as a constant, the duty cycle can be controlled through a change of the turn-off time t_{off}, thereby reducing the conduction loss and improving the efficiency.

[0047] In a specific application embodiment, the constant-current driver chip U1 operates in the discontinuous conduction mode, when the MOSFET in the chip is switched on, the inductor current in the driver module 20 increases, and when the MOSFET is switched off, the inductor current in the circuit decreases, and eventually decrease to zero, until $t_{off} = (V_{in}-1)/(V_o+1)*t_{on}$, the MOSFET switches on again.

[0048] In a specific application embodiment, the constant-current driver chip U1 has a function of over-voltage protection. When the output voltage of the chip is higher than the OVP voltage set in accordance with a connection mode of the over-voltage protection pin OVP of the chip, the chip is locked, until the voltage returns to normal, the chip restarts.

[0049] Specifically, in this embodiment, the fifth resistor R5 is connected to the over-voltage protection pin OVP of the constant-current driver chip U1. The current output from the load 00 is divided through the fifth resistor R5, thereby the OVP voltage is provided as a reference voltage for the constant-current driver chip U1. The voltage of the input pin Vin of the constant-current driver chip U1 is compared with the reference voltage to prevent the voltage of the input pin from being too large, and the reference voltage can vary with the output current of the load 00, which achieves a dynamic over-voltage protection.

[0050] In an embodiment, the current output from the load 00 is divided through the third resistor R3 and the fourth resistor R4 to obtain a divided voltage signal. The divided voltage signal is input to the constant-current driver chip U1 through the current detection pin ISP of the constant-current driver chip U1. Specifically, since the resistance values of the third resistor R3 and the fourth resistor R4 are fixed, the divided voltage signal corresponds to the output current of the load. The constant-current driver chip U1 compares the divided voltage signal with the reference voltage signal provided by the reference voltage signal source, and controls the output current according to the comparison result. In which, the reference voltage signal source may correspond to the highest current threshold or a rated power of the constant-current driver chip U1, so as to avoid a damage of the constant-current driver chip U1 caused by an excessive power (in order to maintain a constant current output) when the load increases.

[0051] In an embodiment, referring to FIG. 4, the constant-current driver chip U1 includes: a reference voltage signal source 21, a first switch tube Q1, a second switch tube Q2, an under-voltage lockout unit 22, a lockout restart unit 23, an over-voltage protection unit 24, a current detection unit 25, a current control unit 26, an on-time control unit 27, and a drive unit 28.

[0052] Specifically, the over-voltage protection unit 24 is configured to sample the output current of the load to generate a reference over-voltage signal, and to generate an over-voltage protection signal when the voltage of the constant-current driving signal is greater than that of the reference over-voltage signal. In which, a first input end of the over-voltage protection unit 24 constitutes the over-voltage protection pin OVP of the constant-current driver chip U1. A first end of the first switch tube Q1 and a first input end of the over-voltage protection unit 24 are connected in common to form the input pin Vin of the constant-current driver chip U1. The under-voltage lockout unit 22 is configured to perform a voltage detection on the input constant-current driving signal, and to generate an under-voltage protection signal when the voltage of the constant-current driving signal is lower than a preset under-voltage threshold. In which, a second end of the first switch tube Q1 is connected to the under-voltage lockout unit 22, and a control end of the first switch tube Q1 is connected to a substrate of the constant-current driver chip U1. The lockout restart unit 23 is configured to lock or restart the drive unit 28 according to the over-voltage protection signal and the under-voltage protection signal. A first input end of the lockout restart unit

23 is connected to the under-voltage lockout unit 22, and a second input end of the lockout restart unit 23 is connected to the over-voltage protection unit 24. The current detection unit 25 is configured to detect the current of the constant-current driving signal, and generate a current detection signal. An input end of the current detection unit 25 constitutes the current detection pin ISP of the constant-current driver chip U1. The current control unit 26 is configured to compare the current detection signal with the reference voltage signal provided by the reference voltage signal source 21, and to generate a current control signal according to the comparison result. A first input end of the current control unit 26 is connected to the reference voltage signal source 21, and a second input end of the current control unit 26 is connected to the current detection unit 25. The on-time control unit 27 is configured to determine the switch duty cycle and generate a drive control signal according to the current control signal. An input end of the on-time control unit 27 is connected to the current control unit 26. The drive unit 28 is configured to control an on state and an off state of the second switch tube Q2 according to the drive control signal. In which, a first input end of the drive unit 28 is connected to the on-time control unit 27, and a second input end of the drive unit 28 is connected to the lockout restart unit 23. A first end of the second switch tube Q2 is connected to the output pin of the constant-current driver chip U1, and a second end of the second switch tube Q2 is connected to the current detection pin of the constant-current driver chip U1.

[0053] In this embodiment, the under-voltage lockout unit 22 is configured to perform a voltage detection on the voltage at the input pin Vin of the constant-current driver chip U1, when the voltage of the input pin Vin is lower than the preset under-voltage threshold (i.e., the starting voltage), the chip triggers an under-voltage lockout function and sends an under-voltage protection signal to the lockout restart unit 23 to lock the drive unit 28 and stop operation, until the voltage of the input pin Vin is restored, the chip restarts.

[0054] In this embodiment, the over-voltage protection unit 24 is configured to determine an OVP voltage (i.e., the voltage of the preset reference over-voltage signal) according to the connection mode of the over-voltage protection pin OVP of the constant-current driver chip U1, meanwhile, the over-voltage protection unit 24 is configured to receive the constant-current driving signal of the input pin Vin, and generate an over-voltage protection signal when the voltage of the constant-current driving signal is greater than that of the reference over-voltage signal and send the over-voltage protection signal to the lockout restart unit 23 to lock the chip for a preset time, and then the chip is restarted.

[0055] The current detection unit 25 is configured to detect the output current of the load 00 by detecting the current at the current detection pin ISP, and generate and send a current detection signal to the current control unit 26. The current control unit 26 is configured to compare the received feedback current detection signal with the reference voltage signal provided by the reference voltage signal source 21, and generate a current control signal according to the comparison result to adjust the output current of the constant-current driver chip U1. Specifically, the on-time control unit 27 is configured to determine the switch duty cycle according to the current control signal, and generate a drive control signal to limit the turn-on time t_on to ensure that the chip operates in the discontinuous conduction mode, and the drive unit 28 is configured to generate a pulse width modulation signal corresponding to the drive control signal to drive the second switch tube Q2 to alternately turn on and off, thereby maintaining the constant output current of the constant-current driver chip U1.

[0056] In an embodiment, the constant-current driver chip U1 also includes a power supply unit 29 for supplying power to other functional units in the chip. Specifically, the constant-current driver chip U1 can draw power according to its output voltage and performs a voltage conversion to generate a variety of voltages to power other functional units.

[0057] In an embodiment, the first switch tube Q1 and the second switch tube Q2 are both N-type MOS tubes.

[0058] In a specific application embodiment, where the constant-current driver chip U1 operates in the discontinuous conduction mode, when the second switch tube Q2 is switched on, the inductor current in the driver module 20 increases, and when the second switch tube Q2 is switched off, the inductor current in the circuit decreases and eventually decrease to zero, until $t\_off=(V\_in-1)/(V\_o+1)*t\_on$, the MOSFET is switched on again.

[0059] The present application also provides a constant-current drive device, which includes the constant-current drive circuit as described above.

[0060] The present application also provides a lamp, which includes a light source module, and any of the constant-current drive circuit as above mentioned. The constant-current drive circuit is connected to the light source module.

[0061] The embodiments of the present application provide a constant-current drive circuit, a constant-current drive device, and a lamp. The AC power is connected via the rectifier module, and rectified by the rectifier module to generate a DC voltage signal. The electrolytic capacitor is provided at the output end of the rectifier module to improve the efficiency of the circuit, and eliminate the stroboscopic phenomenon in the DC voltage signal. The driver module is configured to generate a constant-current driving signal according to the DC voltage signal in the discontinuous conduction mode, and adjust the output duty cycle according to the constant-current driving signal to maintain the constant current of the constant-current driving signal. The electromagnetic suppression module is configured to eliminate the clutter interference signal in the DC voltage signal to improve the electromagnetic performance of the circuit. Such that the problems of higher driving cost and larger size of driving space caused by the additional de-stroboscopic circuit in the circuit can be solved.

[0062] Those skilled in the art can clearly understand that, the division of the above functional units and modules is used only as an example for the convenience and conciseness of description. In practical applications, the above functions can be allocated to different functional units and modules as required, that is, the internal structure of the device is divided into different functional units or modules to complete all or part of the functions described above. The functional units and modules in the embodiments can be integrated into one processing unit, or each unit can exist alone physically, or two or more units can be integrated into one unit. The above-mentioned integrated units can be realized in the form of hardware and can also be realized in the form of software functional units. In addition, the specific names of the functional units and modules are only for the convenience of distinguishing each other, and are not used to limit the protection scope of the present application. For the specific operation process of the units and modules in the foregoing system, reference may be made to the corresponding process in the foregoing method embodiment, which will not be repeated here.

[0063] In the above-mentioned embodiments, the description of each embodiment has its own emphasis. For parts that are not described in detail or recorded in an embodiment, reference may be made to related descriptions of other embodiments.

[0064] The units described as separate components may or may not be physically separated, and the components displayed as units may or may not be physical units, that is, they may be located in one place, or they may be distributed on multiple network units. Some or all of the units may be selected according to actual needs to achieve the objects of solutions of the embodiments.

[0065] In addition, the functional units in the various embodiments of the present application may be integrated into one processing unit, or each unit may exist alone physically, or two or more units may be integrated into one unit. The above-mentioned integrated unit can be implemented in the form of hardware or software functional unit.

[0066] The above-mentioned embodiments are merely used for illustration of the technical solutions of the present application, rather than limitation. Although the present application has been described in detail with reference to the foregoing embodiments, it should be understood to those of ordinary skill in the art that the technical solutions recorded in the above embodiments may be modified, or some of the technical features may be equivalently replaced. When these modifications or replacements do not cause the essence of the corresponding technical solutions to deviate from the spirit and scope of the technical solutions of the embodiments of the present application, then should be included within the protection scope of the present application.

Claims

1. A constant-current drive circuit, comprising:

a rectifier module (10), configured to receive an AC power and perform a rectification on the AC power to generate a DC voltage signal;
an electrolytic capacitor (C3), connected to the rectifier module (10), configured to improve an efficiency of circuit and eliminate a stroboscopic phenomenon in the DC voltage signal;
a driver module (20), connected to the rectifier module (10), configured to generate a constant-current driving signal according to the DC voltage signal in a discontinuous conduction mode, and adjust an output duty cycle according to the constant-current driving signal to maintain a constant current of the constant-current driving signal; and
an electromagnetic suppression module (30), connected to the driver module (20), configured to eliminate a clutter interference signal in the DC voltage signal to improve an electromagnetic performance of the circuit.

2. The constant-current drive circuit of claim 1, wherein the driver module (20) is further configured to perform a current sampling on the constant-current driving signal, and adjust a switch duty cycle of the driver module (20) according to a sampling result.

3. The constant-current drive circuit of claim 2, wherein the driver module (20) is configured to control the switch duty cycle according to a preset on-off time relation, and the preset on-off time relation is: $t\_off=(V\_in-1)/(V\_o+1)*t\_on$;
wherein, t_off is a turn-off time, t_on is a turn-on time, V_in is an input voltage, and V_o is an output voltage.

4. The constant-current drive circuit according to any of the preceding claims, further comprising:
a filter module (40), connected to the driver module (20), configured to filter the constant-current driving signal.

5. The constant-current drive circuit according to claim 4, wherein the filter module (40) comprises at least one electrolytic capacitor (C3), a first end of the at least one electrolytic capacitor (C3) is connected to the driver module (20), and a second end of the at least one electrolytic capacitor (C3) is grounded.

6. The constant-current drive circuit according to any of the preceding claims, wherein the electromagnetic suppression module (30) comprises: a first capacitor (C1), a first diode (D1), and a first resistor (R1);
wherein a first end of the first capacitor (C1) and an anode of the first diode (D1) are connected in com-

mon to the rectifier module (10); a second end of the first capacitor (C1) is connected to a first end of the first resistor (R1); and a second end of the first resistor (R1) and a cathode of the first diode (D1) are connected in common to an output end of the driver module (20).

7. The constant-current drive circuit according to any of the preceding claims, wherein the driver module (20) comprises: a first inductor (L1), a second capacitor (C2), a second resistor (R2), a third resistor (R3), a fourth resistor (R4), a fifth resistor (R5), and a second diode D2() and a constant-current driver chip (U1);
wherein, a first end of the first inductor (LI) is connected to the rectifier module (10); a second end of the first inductor (L1), a first end of the second capacitor (C2), and an anode of the second diode (D2) are connected in common to an output pin (Drain) of the constant-current driver chip (U1);a second end of the second capacitor (C2) and a first end of the second resistor (R2) are commonly connected; a cathode of the second diode (D2) and a second end of the second resistor (R2) are connected in common to an input pin (Vin) of the constant-current driver chip (U1);a current detection pin (ISP) of the constant-current driver chip (U1), a first end of the third resistor (R3), and a first end of the fourth resistor (R4) are commonly connected; an over-voltage protection pin (OVP) of the constant-current driver chip (U1) is connected to a first end of the fifth resistor (R4); and a second end of the third resistor (R3), a second end of the fourth resistor (R4), and a second end of the fifth resistor (R1) are connected in common to an output end of a load (00).

8. The constant-current drive circuit according to claim 7, wherein the

constant-current driver chip (U1) comprises: a reference voltage signal source (21), a first switch tube (Q1), a second switch tube (Q2), an under-voltage lockout unit (22), a lockout restart unit (23), an over-voltage protection unit (24), a current detection unit (25), a current control unit (26), an on-time control unit (27) and a drive unit (28);
wherein, a first input end of the over-voltage protection unit (24) constitutes the over-voltage protection pin (OVP) of the constant-current driver chip (U1);a first end of the first switch tube (Q1) and the first input end of the over-voltage protection unit (24) are connected in common to form the input pin (Vin) of the constant-current driver chip (U1);a second end of the first switch tube (Q1) is connected to the under-voltage lockout unit (22); a control end of the first switch tube (Q1) is connected to a substrate of the constant-current driver chip (U1);an input end of the current detection unit (25) constitutes the current detection pin (ISP) of the constant-current driver chip (U1);a first input end of the lockout restart unit (23) is connected to the under-voltage lockout unit (22); a second input end of the lockout restart unit (23) is connected to the over-voltage protection unit (24); a first input end of the current control unit (26) is connected to the reference voltage signal source (21); a second input end of the current control unit (26) is connected to the current detection unit (25); an input end of the on-time control unit (27) is connected to the current control unit (26); a first input end of the drive unit (28) is connected to the on-time control unit (27); a second input end of the drive unit (28) is connected to the lockout restart unit (23); a first end of the second switch tube (Q2) is connected to the output pin (Drain) of the constant-current driver chip (U1);and a second end of the second switch tube (Q2) is connected to the current detection pin (ISP) of the constant-current driver chip (U1).

9. The constant-current drive circuit according to claim 8, wherein the over-voltage protection unit (24) is configured to sample an output current of the load (00) to generate a reference over-voltage signal, and generate an over-voltage protection signal when the voltage of the constant-current driving signal is greater than that of the reference over-voltage signal;

the under-voltage lockout unit (22) is configured to perform a voltage detection on the input constant-current driving signal, and generate an under-voltage protection signal when the voltage of the constant-current driving signal is lower than a preset under-voltage threshold; and
the lockout restart unit (23) is configured to lock or restart the drive unit (28) according to the over-voltage protection signal and the under-voltage protection signal.

10. The constant-current drive circuit according to claim 8 or 9, wherein the current detection unit (25) is configured to perform a current detection of the constant-current driving signal and generate a current detection signal; and
the current control unit (26) is configured to compare the current detection signal with the reference voltage signal provided by the reference voltage signal source (21), and generate a current control signal according to a comparison result to control a current magnitude of the constant-current driving signal.

11. The constant-current drive circuit according to claim 10, wherein the on-time control unit (27) is configured to determine a switch duty cycle according to the current control signal, and generate a drive control signal according to the switch duty cycle to control the current magnitude of the constant-current driving signal.

12. The constant-current drive circuit according to claim 11, wherein the drive unit (28) is configured to control an on state and an off state of the second switch tube (Q2) according to the drive control signal.

13. The constant-current drive circuit according to any of claims 8-12, wherein the constant-current driver chip (U1) operates in the discontinuous conduction mode, when the second switch tube (Q2) is switched on, an inductor current output from the driver module (20) increases, and when the second switch tube (Q2) is switched off, the inductor current output from the driver module (20) decreases, and when a turn-off time t_off=(V in-1)/(V_o+1)*t_on, the second switch tube (Q2) is switched on again; wherein, t_off is the turn-off time, t on is a turn-on time, V_in is an input voltage, and V_o is an output voltage.

14. A constant-current drive device, comprising the constant-current drive circuit according to any one of claims 1-13.

15. A lamp, comprising:

a light source module; and
the constant-current drive circuit according to any one of claims 1-13, the constant-current drive circuit being connected to the light source module.

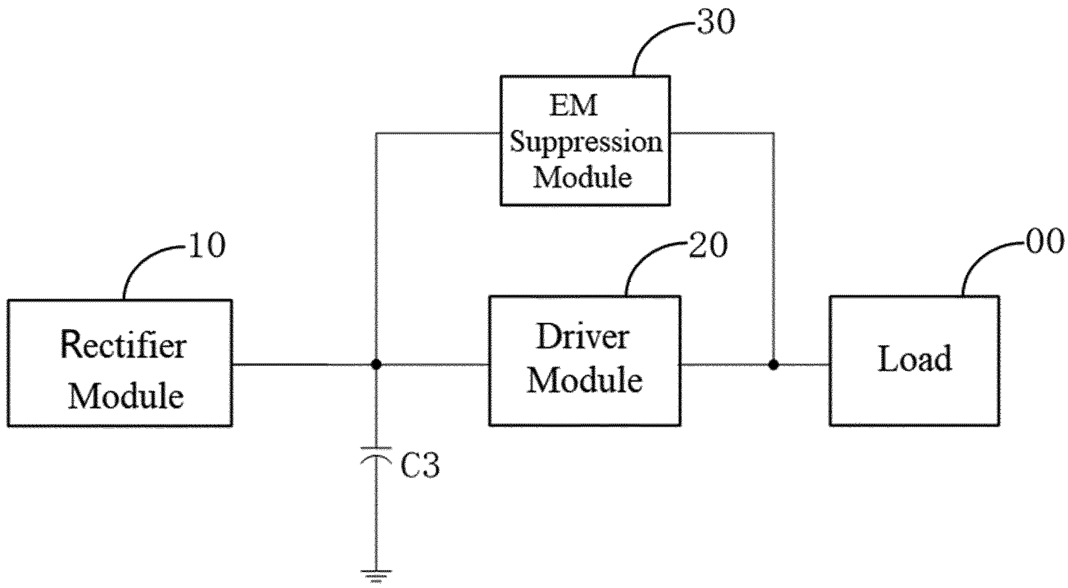
30
EM Suppression Module
10
Rectifier Module
20
Driver Module
00
Load
C3

FIG.1

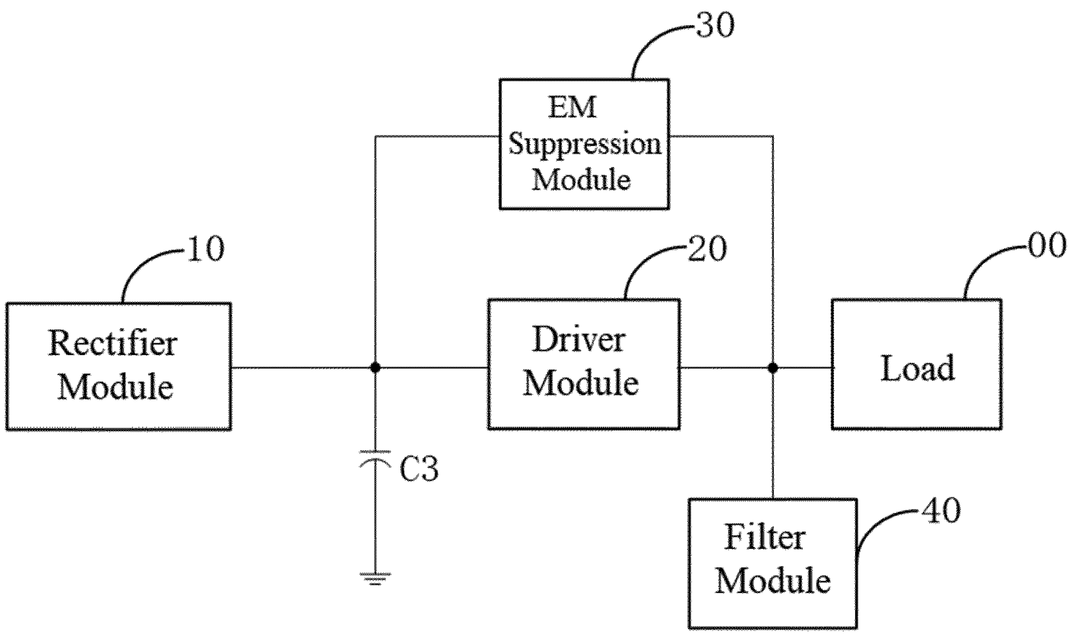
30
EM Suppression Module
10
Rectifier Module
20
Driver Module
00
Load
C3
Filter Module
40

FIG.2

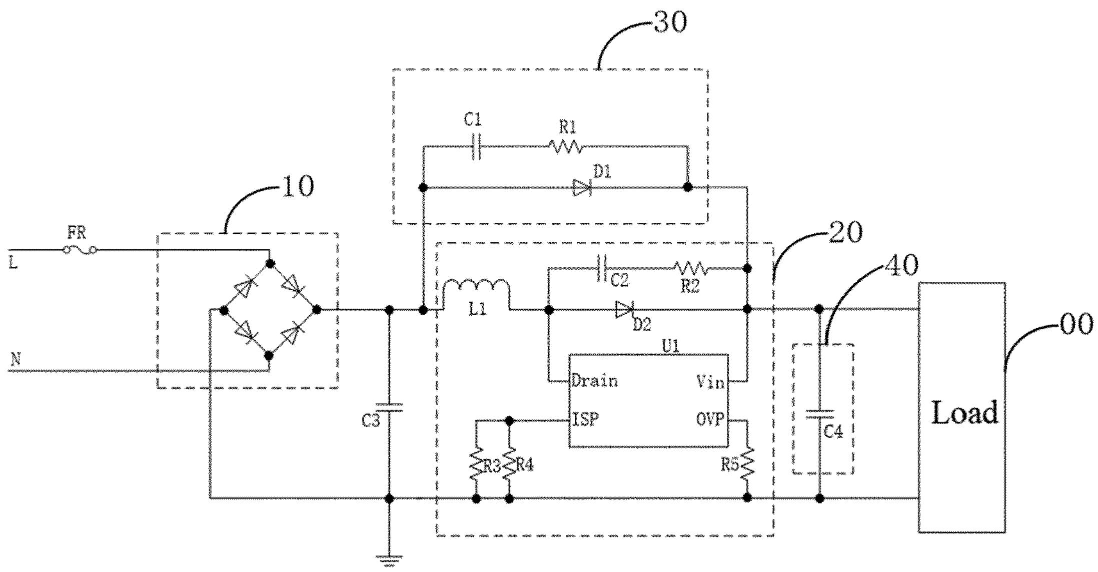
30
C1
R1
D1
10
20
40
00
FR
L
N
C2
R2
L1
D2
U1
Drain
Vin
ISP
OVP
C3
R3
R4
R5
C4
Load

FIG.3

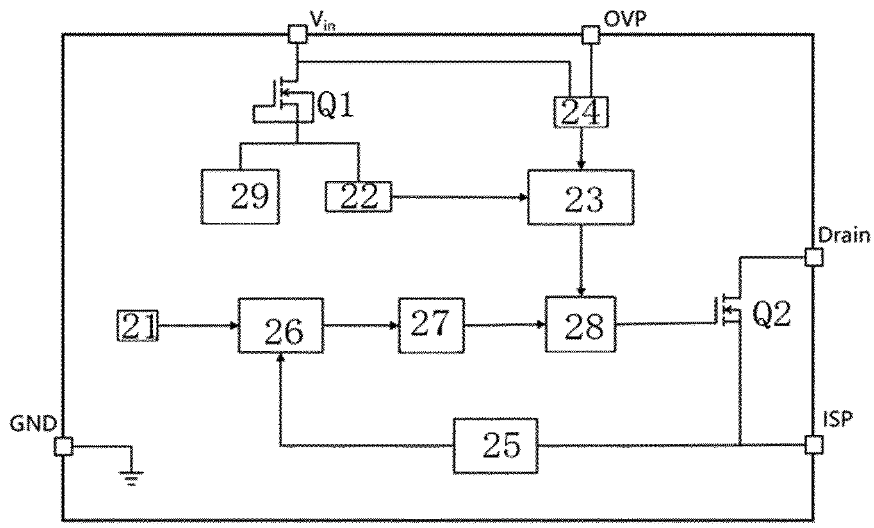
V_{in}
OVP
Q1
24
29
22
23
Drain
21
26
27
28
Q2
GND
25
ISP

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 21 21 5168

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2018/224074 A1 (XIONG AIMING [CN] ET AL) 9 August 2018 (2018-08-09) * paragraph [0149] - paragraph [0318]; figures 8A-16D * -----	1-6, 10-15 9	INV. H05B45/36 H05B45/345 H05B45/59
X A	CN 203 435 204 U (NANJING HANDSON CO LTD) 12 February 2014 (2014-02-12) * paragraph [0011] - paragraph [0022]; figures 1-2, 7 * -----	1-8,14, 15 9	
X A	CN 102 594 155 A (JIANGSU SENCHIP MICROELECTRONICS CO LTD) 18 July 2012 (2012-07-18) * paragraph [0012] - paragraph [0015]; figures 1-2 * -----	1-6,14, 15 9	
			TECHNICAL FIELDS SEARCHED (IPC)
			H05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 May 2022	Beaugrand, Francois

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24-05-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018224074 A1	09-08-2018	US 2018224074 A1	09-08-2018
		US 2019186699 A1	20-06-2019
CN 203435204 U	12-02-2014	NONE	
CN 102594155 A	18-07-2012	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82