



(11)

EP 3 678 456 A1

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:

(51) Int Cl.:

(21) Application number: 19205525.9

(22) Date of filing: **28.10.2019**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB  
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO  
PL PT RO RS SE SI SK SM TR**

Designated Extension States:  
**BA ME**

Designated Validation States:  
**KH MA MD TN**

(30) Priority: 02.01.2019 TW 108100017  
14.05.2019 TW 108116546

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(54) CARRY-SIGNAL CONTROLLED LED LIGHTS WITH LOW POWER CONSUMPTION CHARACTERISTIC AND LED LIGHT STRING HAVING THE SAME

(57) A carry-signal controlled LED light with low power consumption characteristic includes at least one LED and a drive unit. The drive unit is coupled to the at least one LED, and receives a carry light signal to control the at least one LED. The drive unit includes a light control unit (311). The light control unit (311) drives

the at least one LED according to a light command content of the carry light signal. When a voltage of the carry light signal is less than a low-level voltage ( $V_{low}$ ), the light control unit (311) enters a low power consumption mode.

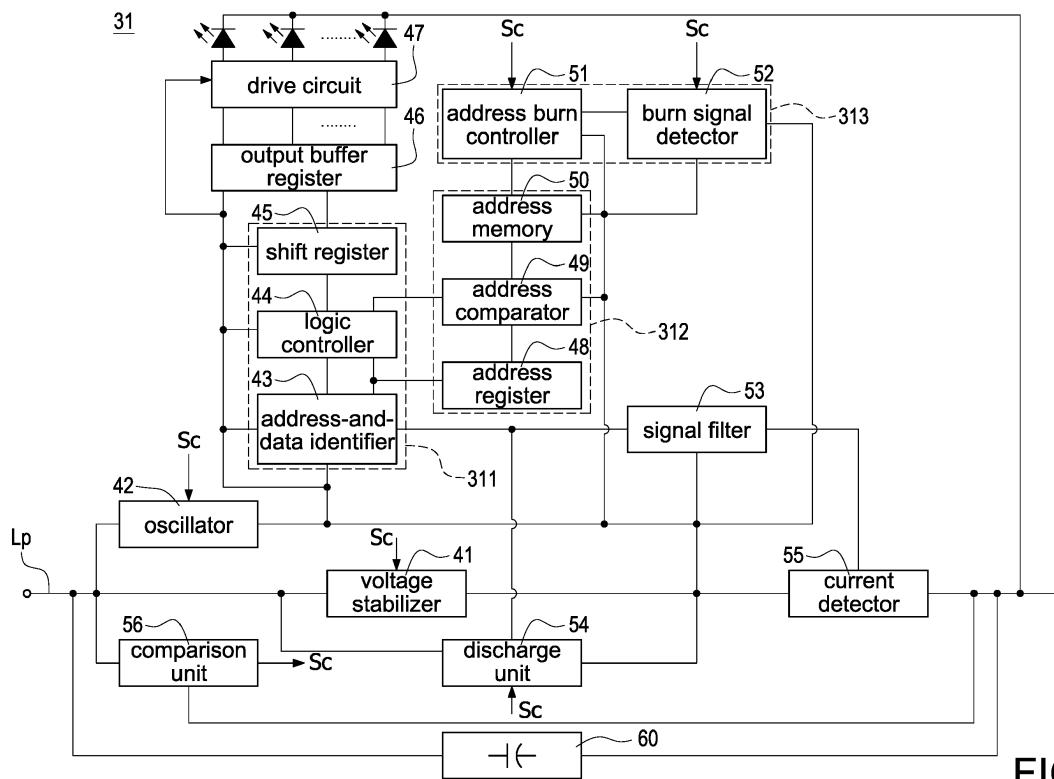


FIG.4A

## Description

### BACKGROUND

#### Technical Field

**[0001]** The present disclosure relates to an LED light and an LED light string, and more particularly to carrier signal controlled LED lights with low power consumption characteristic and an LED light string having the same.

#### Description of Related Art

**[0002]** The statements in this section merely provide background information related to the present disclosure and do not necessarily constitute prior art.

**[0003]** Since light-emitting diode (LED) has the advantages of high luminous efficiency, low power consumption, long life span, fast response, high reliability, etc., LEDs have been widely used in lighting fixtures or decorative lighting, such as Christmas tree lighting, lighting effects of sport shoes, etc. by connecting light bars or light strings in series, parallel, or series-parallel.

**[0004]** Take the festive light for example. Basically, a complete LED lamp includes an LED light string having a plurality of LEDs and a drive unit for driving the LEDs. The drive unit is electrically connected to the LED light string, and controls the LEDs by a point control manner or a synchronous manner by providing the required power and the control signal having light data to the LEDs, thereby implementing various lighting output effects and changes of the LED lamp.

**[0005]** With the progress of the technology, the carrier manner can be utilized for the control signal having the light data to transmit the light signal through the power line. The functions of providing power and data transmission can be achieved by the same circuit structure to simplify the layout design, reduce the volume of the circuit, and benefit the design of the control circuit.

**[0006]** The drive unit mainly provides a light control signal with a high voltage level and a low voltage level to drive the LED light string. For driving the LED light string, if the LED light string includes more of the numbers of the LED lights in series, since the connection lines connecting the LEDs are thicker and longer, the parasitic capacitance of the LED light string increases so that the speed of the system processing the signals is not fast enough. Thus, the possibility of determining the light signal incorrectly increases. If effectively avoiding the LED light string interpreting/decoding the light control signal incorrectly is required, the speed of the light control signal at the high voltage and low voltage transition has to slow. However, this results that the number of the lights driven by the LED light string is less and/or the speed of changing lights/colors slows.

**[0007]** Please refer to FIG. 1, which shows a schematic waveform of a light control signal of an LED light string in the related art. FIG. 1 shows two waveforms of light

control signals including a first waveform Cv1 and a second waveform Cv2. The abscissa indicates time t and the ordinate indicates input voltage Vin, and a low-level voltage Vlow and a reset voltage Vreset are labeled. The

5 low-level voltage Vlow means a voltage for identifying a low level of the light control signal, and the reset voltage Vreset means a voltage for resetting the LED. Take the second waveform Cv2 for example, the second waveform Cv2 is the natural discharge of the light control signal. Therefore, the existing problem of the second waveform Cv2 is that when the parasitic capacitance of the circuit is too large, the discharge time is longer, resulting that when entering the next cycle, the second waveform Cv2 still cannot reach the low-level voltage Vlow so that 10 the light control signal cannot be identified as the low level (namely, the light control signal is continuously determined as the high level voltage). At this condition, only increasing the width between two cycles (so the natural discharge is able to reach the low-level voltage Vlow) 15 achieves the identification of the low-level voltage Vlow. However, such control manner is only suitable for less numbers of the LEDs in series in the LED light string (better control effect can just be achieved). In other words, since the complete light control signal cannot be 20 achieved by rapidly discharging, such control manner cannot be suitable for more numbers of the lights (for example, over hundreds of the numbers of the lights) in series. That is, all of the numbers of the lights in series 25 able to receive the complete light control signal cannot be ensured.

**[0008]** Accordingly, a rapid discharge circuit can be utilized to control the light control signal to rapidly reduce the voltage level of the light control signal, or the LED light string having lesser circuit total parasitic capacitance 30 easily reduces the voltage level of the light control signal rapidly, such as the first waveform Cv1 shown in FIG. 1. However, when the light control signal rapidly reduces, the light control signal easily happens that: after the light control signal is lower than the identifiable low-level voltage Vlow (for example, at the time point t2), the light control signal still rapidly reduces so that the light control signal reaches the reset voltage Vreset (for example, at the time point t3) so that the circuit happens unnecessary 35 reset failure, resulting in the abnormal determination and malfunction of the LED module.

**[0009]** The related art utilizes a set of signal voltage generation circuit on the control circuit to clamp the voltage so that the voltage does not reduce to be the reset voltage Vreset. However, eventually the circuits of such 40 related art are complicated. Therefore, the inventor of the present disclosure would like to provide a simple circuit to solve the problem that how to design a carrier controlled LED light and the LED light string having the carrier controlled LED light for solving the voltage of the 45 light control signal reaching the reset voltage due to too small parasitic capacitance which results in the abnormal determination and malfunction problems of the LED module.

## SUMMARY

**[0010]** An object of the present disclosure is to provide a carry-signal controlled LED light with low power consumption characteristic to solve determination abnormality and malfunction of the LED module since the light drive signal reduces to reach to the reset voltage by using simple application circuits.

**[0011]** In order to achieve the above-mentioned object, a carry-signal controlled LED light with low power consumption characteristic includes at least one LED and a drive unit. The drive unit is coupled to the at least one LED, the drive unit receives a carry light signal to control the at least one LED. The drive unit includes a light control unit. The light control unit drives the at least one LED according to a light command content of the carry light signal. When a voltage of the carry light signal is less than a low-level voltage, the light control unit entering a low power consumption mode.

**[0012]** Accordingly, the carry-signal controlled LED light with low power consumption characteristic is provided to effectively reduce power consumption of the analogy circuits with relatively high power consumption and to make the LED module normally operate.

**[0013]** Another object of the present disclosure is to provide a carry-signal controlled LED light string to solve determination abnormality and malfunction of the LED module since the light drive signal reduces to reach to the reset voltage by using simple application circuits.

**[0014]** In order to achieve the above-mentioned object, the carry-signal controlled LED light string includes a power line, a controller, and at least one LED light. The controller is coupled to the power line. The at least one LED light is coupled to the controller through the power line, and receives a DC working power and the carry light signal transmitted from the controller through the power line.

**[0015]** Accordingly, the carry-signal controlled LED light string is provided to effectively reduce power consumption of the analogy circuits with relatively high power consumption and to make the LED module normally operate.

**[0016]** It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the present disclosure as claimed. Other advantages and features of the present disclosure will be apparent from the following description, drawings and claims.

## BRIEF DESCRIPTION OF DRAWING

**[0017]** The present disclosure can be more fully understood by reading the following detailed description of the embodiment, with reference made to the accompanying drawings as follows:

FIG. 1 is a schematic waveform of a light control

signal of an LED light string in the related art.

FIG. 2A is a block circuit diagram of a drive system of a carry-signal controlled LED light string according to a first embodiment of the present disclosure.

FIG. 2B is a block circuit diagram of the drive system of the carry-signal controlled LED light string according to a second embodiment of the present disclosure.

FIG. 3A is a detailed circuit diagram of a power conversion circuit and a control circuit according to a first embodiment in FIG. 2A.

FIG. 3B is a detailed circuit diagram of the power conversion circuit and the control circuit in FIG. 2B. FIG. 3C is a detailed circuit diagram of the power conversion circuit and the control circuit according to a second embodiment in FIG. 2A.

FIG. 4A is a block circuit diagram of an LED module according to a first embodiment of the present disclosure.

FIG. 4B is a block circuit diagram of the LED module according to a second embodiment of the present disclosure.

FIG. 5 is a circuit diagram of a comparison unit according to the present disclosure.

FIG. 6 is a schematic waveform of a light drive signal according to the present disclosure.

FIG. 7 is a schematic waveform of another light drive signal according to the present disclosure.

FIG. 8A is a block circuit diagram of the LED module according to a third embodiment of the present disclosure.

FIG. 8B is a block circuit diagram of the LED module according to a fourth embodiment of the present disclosure.

FIG. 9 is a schematic circuit diagram of an oscillator according to the present disclosure.

FIG. 10 is a schematic waveform of operating a latch unit according to the present disclosure.

## DETAILED DESCRIPTION

**[0018]** Reference will now be made to the drawing figures to describe the present disclosure in detail. It will be understood that the drawing figures and exemplified embodiments of present disclosure are not limited to the details thereof.

**[0019]** Please refer to FIG. 2A, which shows a block circuit diagram of a drive system of a carry-signal controlled LED light string according to a first embodiment of the present disclosure. The drive system of the first embodiment includes a power conversion circuit 10, a control circuit 20, and an LED (light-emitting diode) light string 30. The power conversion circuit 10 and the control circuit 20 may be integrated into a controller 100. Specifically, the controller 100 may be implemented by a physical circuit control box including the power conversion circuit 10 and the control circuit 20. The power conversion circuit 10 receives an AC power Vac and converts

the AC power Vac into a DC power Vdc. The DC power Vdc is across an output capacitor (not labeled) connected at output terminals of the power conversion circuit 10.

**[0020]** The control circuit 20 receives the DC power Vdc to supply the required DC power for the control circuit 20 and the LED light string 30. The controller 100 is coupled to the AC power Vac and the LED light string 30 through a power line Lp. Broadly speaking, the power line Lp is not limited by the labeled indication in FIG. 2A. As long as the power line can be used as a line for transmitting AC power Vac or the DC power Vdc, it should belong to the power line Lp. For example, an electrical connection between the AC power Vac and the power conversion circuit 10, an electrical connection between the control circuit 20 and an anode terminal of the LED light string 30, or an electrical connection between the control circuit 20 and a cathode terminal of the LED light string 30. In one embodiment, the LED light string 30 includes a plurality of LED modules 31,32,...,3n (also refer to the LED light). The LED modules 31,32,...,3n are connected in series and electrically connected to the control circuit 20. In one embodiment, the LED light string 30 is a light string having data burning function, and therefore each of the LED modules 31,32,...,3n has own digital and analog circuits for burning light data and address data, the detailed description will be made as follows.

**[0021]** The control circuit 20 can receive external light control data Sec through a wired manner or a wireless manner as well as read internal light data stored inside the control circuit 20 so that the control circuit 20 can control each of the LED modules 31,32,...,3n of the LED light string 30 according to the content of the light control data Sec. For example, the user may operate a computer through the wired manner to transmit the light control data Sec to the control circuit 20 so that the control circuit 20 controls the LED modules 31,32,...,3n according to the light control data Sec. Alternatively, the user may operate a mobile phone or a wearable device through the wireless manner to transmit the light control data Sec to the control circuit 20 so that the control circuit 20 controls the LED modules 31,32,...,3n according to the light control data Sec. However, the present disclosure is not limited by the above-mentioned manners of transmitting the light control data Sec and the devices operated by the user.

**[0022]** Please refer to FIG. 2B, which shows a block circuit diagram of the drive system of the carry-signal controlled LED light string according to a second embodiment of the present disclosure. The major difference between the second embodiment and the first embodiment shown in FIG. 2A is that the LED modules 31,32,...,3n of the LED light string 30 are electrically connected in parallel and electrically connected to the control circuit 20 in the former (i.e., the second embodiment). Therefore, the control circuit 20 and the LED modules 31,32,...,3n are directly supplied power by a DC power Vdc for example but not limited to a battery unit. In comparison with the first embodiment shown in FIG. 2A, the absence of the

power conversion circuit 10 is to omit converting the AC power Vac into the DC power Vdc. Similarly, the LED light string 30 is a light string having data burning function, and therefore each of the LED modules 31,32,...,3n has own digital and analog circuits for burning light data and address data, the detailed description will be made as follows.

**[0023]** Please refer to FIG. 3A and FIG. 3B, which show detailed circuit diagrams of a power conversion circuit and a control circuit in FIG. 2A and FIG. 2B, respectively. The power conversion circuit 10 includes a fuse FUSE, a varistor VAR, an input resistor R10, an input capacitor C11 connected to the input resistor R10 in parallel, and a full-bridge rectifier composed of a plurality of diodes D11-D14. The fuse FUSE provides an over-current protection for the power conversion circuit 10, and the varistor VAR provides an over-voltage protection for the power conversion circuit 10. The input resistor R10 and the input capacitor C11 are coupled between the fuse FUSE, the varistor VAR, and the full-bridge rectifier, and excess energy can be absorbed by the input capacitor C11 so as to adjust a total voltage for supplying the LED light string 30. The AC power Vac is rectified into the DC power Vdc by the full-bridge rectifier, and the DC power Vdc is across an output capacitor C2 connected at output terminals of the power conversion circuit 10.

**[0024]** The control circuit 20 includes a control unit CONR, an output control switch Qsw, and a work voltage generation circuit. The control unit CONR is coupled to the output control switch Qsw and the work voltage generation circuit. The output control switch Qsw receives the DC power Vdc and the output control switch Qsw is turned on or turned off by the control unit CONR to connect or disconnect the DC power Vdc to the LED light string 30. In one embodiment, the output control switch Qsw is coupled to an anode terminal of the LED light string 30, and the output control switch Qsw is a p-channel MOSFET and coupled to the control unit CONR through a resistor R23. In another embodiment, the output control switch Qsw may be coupled to a cathode terminal of the LED light string 30, and the output control switch Qsw is an n-channel MOSFET and coupled to the control unit CONR through the resistor R23, and therefore the equivalent characteristics of the circuit can be achieved.

**[0025]** In one embodiment, the work voltage generation circuit includes a resistor R22, a capacitor C21, and a Zener diode Dz. The capacitor C21 is connected in parallel to the Zener diode Dz, and then connected to the resistor R22. The Zener diode Dz receives the DC power Vdc through the resistor R22, and clamps the DC power Vdc in a fixed voltage value for providing the required work voltage to the control unit CONR. The present disclosure is not limited by the architecture of the work voltage generation circuit shown in FIG. 3A, that is, as long as the circuit architecture capable of achieving the function of generating the working voltage should be included in the scope of the present disclosure.

**[0026]** Please refer to FIG. 3C, which shows a detailed circuit diagram of the power conversion circuit and the control circuit according to a second embodiment in FIG. 2A. In comparison with FIG. 3A, the control circuit 20 further includes a voltage adjust unit 24. The voltage adjust unit 24 can be a quick discharge circuit for quickly discharging the DC working power to supply the LED light string 30. Alternatively, the voltage adjust unit 24 is a voltage adjust capacitor for slowly discharging the DC working power to supply the LED light string 30.

**[0027]** If the voltage adjust unit 24 is the voltage adjust capacitor, the voltage adjust unit 24 is coupled in parallel to the LED light string 30 for slowly discharging the DC working power to supply the LED light string 30 according to the capacitance value of the voltage adjust capacitor.

**[0028]** If the voltage adjust unit 24 is the quick discharging circuit, the voltage adjust unit 24 is coupled to the output control switch Qsw, the LED light string 30, and the control unit CONR, and the voltage adjust unit 24 is controlled by the control unit CONR. When the control unit CONR turns off the output control switch Qsw, the control unit CONR controls an output voltage, i.e., a voltage outputted from the LED light string 30 by a discharging manner, or controls the quick discharging circuit (i.e., the voltage adjust unit 24), or controls a quick discharging circuit (not shown) inside each of the LED modules 31, 32, ..., 3n so as to quickly reduce a voltage of the DC working power outputted to the LED light string 30. The control unit CONR turns on the output control switch Qsw according to the predetermined time to restore (increase) the output voltage outputted to the LED light string 30, and produces a light drive signal according to the received light control data Sec so that the LED light string 30 operates in an illumination mode according to the light drive signal.

**[0029]** On the contrary, if no light drive signal is transmitted to the LED light string 30, the control unit CONR turns on the output control switch Qsw so that the DC power Vdc (i.e., the DC working electricity) supplies power to the LED light string 30 through the output control switch Qsw. Accordingly, as long as the output control switch Qsw is turned off or turned on, the light drive signal and the supplying power can be both transmitted to the LED light string 30 under the same circuit architecture.

**[0030]** Please refer to FIG. 4A, which shows a block circuit diagram of an LED module according to a first embodiment of the present disclosure. As mentioned above, since the LED light string 30 is a light string which has burn functions, each of the LED modules 31, 32, ..., 3n respectively comprises digital and analog circuits which burn and process the light data and the address data, for example, a light control unit 311 which is in charge of light control, an address signal process unit 312 which is in charge of address signal processing, and an address burn unit 313 which is in charge of burning the address. Taking the LED module 31 with the burn function shown in Fig. 4A as an example, the LED module 31 (namely, the LED light) comprises a voltage stabilizer

41 (namely, voltage regulator), an oscillator 42, an address and data identifier 43 (namely, address and data recognizer), a logic controller 44, a shift register 45, an output buffer register 46, a drive circuit 47, an address register 48, an address comparator 49, an address memory 50, an address burn controller 51, a burn signal detector 52, a signal filter 53, a discharge unit 54, a current detector 55, and a comparison unit 56.

**[0031]** The discharge unit 54 implements a function of discharging by turning on and turning off the power switch. The current detector 55 may be a voltage-dividing network for dividing the received voltage to detect the corresponding current value. By the way, the light control unit 311 includes the above-mentioned address and data identifier 43, logic controller 44, and shift register 45. The light control unit 311 drives the LEDs according to a light command content of the carry light signal. In particular, the light command content is specific identified encoded content corresponding to luminous behaviors of the LEDs, such as color change, light on/off manner, light on/off frequency, etc. The address signal process unit 312 includes the above-mentioned address register 48, address comparator 49, and address memory 50. The address burn unit 313 includes the above-mentioned address burn controller 51 and burn signal detector 52.

**[0032]** By the way, since the LED module 31 shown in FIG. 4A is applied to the in-series connection shown in FIG. 2A and FIG. 3A, the voltage stabilizer 41 is necessary for voltage regulation and voltage stabilization. Since the LED module 31 shown in FIG. 4A operates by a point control manner, the LED module 31 includes the address signal process unit 312 and the address burn unit 313 for processing (including determining, memorizing, burning, etc.,) address data. That is, the address register 48, the address comparator 49, the address memory 50, the address burn controller 51, the burn signal detector 52 are involved. In other words, if the LED module 31 operates by a synchronous control, the address signal process unit 312 and the address burn unit 313 can be omitted, that is, only the light control unit 311 with processing light data is necessary.

**[0033]** In the above circuit, the difference in signal characteristics can be divided into analog circuits and digital circuits. The voltage stabilizer 41, the oscillator 42, the address burn controller 51, the burn signal detector 52, and the discharge unit 54 belong to the analog circuits, and others belong to the digital circuits. In different embodiments, however, the address burn controller 51 and the burn signal detector 52 may be implemented by both the analog circuit and the digital circuit. In comparison with the low power consumption of the digital circuits, the analog circuits, including the voltage stabilizer 41, the oscillator 42, the light control unit 311, the address signal process unit 312, the address burn unit 313, and the discharge unit 54 are the circuit components with relatively high power consumption of the LED module 31. Therefore, the features of the present disclosure focus on both effectively reducing the power consumption of the analog

circuits in the eco mode and the sleep mode and normally operating the LED module 31, as explained below.

**[0034]** The voltage stabilizer 41 receives an input voltage and regulates and controls the received input voltage to provide a stable output voltage. The oscillator 42 produces a periodic clock signal as a time reference for the light control unit 311, the address signal process unit 312, and the address burn unit 313 normally and orderly operating. When the oscillator 42 enters the sleep mode to stop oscillating, the light control unit 311, the address signal process unit 312, and the address burn unit 313 are controlled to enter the sleep mode.

**[0035]** The address and data identifier 43 is coupled to the oscillator 42. The logic controller 44 is coupled to the address and data identifier 43. The shift register 45 is coupled to the logic controller 44. The output buffer register 46 is coupled to the shift register 45 and the drive circuit 47. The drive circuit 47 is coupled to a plurality of LEDs.

**[0036]** The address register 48 is coupled to the logic controller 44. The address comparator 49 is coupled to the logic controller 44 and the address register 48. The address memory 50 is coupled to the address comparator 49. The address burn controller 51 is coupled to the address memory 50. The burn signal detector 52 is coupled to the address memory 50 and the address burn controller 51. The signal filter 53 is coupled to the address and data identifier 43, the voltage stabilizer 41, and the oscillator 42.

**[0037]** The light drive signal  $V_d$  produced from the control circuit 20 is transmitted to the LED module 31, and then is filtered by the signal filter 53, and then is provided to the address and data identifier 43 for identifying. The address and data identifier 43 identifies out the address data and the light data of the light drive signal  $V_d$ , and then the address and data identifier 43 transmits the address data and the light data to the logic controller 44. The logic controller 44 transmits the address data to the address register 48. However, it is not limited to the present disclosure. The address data identified from the address and data identifier 43 may be transmitted to the address register 48 by the address and data identifier 43.

**[0038]** The address comparator 49 receives the address data of the address register 48, and also receives the local address data stored in the address memory 50. Afterward, the address data are compared with the local address data. If the address data are identical with the local address data, it means that the light data received by the logic controller 44 are the light control data of the LED module 31. At this condition, the address comparator 49 notifies the logic controller 44 to transmit the light data to the drive circuit 47 through the shift register 45 and the output buffer register 46 for driving the LEDs. On the contrary, if the address data are not identical with the local address data, it means that the light data received by the logic controller 44 are not the light control data of the LED module 31, but the light control data of any one of the LED modules 32,...,3n.

**[0039]** When the burn signal detector 52 detects a burn start signal, the burn signal detector 52 notifies the address burn controller 51. At this condition, the address burn controller 51 starts to receive burn address data and then burns the burn address data into the address memory 50 so that the local address data are stored in the address memory 50.

**[0040]** FIG. 4B shows a circuit block diagram of the second embodiment of the LED module of the present disclosure. Continuing from the contents mentioned above, since the LED module shown in FIG. 4B is applied to the parallel connection pattern shown in FIG. 2B and FIG. 3B, the main difference between the second embodiment of FIG. 4B and the first embodiment of FIG. 4A is that no extra voltage stabilizer 41 is required to be used for voltage regulating/adjusting and voltage stabilizing for the former (namely, the second embodiment of FIG. 4B). The other circuit operating principles and actions are the same with the contents recorded/mentioned for FIG. 4A, and are omitted here for brevity.

**[0041]** Continuing from the contents mentioned above, in order to achieve effectively reducing the power consumption of the analog circuits, and in order to maintain the normal operation of the LED module 31 at the same time, the LED module 31 further comprises a comparison unit, for example, a comparison unit 56 which is used to compare voltages. Taking the light drive signal to be the voltage signal as an example, the comparison unit 56 receives the light drive signal  $V_d$  and a reference voltage value  $V_{th}$  which is predetermined, as shown in FIG. 5. FIG. 5 shows a circuit diagram of the comparison unit of the present disclosure. In this embodiment, an operation amplifier circuit used as a comparator can achieve the comparison unit 56, wherein the light drive signal  $V_d$  received by the comparison unit 56 inputs to (namely, is received by) a non-inverting input end of the comparator, and the reference voltage value  $V_{th}$  inputs to (namely, is received by) an inverting input end of the comparator. By comparing the light drive signal  $V_d$  with the reference voltage value  $V_{th}$ , when the light drive signal  $V_d$  is greater than the reference voltage value  $V_{th}$ , the comparison unit 56 outputs a high-level control signal  $S_c$ . Conversely, when the light drive signal  $V_d$  is less than the reference voltage value  $V_{th}$ , the comparison unit 56 outputs a low-level control signal  $S_c$ . However, the present disclosure is not limited by it. The light drive signal  $V_d$  and the reference voltage value  $V_{th}$  can input to (namely, be received by) the inverting input end and the non-inverting input end of the comparator respectively; after comparing, the control signal  $S_c$  with reverse level mentioned above can be obtained; the determination for the light drive signal  $V_d$  can be achieved as well. Besides, for the determination of the light drive signal  $V_d$ , the present disclosure is not limited by using the operation amplifier circuit to achieve the determination of the light drive signal  $V_d$ ; any circuit which is able to be used to compare voltages should be included in the scope of the present disclosure.

**[0042]** FIG. 6 shows a waveform diagram of the light drive signal of the present disclosure. Continuing from the contents mentioned above, when the control unit CONR controls the output control switch Qsw to be turned off, the LED light string 30 reduces the voltage by the discharge method, to supply the low-level voltage of the light drive signal Vd for driving each of the LED modules 31, 32... 3n of the LED light string 30. Or, the rapid discharge circuit inside each of the LED modules 31, 32... 3n is controlled to rapidly reduce the voltage generated by the light signal voltage generation circuit, to supply the low-level voltage of the light drive signal Vd for driving each of the LED modules 31, 32... 3n of the LED light string 30. Moreover, by the comparison unit 56 comparing the light drive signal Vd with the reference voltage value Vth, the light drive signal Vd rapidly reducing to touch the reset voltage Vreset due to rapid discharge operation can be solved, wherein the light drive signal Vd rapidly reducing to touch the reset voltage Vreset results that the circuit happens unnecessary reset malfunction, resulting in abnormal determination and malfunction of the LED module 31.

**[0043]** Concretely, as a fourth waveform Cv4 shows, at a time t1, the control unit CONR controls the output control switch Qsw to be turned off; at this time, the light drive signal Vd reduces rapidly. At a time t2, when the light drive signal Vd reaches the reference voltage value Vth, because the light drive signal Vd is less than (could be also less than or equal to) the reference voltage value Vth, after the comparison unit 56 shown in FIG. 5 compares the two voltages (namely, compares the light drive signal Vd with the reference voltage value Vth), the comparison unit 56 outputs the low level control signal Sc. At this time, in order to prevent the light drive signal Vd from further reducing rapidly due to the rapid discharge, the control signal Sc generated by the comparison unit 56 controls the power consumption higher circuits of the LED module 31, for example but not limited to, the analog circuits, such as the voltage stabilizer 41, the oscillator 42, the light control unit 311, the address signal processing unit 312, the address burn unit 313, and the discharge unit 54 shown in FIG. 4A, to enter the sleep mode (or can be named as the eco mode) to reduce the power consumption of the LED module 31 significantly/greatly, so that the reducing speed of the light drive signal Vd decreases significantly/greatly (namely, the reducing speed of the light drive signal Vd becomes much mitigating, and the light drive signal Vd becomes much more even). Incidentally, in order to simplify the contents of FIG. 4A and FIG. 4B, the control signals Sc inputting to the voltage stabilizer 41, the oscillator 42, the address burn controller 51, the burn signal detector 52, and the discharge unit 54 are actually from the comparison unit 56 coupled to the voltage stabilizer 41, the oscillator 42, the address burn controller 51, the burn signal detector 52, and the discharge unit 54 respectively. The comparison unit 56 supplies/outputs the control signals Sc to the circuit units.

**[0044]** After the time t2 shown in FIG. 6, when the light drive signal Vd is less than the reference voltage value Vth, because the analog circuits mentioned above enter the sleep mode, the fading/falling speed of the light drive signal Vd is slow down to avoid touching the reset voltage Vreset. Incidentally, rapid discharge detection, reducing power consumption effectively, and correctly determining (identifying/recognizing) the low level voltage of the light drive signal Vd can be achieved by designing that the low level voltage for identifying/recognizing the light drive signal Vd is the reference voltage value Vth, or is slightly less than the reference voltage value Vth (but is greater than the voltage value of the reset voltage Vreset), so that the LED module 31 can be driven normally and can operate normally. For example, the reset voltage Vreset can be designed as 0.7 volts, the reference voltage value Vth can be designed as 1.1 volts, and the low-level voltage of the light drive signal Vd can be designed as 1.1 volts (or smaller/lower 0.8~1.0 volts). Cooperating with the requirement of the response or the action of the whole circuit, the present disclosure can properly design and adjust the reset voltage Vreset, the reference voltage value Vth and the low-level voltage of the light drive signal Vd.

**[0045]** Until a time t3, the control unit CONR turns on the output control switch Qsw to recover (increase) the output voltage outputted to the LED light string 30, and generates the light drive signal based on the light control data Sec received by the control unit CONR, so that the LED light string 30 proceeds the operation of the light mode based on the light drive signal. Therefore, because the light drive signal Vd is greater than the reference voltage value Vth, the control signals Sc generated by the comparison unit 56 are switched/converted/changed from the low level to the high level, so that the control signals Sc control the voltage stabilizer 41, the oscillator 42, the light control unit 311, the address signal processing unit 312, the address burn unit 313 and the discharge unit 54 to leave from the sleep mode, to recover the normal operations of the circuit units. Similarly, the other LED modules 32... 3n are supplied controls (namely, are controlled) by the subsequent cycles of the light drive signal Vd. Similar operations are not repeated here for brevity. Therefore, the drives and the light controls of all of the LED modules 31, 32... 3n of the LED light string 30 are accomplished.

**[0046]** Besides the embodiments and the methods mentioned above, referring to FIG. 3A or FIG. 3B again, the LED light string 30 can be coupled to the voltage adjustment capacitor (the voltage adjustment unit 24) in parallel as well. Namely, an external capacitor is coupled between the anode side and the cathode side of the LED light string 30, to increase the equivalent total capacitance of the circuit of the LED light string 30, so that the reducing speed of the light drive signal Vd becomes slow, to avoid touching the reset voltage Vreset, happening unnecessary reset malfunction for the circuit, and resulting in abnormal determination and malfunction of the LED

module 31. Incidentally, for the control of the LED module 31, the normal control is a third waveform Cv3 shown in FIG. 6. Namely, the present disclosure can operate continuously in the condition that: the light control signal can be normally recognized/identified as the low level but does not touch the reset voltage Vreset, even does not touch the reference voltage value Vth, to maintain the light control unit 311, the address signal processing unit 312 and the address burn unit 313 do not enter the sleep mode, to achieve the best control efficiency. In other words, by the designs of the circuit parameters and the clocks, the width between two cycles are adjusted, for examples, shortening the width and/or cooperating with a rapid discharge circuit. Such control method can be applied to both: more numbers of lights in series and fast identification/recognition for the light control signal which is the low-level voltage; the best control efficiency without entering the sleep mode can be maintained as well.

**[0047]** Please refer to FIG. 7, which shows a schematic waveform of a light drive signal according to the present disclosure. As mentioned above, when the control unit CONR turns off the output control switch Qsw, the voltage outputted from the LED light string 30 is reduced by the discharging manner so as to provide a low-level voltage of a light drive signal Vd for each of the LED modules 31,32,...,3n of the LED light string 30. Alternatively, the quick discharging circuit (not shown) inside each of the LED modules 31,32,...,3n is controlled to quickly reduce the voltage generated from a light signal voltage generation circuit to provide the low-level voltage of the light drive signal Vd for each of the LED modules 31,32,...,3n of the LED light string 30. In particular, three modes are provided to control the LED modules 31,32,...,3n in the present disclosure. The first mode is a work mode, the second mode is an eco mode, and the third mode is a sleep mode. Therefore, the LED modules 31,32,...,3n can normally operate and meet the requirement of low power consumption.

**[0048]** The work mode means that internal circuits, including analog circuits and digital circuits in each of the LED modules 31,32,...,3n can normally operate. In order to achieve the purpose of low power consumption, the eco mode first operates, and then the sleep mode operates. The purpose of the eco mode is to first turn off (disable) the analog circuits with higher power consumption. The cooperation consideration between the oscillator and the digital circuits is necessary, however, the analog circuits except the oscillator or the analog circuits involving the oscillator are first turned off (disabled) in the eco mode to significantly reduce more power consumption and maintain the normal operation of the digital circuits, and therefore signal detection and signal recognition can normally work. In the eco mode, the oscillator is controlled to be in an oscillation operation at low power without turning off. After the signal detection and signal recognition is completed, the oscillator is turned off to enter the sleep mode. Accordingly, it is to avoid unnecessary reset failure of the circuits to cause determination abnormality and

malfunction of the LED module 31 since the light drive signal Vd quickly reduces to reach to the reset voltage Vreset during the quick discharging operation.

**[0049]** Specifically, as shown in FIG. 7, and also refer to FIG. 3A. Before the time point t11, the output control switch Qsw is controlled to be turned on by the control unit CONR, and therefore each of the LED modules 31,32,...,3n is in the work mode. At the time point t11, the output control switch Qsw is controlled to be turned off by the control unit CONR. At this condition, the light drive signal Vd quickly reduces. At the time point t12, the light drive signal Vd reaches to the low-level voltage Vlow so as to identify that the light drive signal Vd is a proper drive signal for driving the LED modules 31,32,...,3n (the following description is based on the LED module 31). However, in order to avoid unnecessary reset failure of the circuits to cause determination abnormality and malfunction of the LED module 31 since the light drive signal Vd gradually reduces to reach to the reset voltage Vreset, it is to enter the eco mode at the time point t12. The analog circuits except the oscillator or the analog circuits involving the oscillator are first turned off (disabled) to significantly reduce more power consumption. Moreover, in order to maintain the normal operation of the digital circuits and the oscillator, the signal detection and signal recognition must be completed within a time interval T, and then it is to enter the sleep mode at the time point t13, thereby significantly reducing power consumption of the LED module 31. The time interval T means a time interval between the time point t12 and the time point t13, for example but not limited to, a time length of several (3 or 4) clock cycles. Therefore, after the time point t13, the oscillator is completely turned off so that the power consumption of the LED module 31 is minimized. Accordingly, it is not only to optimize the low power consumption but also to avoid causing abnormal conditions since the light drive signal Vd reduces to reach to the reset voltage Vreset. At the time point t14, the output control switch Qsw is controlled to be turned on by the control unit CONR, and therefore the voltage level of the light drive signal Vd is restored. At this condition, since the voltage level of the light drive signal Vd is greater than the low-level voltage Vlow, it is to leave the sleep mode and enter the work mode again in the next cycle.

**[0050]** FIG. 7 further shows the light drive signal Vd with a narrow-width cycle, for example but not limited to 1 microsecond. In comparison with the narrow-width cycle, a wide-width cycle between the time point t11 and the time point t14 is about 3 microseconds. The difference between the narrow-width cycle and the wide-width cycle is that the voltage level of the light drive signal Vd is restored before the time interval T has ended (i.e., before entering the sleep mode) in the former. At this condition, since the output control switch Qsw is controlled to be turned on by the control unit CONR, the voltage level of the light drive signal Vd is restored to enter the work mode again, thereby avoiding causing abnormal conditions since the light drive signal Vd reduces to reach to the

reset voltage Vreset.

**[0051]** Please refer to FIG. 8A, which shows a block circuit diagram of the LED module according to a third embodiment of the present disclosure. As mentioned above, since the LED light string 30 is a light string having data burning function, each of the LED modules 31,32,...,3n has own digital and analog circuits for burning light data and address data. For example, a light control unit 311 is responsible for controlling illumination, an address signal process unit 312 is responsible for processing address signal, and an address burn unit 313 is responsible for burning address. Take the LED module 31 shown in FIG. 8A for example, and the remaining LED modules 32,...,3n have the same circuit topologies and will not be described again. The LED module 31, i.e., the LED light includes a voltage stabilizer 41, an oscillator 42, an address and data identifier 43, a logic controller 44, a shift register 45, an output buffer register 46, a drive circuit 47, an address register 48, an address comparator 49, an address memory 50, an address burn controller 51, a burn signal detector 52, a signal filter 53, a discharge unit 54, a current detector 55, and a latch unit 57.

**[0052]** Since the above-mentioned units and circuits have been described in detail in FIG. 4A and FIG. 4B, the repeated description will not be disclosed, and only the differences will be described.

**[0053]** In the above circuit, the difference in signal characteristics can be divided into analog circuits and digital circuits. The voltage stabilizer 41, the oscillator 42, the address burn controller 51, the burn signal detector 52, and the discharge unit 54 belong to the analog circuits, and others belong to the digital circuits. In different embodiments, however, the address burn controller 51 and the burn signal detector 52 may be implemented by both the analog circuit and the digital circuit. In comparison with the low power consumption of the digital circuits, the analog circuits, including the voltage stabilizer 41, the oscillator 42, the light control unit 311, the address signal process unit 312, the address burn unit 313, and the discharge unit 54 are the circuit components with relatively high power consumption of the LED module 31. Therefore, the features of the present disclosure focus on both effectively reducing the power consumption of the analog circuits in the eco mode and the sleep mode and normally operating the LED module 31, as explained below.

**[0054]** Please refer to FIG. 8B, which shows a block circuit diagram of the LED module according to a fourth embodiment of the present disclosure. In comparison with the third embodiment shown in FIG. 8A, the LED module 31 further includes a latch unit 57, the remaining circuits are the same in FIG. 5. The latch unit 57 is coupled between an input side and an output side inside the LED module 31. The latch unit 57 is used to replace the oscillator 42 in the sleep mode so that the LED module 31 can continuously perform the signal detection and signal recognition. In one embodiment, the latch unit 57 may be an analog charging and discharging circuit composed of a resistor and a capacitor.

**[0055]** Hereinafter, a description will be given of how the present disclosure achieves reducing power consumption and saving energy. Please refer to FIG. 7, when the light drive signal Vd reaches to the low-level voltage Vlow (at the time point t12 or time point t22 shown in FIG. 7), the current detector 55 produces the control signal Sc. At this condition, the analog circuit with relatively high power consumption of the LED module 31 such as the voltage stabilizer 41, the oscillator 42, the address burn controller 51, the burn signal detector 52, and the discharge unit 54 are controlled by the control signal Sc to enter the eco mode, thereby reducing the main source of power consumption. The eco mode can be regarded as a first stage control mode to reduce power consumption. However, since the operation of the digital circuits is closely related to the oscillator 42 and in order to ensure that the digital circuit can perform its necessary operation, the oscillator 42 is then controlled to enter to the sleep, which can be regarded as a second stage control mode to reduce power consumption. Specifically, two embodiments are proposed to reduce the power consumption of the oscillator 42 in the eco mode. The first one is that the oscillator 42 is controlled to be in an oscillation operation at low power without turning off, and the second one is that the oscillator 42 is replaced by the charging and discharging circuit.

**[0056]** Please refer to FIG. 9, which shows a schematic circuit diagram of an oscillator according to the present disclosure, and also refer to FIG. 8A. In terms of control accuracy, the best manner is to use the oscillator 42 to produce the periodic clock signal as the time reference. However, in order to have requirements of accurate control and low-power consumption, the specific design of the oscillator 42 is provided to implement the low-power oscillation in a first embodiment. The oscillator 42 shown in FIG. 9 includes a plurality of inverters In11-In22, a resistor Ro, and a capacitor Co. However, the connection thereof is for illustrative purposes only, and is not intended to limit the present disclosure. The inverters In11-In22 are CMOS transistor circuit inverters. The design of different transistor sizes and the control of enabling and disabling are implemented to achieve the accurate control and low power consumption. For example, but not limited to that the size of the inverter In12 and the size of the inverter In22 are smaller than that of the inverter In11 and that of the inverter In21, respectively. Further, the inverter In11 and the inverter In21 are controlled by the control signal Sc.

**[0057]** When the oscillator 42 normally operates, i.e., the LED module 31 is in the work mode (before the time point t12 shown in FIG. 7), the inverters In11-In22 are enabled. At this condition, the oscillator 42 operates at a full-power condition to provide a clock signal. When the light drive signal Vd reaches to the low-level voltage Vlow (at the time point t12 shown in FIG. 7), the control signal Sc produced from the current detector 55 controls the inverter In11 and the inverter In21 to be disabled, at this condition, the inverter In12 and the inverter In22 are still

enabled. Alternatively, the inverter In12 and inverter In22 may be controlled by the control signal Sc to be disabled, but the inverter In11 and the inverter In21 are still enabled. Accordingly, the oscillator 42 can be controlled by the control signal Sc to be in an oscillation operation at low power, thereby ensuring that the digital circuit can perform its necessary operation and implementing the lower power consumption of the oscillator 42. Until the LED module 31 completes the signal detection and signal recognition within the time interval T between the time point t12 and the time point t13 shown in FIG. 7, the oscillator 42 is turned off to enter to the sleep mode after the time point t13. However, the connection relationship, the number, the size, and the signal control manner of the inverters In11-In22 are for illustrative purposes only and are not intended to limit the present disclosure.

**[0058]** Please refer to FIG. 10, which shows a schematic waveform of operating a latch unit according to the present disclosure, and also refer to FIG. 8B. In order to respond the light drive signal Vd with wider width (for example but not limited to 6 to 8 microsecond) as a latch signal for ending the signal recognition, a latch unit 57 is provided as shown in FIG. 8B. The latch unit 57 is used to make end the signal recognition being correct to avoid too early turning off the oscillator 42 to cause the digital circuits to be out of order and malfunction. Moreover, in order to early turn off the oscillator 42 with relatively high power consumption to achieve low power consumption, the latch unit 57 having charging and discharging functions is proposed by a resistor-capacitor charging and discharging circuit, thereby replacing the timing function of the oscillator 42. As mentioned above, for the light drive signal Vd with 3-microsecond or 1-microsecond cycle width (as shown in the first two cycle signals in FIG. 10). Since the first two cycle signals are not latching signals, a discharge voltage Vdis is greater than a predetermined latch voltage Vlatch, wherein the discharge voltage Vdis is provided by discharging operation through a capacitor of the latch unit 57. Alternatively, a charging operation of the capacitor of the latch unit 57 may be provided to achieve the similar determination. At this condition, a latch determine signal Slatch is low level, and the oscillator 42 can operate at low power in the eco mode and be turned off in the sleep mode, thereby implementing lower power consumption.

**[0059]** When the light drive signal Vd is the latching signal with 6-microsecond to 8-microsecond cycle width (as shown in the third cycle signal in FIG. 10), the discharge voltage Vdis is equal to or less than the latch voltage Vlatch at the time point t1 since the discharging time of the capacitor of the latch unit is longer. At this condition, that latch determine signal Slatch is transited from the low level to the high level. Moreover, by continuously discharging the capacitor of the latch unit 57, it is to ensure that the light drive signal Vd as the latching signal to be normally detected and controlled after the oscillator 42 is turned off. Until the time point t2, since the output control switch Qsw is controlled to be turned

on by the control unit CONR, the voltage level of the light drive signal Vd is restored. At this condition, since the voltage level of the light drive signal Vd is greater than the low-level voltage Vlow, the latch determine signal Slatch is transited from the high level to the low level, and therefore it is to leave the sleep mode and enter the work mode again in the next cycle.

**[0060]** However, the detection and control of the latching signal are not limited by comparing the discharge voltage Vdis with the latch voltage Vlatch. Alternatively, a predetermined time length is set for latching operation of the latch unit 57. For example, the latch unit 57 may be implemented by a timing circuit. Therefore, when the predetermined time length reaches or exceeds, the latching operation of the latch unit 57 is activated to meet the requirement of low power consumption.

**[0061]** In conclusion, the present disclosure has following features and advantages:

- 20 1. In the same architecture, the light drive signal and the power supplying source are both transmitted to the LED light string.
- 25 2. The quick discharging circuit inside each of the LED modules is provided to quickly reduce the voltage level of the light drive signal to ensure that all in-series LEDs are completely controlled.
- 30 3. The simple application circuits are provided to solve determination abnormality and malfunction of the LED module since the light drive signal reduces to reach to the reset voltage.
- 35 4. It is to effectively reduce power consumption of the analogy circuits with relatively high power consumption and to make the LED module normally operate.
- 40 5. The LED module operates by the point control or by the synchronous control, and therefore to increase flexibility and convenience of designing the control circuit and implement diverse lighting effects and changes of the LED lamp.
- 45 6. The specific design of the oscillator is provided to implement the low-power oscillation, provide the clock signal, and ensure that the digital circuit can perform its necessary operation before the oscillator enters the sleep mode, thereby achieving the lower power consumption of the oscillator.
- 50 7. The charging and discharging time design and the predetermined time design of the latch unit ensure that the light drive signal as the latching signal to be normally detected and controlled, thereby achieving the lower power consumption of the oscillator.

## Claims

- 55 1. A carry-signal controlled LED light with low power consumption characteristic, characterized in that the carry-signal controlled LED light comprising:

at least one LED, and a drive unit coupled to the at least one LED, the drive unit configured to receive a carry light signal to control the at least one LED, and the drive unit comprising: a light control unit (311) configured to drive the at least one LED according to a light command content of the carry light signal, wherein when a voltage of the carry light signal is less than a low-level voltage (Vlow), the light control unit (311) entering a low power consumption mode.

2. The carry-signal controlled LED light with low power consumption characteristic in claim 1, wherein the light control unit (311) comprises a comparison unit (56),

wherein when the voltage of the carry light signal is less than the low-level voltage (Vlow), the comparison unit (56) is configured to output a control signal (Sc) to control the light control unit (311) entering a sleep state of the low power consumption mode; when the voltage of the carry light signal is greater than the low-level voltage (Vlow), the comparison unit (56) is configured to output the control signal (Sc) according to the light command content of the carry light signal to control the light control unit (311) entering a work mode.

3. The carry-signal controlled LED light with low power consumption characteristic in claim 2, wherein the drive unit further comprises:

an address signal process unit (312) coupled to the light control unit (311) and the comparison unit (56) and configured to memorize a light address, the address signal process unit (312) configured to receive an address signal transmitted from the light control unit (311) and compare the address signal with the light address; when the address signal matching the light address, the light control unit (311) configured to drive the at least one LED according to the light command content of the carry light signal, and an address burn unit (313) coupled to the address signal process unit (312) and the comparison unit (56), wherein the carry light signal comprises a burn start signal and a burn address signal; when the address burn unit (313) is configured to receive the burn start signal, the address burn unit (313) is configured to write the light address into the address signal process unit (312); when the comparison unit (56) configured to output a second control signal to the address signal process unit (312) to make the address signal process unit (312) enter the sleep state of the low power consumption mode, and the address

signal process unit (312) entering the work mode until the address signal process unit (312) configured to receive a first control signal.

5 4. The carry-signal controlled LED light with low power consumption characteristic in claim 3, wherein the drive unit further comprises:

an oscillator (42) coupled to the light control unit (311), the address signal process unit (312), the address burn unit (313), and the comparison unit (56); when the comparison unit (56) configured to output the second control signal to the oscillator (42), the oscillator (42) entering the sleep state of the low power consumption mode to stop oscillating, and the oscillator (42) entering the work mode to start oscillating and provide an oscillation signal until the oscillator (42) configured to receive the first control signal; when the oscillator (42) in the sleep state of the low power consumption mode and stopping oscillating, the light control unit (311), the address signal process unit (312), and the address burn unit (313) doing not receive the oscillation signal provided by the oscillator (42) and entering the sleep state of the low power consumption mode.

5. The carry-signal controlled LED light with low power consumption characteristic in claim 1, wherein the light control unit (311) comprises a current detection unit (55),

wherein when the voltage of the carry light signal is less than the low-level voltage (Vlow), the current detection unit (55) is configured to output a control signal (Sc) to control the light control unit (311) entering an eco mode of the low power consumption mode.

6. The carry-signal controlled LED light with low power consumption characteristic in claim 5, wherein within a time interval after entering the eco state of the low power consumption mode, the light control unit (311) is configured to perform a signal detection and a signal recognition; after the time interval, the control signal (Sc) controls the light control unit (311) entering a sleep state of the low power consumption mode.

7. The carry-signal controlled LED light with low power consumption characteristic in claim 6, wherein after the sleep state of the low power consumption mode, when the voltage of the voltage of the carry light signal is greater than the low-level voltage (Vlow), the light control unit (311) is configured to leave the sleep state of the low power consumption mode.

8. The carry-signal controlled LED light with low power consumption characteristic in claim 5, wherein the

light control unit (311) further comprises an oscillator (42),  
 wherein in the eco state of the low power consumption mode, the oscillator (42) is configured to receive the control signal (Sc), and the oscillator (42) is controlled by the control signal (Sc) to be in an oscillation operation at low power. 5

9. The carry-signal controlled LED light with low power consumption characteristic in claim 5, wherein the light control unit (311) further comprises a latch unit (57) and an oscillator (42),  
 wherein in the eco state of the low power consumption mode, the latch unit (57) and the oscillator (42) are configured to receive the control signal (Sc), and the oscillator (42) is controlled by the control signal (Sc) to be disabled and the latch unit (57) is controlled by the control signal (Sc) to be in a timing operation. 10

10. The carry-signal controlled LED light with low power consumption characteristic in claim 9, wherein the latch unit (57) is a charging and discharging circuit with a resistor and a capacitor. 20

11. The carry-signal controlled LED light with low power consumption characteristic in claim 9, wherein the latch unit (57) is a timing circuit. 25

12. The carry-signal controlled LED light with low power consumption characteristic in claim 7, wherein the drive unit further comprises:  
 an address signal process unit (312) coupled to the light control unit (311) and configured to memorize a light address, the address signal process unit (312) configured to receive an address signal transmitted from the light control unit (311) and compare the address signal with the light address; when the address signal matching the light address, the light control unit (311) configured to drive the at least one LED according to the light command content of the carry light signal. 30

13. The carry-signal controlled LED light with low power consumption characteristic in claim 12, wherein the drive unit further comprises:  
 an address burn unit (313) coupled to the address signal process unit (312), wherein the carry light signal includes a burn start signal and a burn address signal; when the address burn unit (313) is configured to receive the burn start signal, the address burn unit (313) is configured to write the light address into the address signal process unit (312) according to a burn command content of the burn address signal. 35

14. A carry-signal controlled LED light string, characterized in that the carry-signal controlled LED light string comprising:  
 a power line (Lp),  
 a controller (100) coupled to the power line (Lp), and  
 at least one LED light, each LED light comprising the carry-signal controlled LED light with low power consumption characteristic in any one of claims 1 to 13,  
 wherein the at least one LED light is coupled to the controller (100) through the power line (Lp), and is configured to receive a DC working power and the carry light signal transmitted from the controller (100) through the power line (Lp). 40

15. The carry-signal controlled LED light string in claim 14, wherein the controller (100) comprises:  
 a rectifier unit coupled to the power line (Lp) and configured to provide the DC working power, a switch (Qsw) coupled to the power line (Lp) and the at least one LED light, a control unit (20) coupled to the rectifier unit and the switch (Qsw), wherein when the control unit (20) is configured to turn on the switch (Qsw), the DC working power forms a power supply loop for the LED light through the power line (Lp),  
 a discharge circuit coupled to the power line (Lp) and the control unit (20), wherein when the switch (Qsw) is turned off, the controller (100) is configured to drive the discharge circuit to receive the DC working power and to start discharging the DC working power, and  
 a voltage adjust capacitor coupled to the power line (Lp), wherein when the switch (Qsw) is turned off, the voltage adjust capacitor is configured to provide the DC working power to the at least one LED light,  
 wherein when the control unit (20) is configured to produce the carry light signal, the control unit (20) is configured to continuously turn on and turn off the switch (Qsw) according to the light command content of the carry light signal so that the DC working power of the power line (Lp) forms a plurality of a plurality of pulse waves to be combined into the carry light signal, and transmit the carry light signal to the LED light through the power line (Lp). 45

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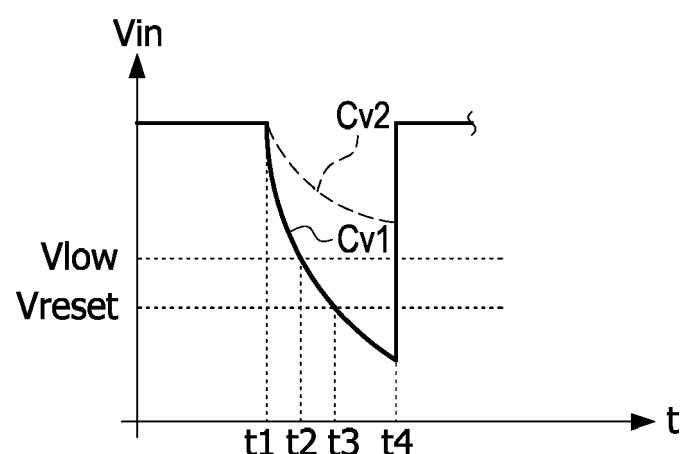


FIG.1

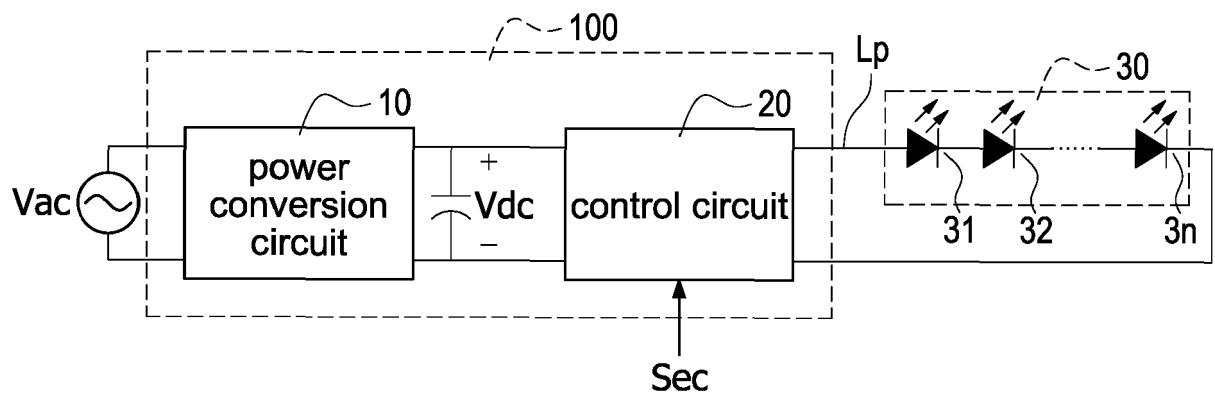


FIG.2A

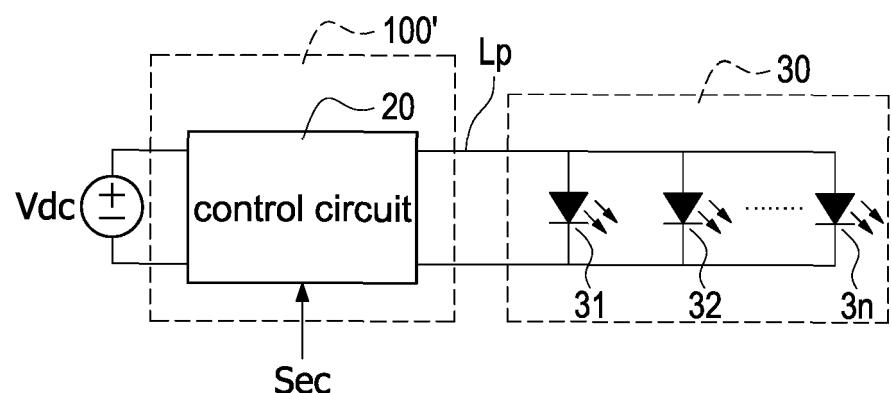


FIG.2B

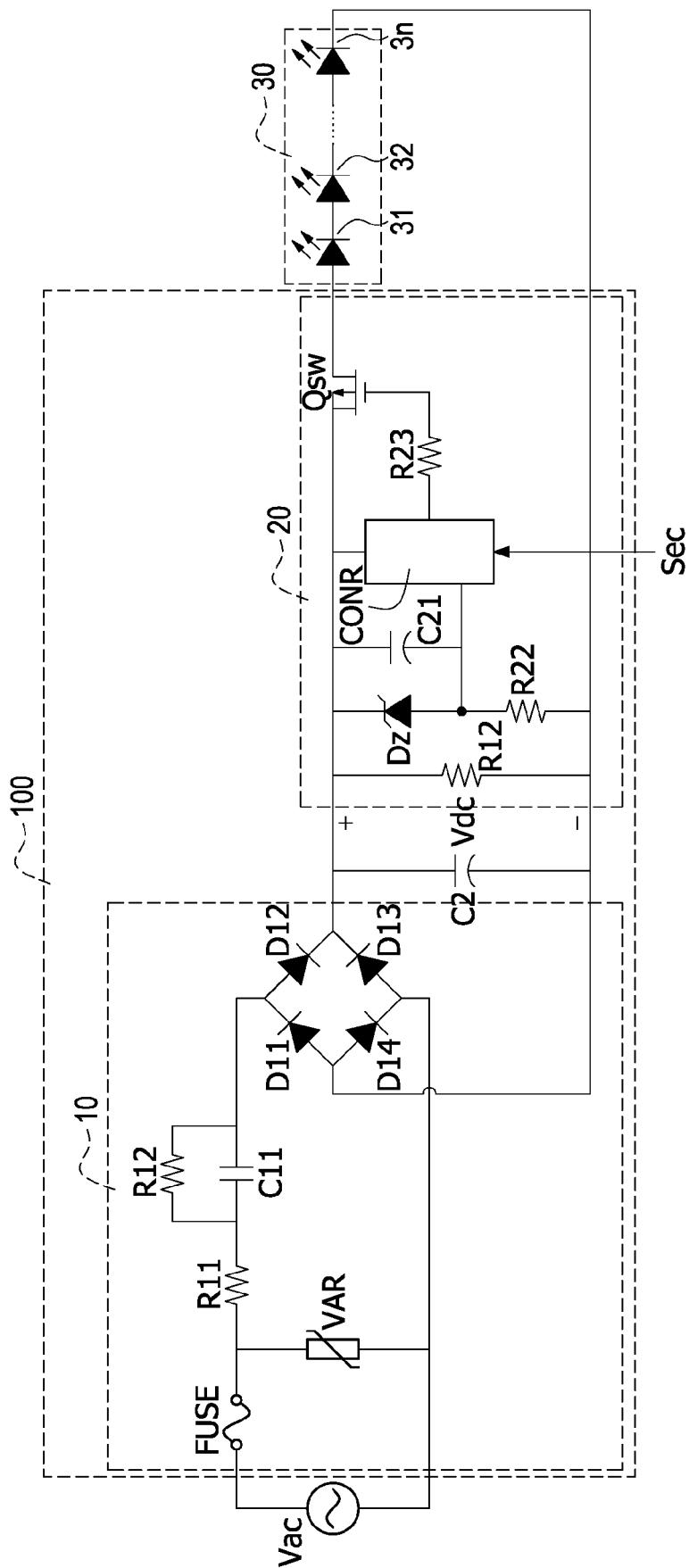


FIG. 3A

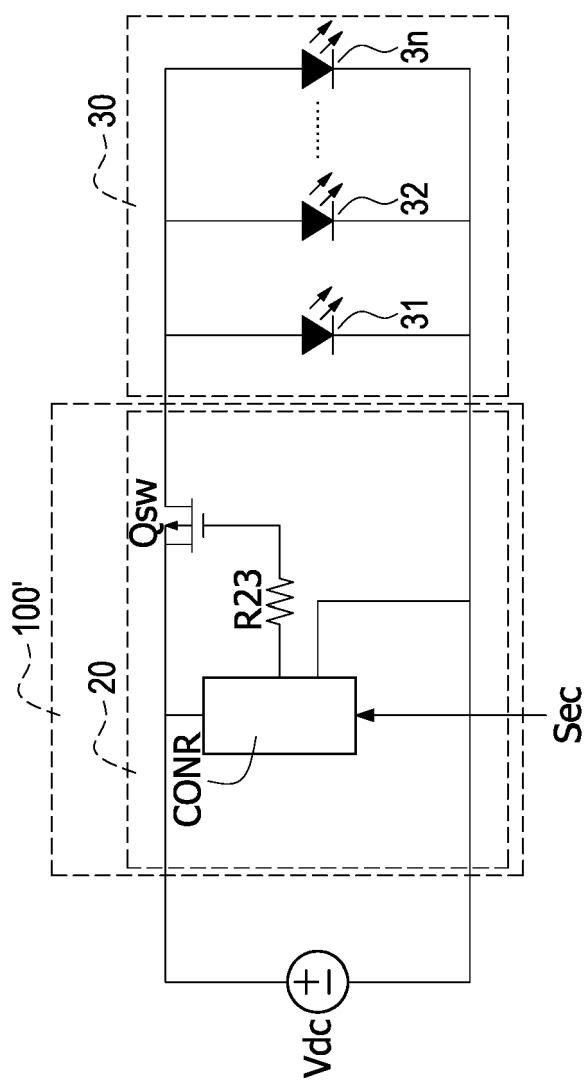


FIG.3B

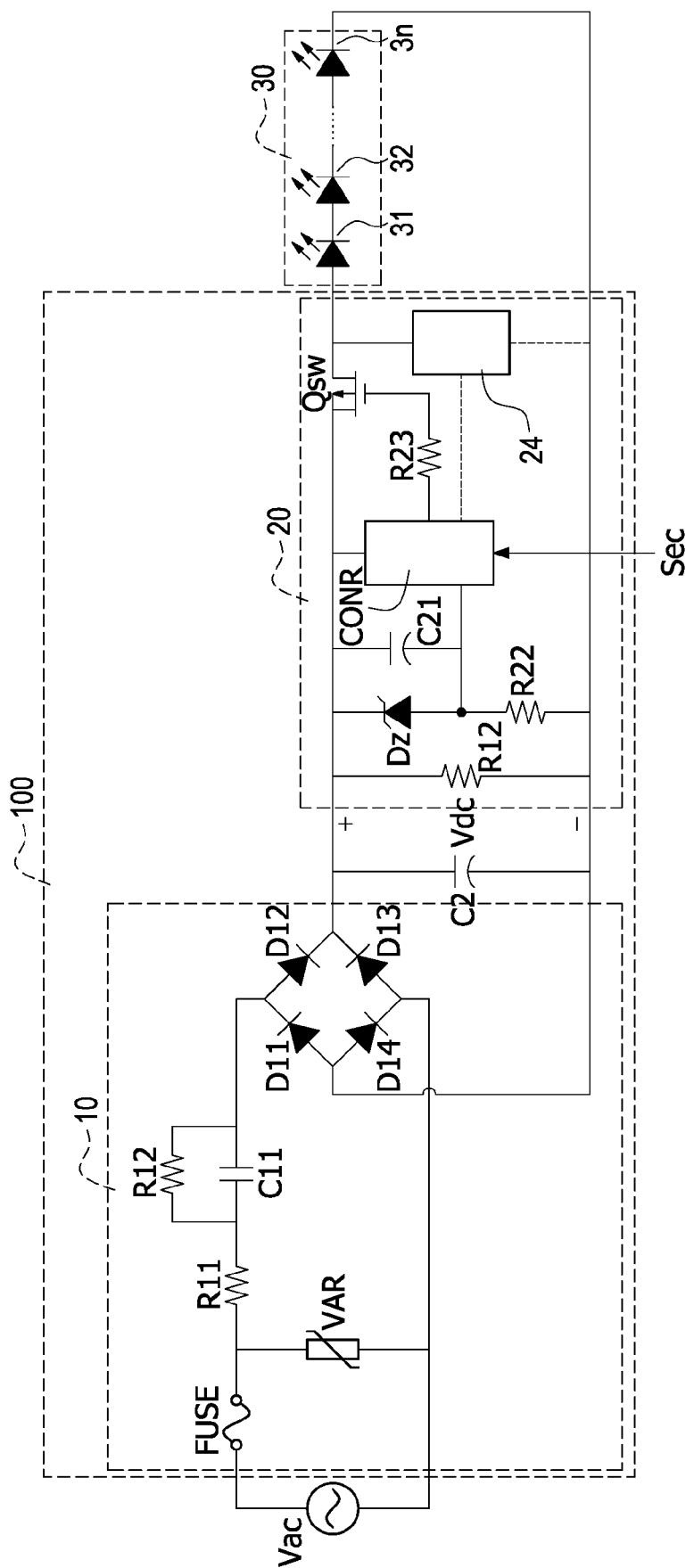
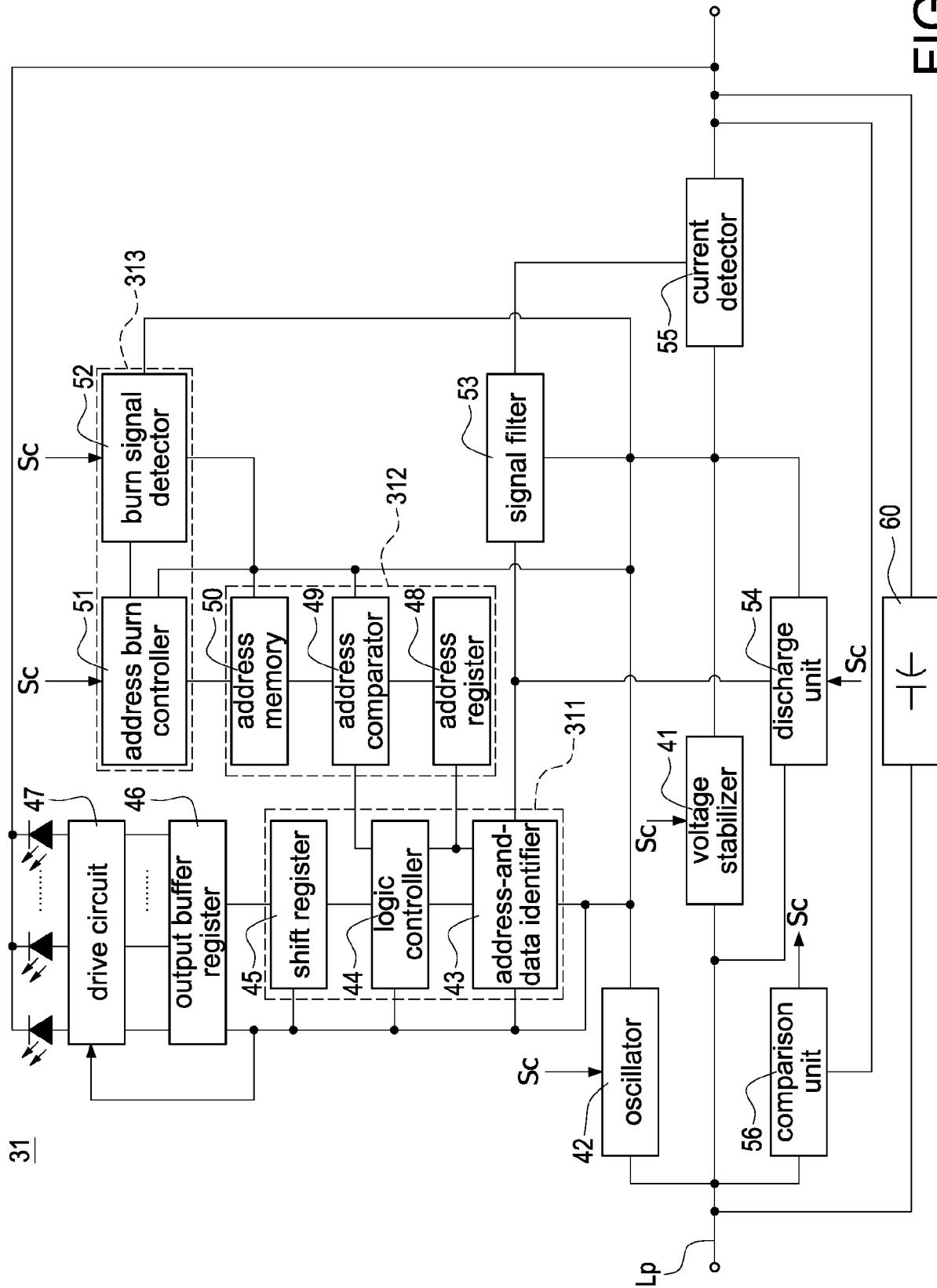


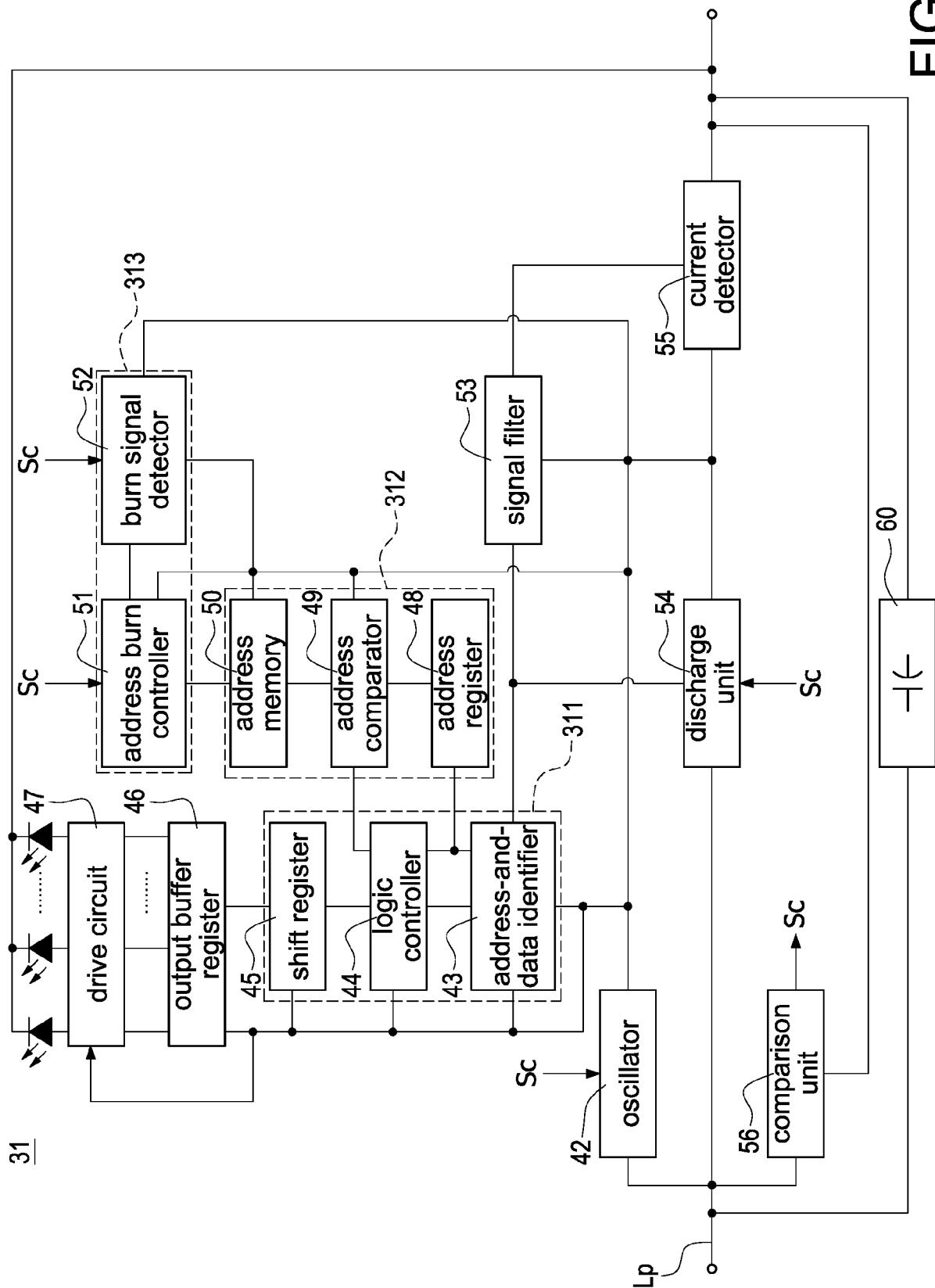
FIG.3C

FIG.4A



31

FIG.4B



31

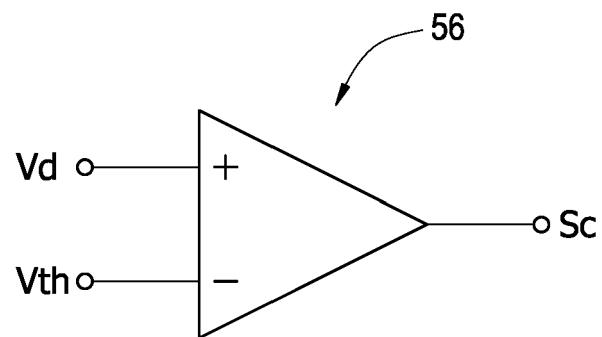


FIG.5

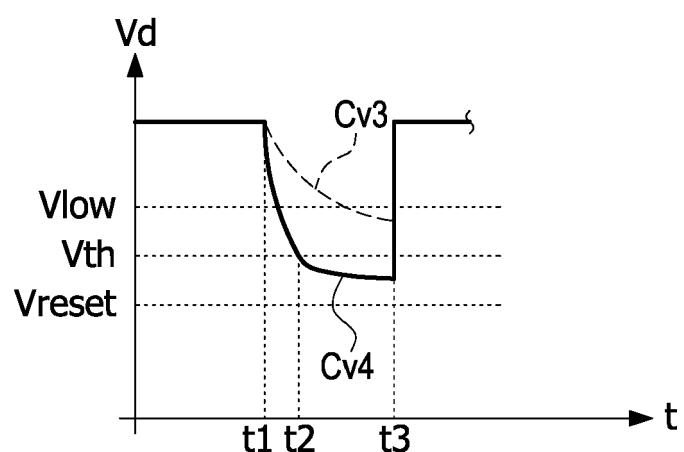


FIG.6

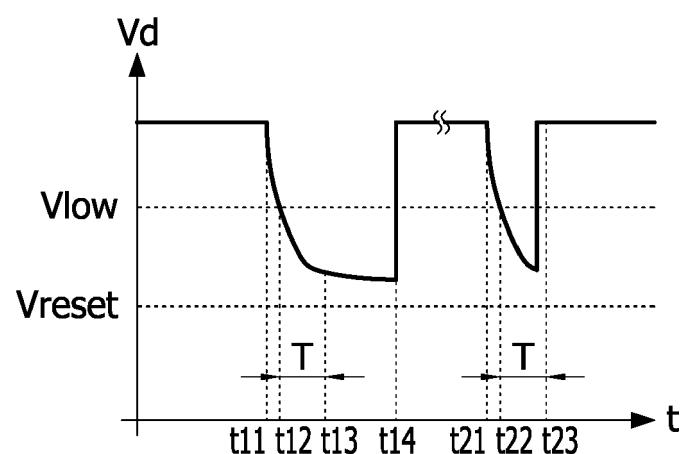
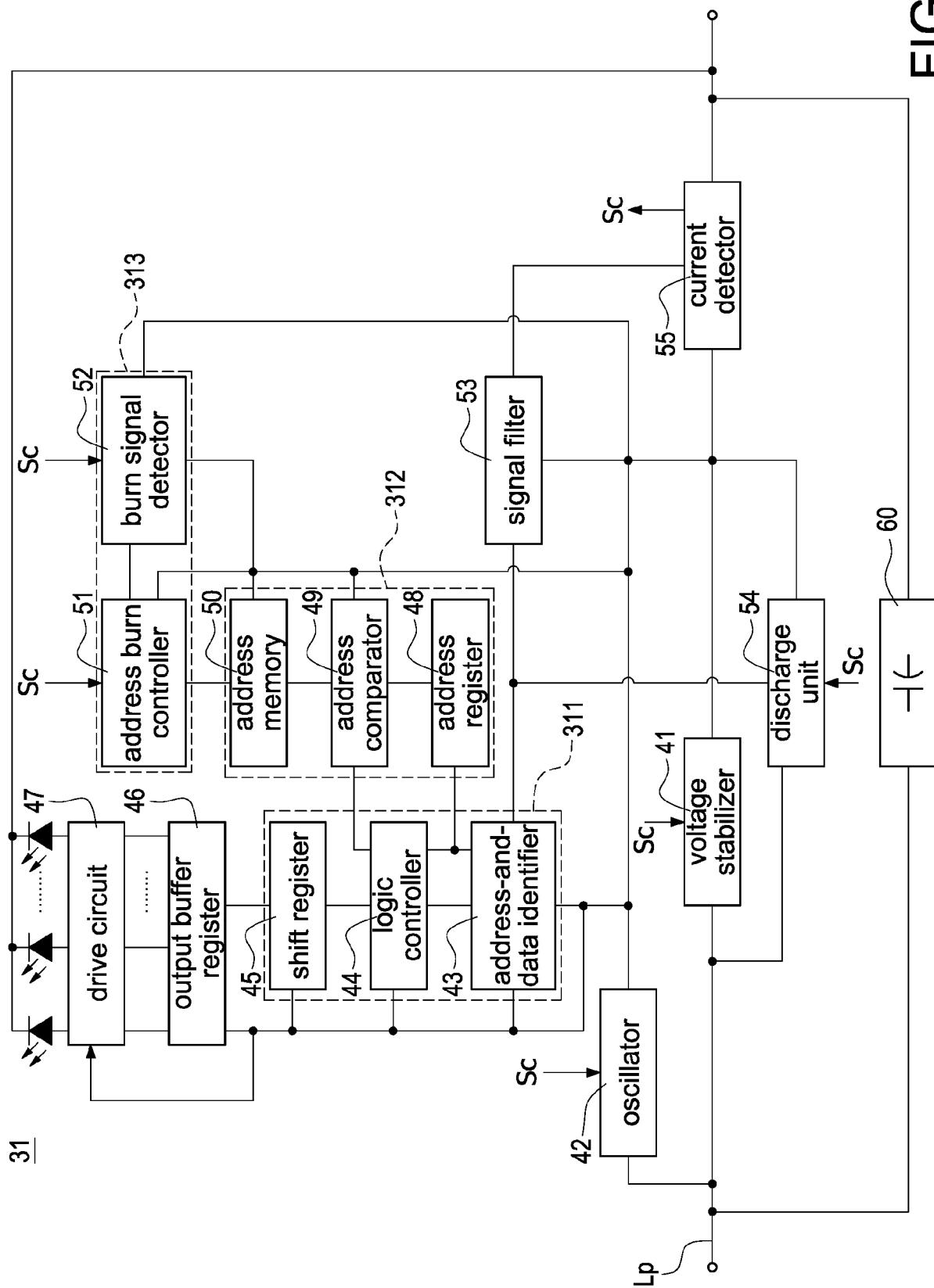


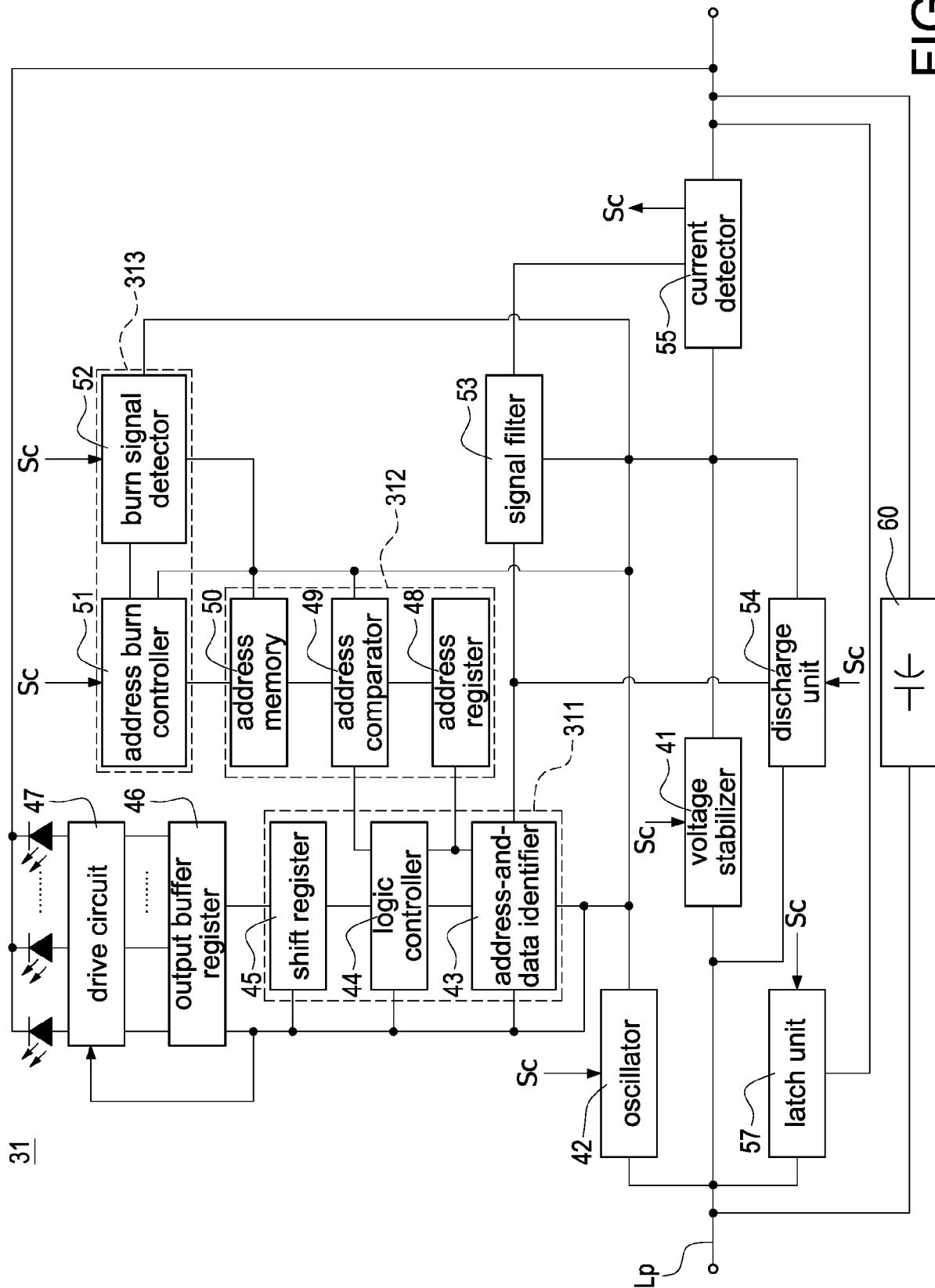
FIG.7

FIG.8A



31

## FIG. 8B



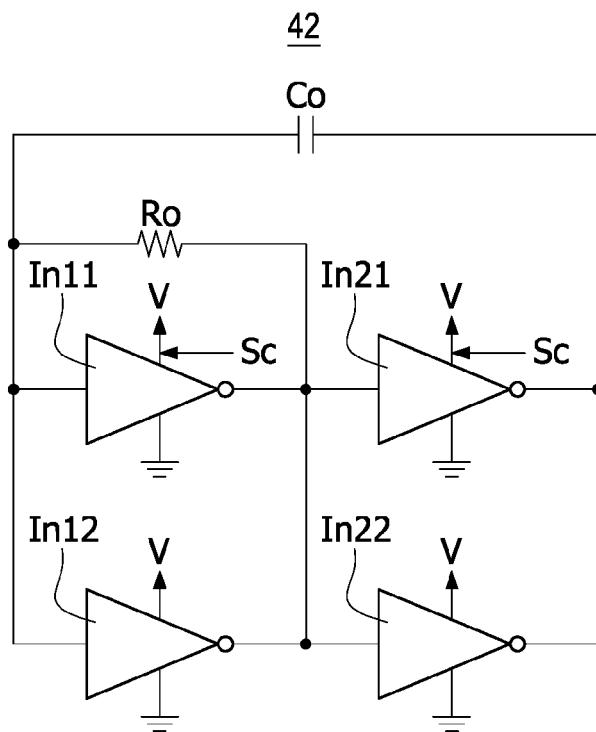


FIG.9

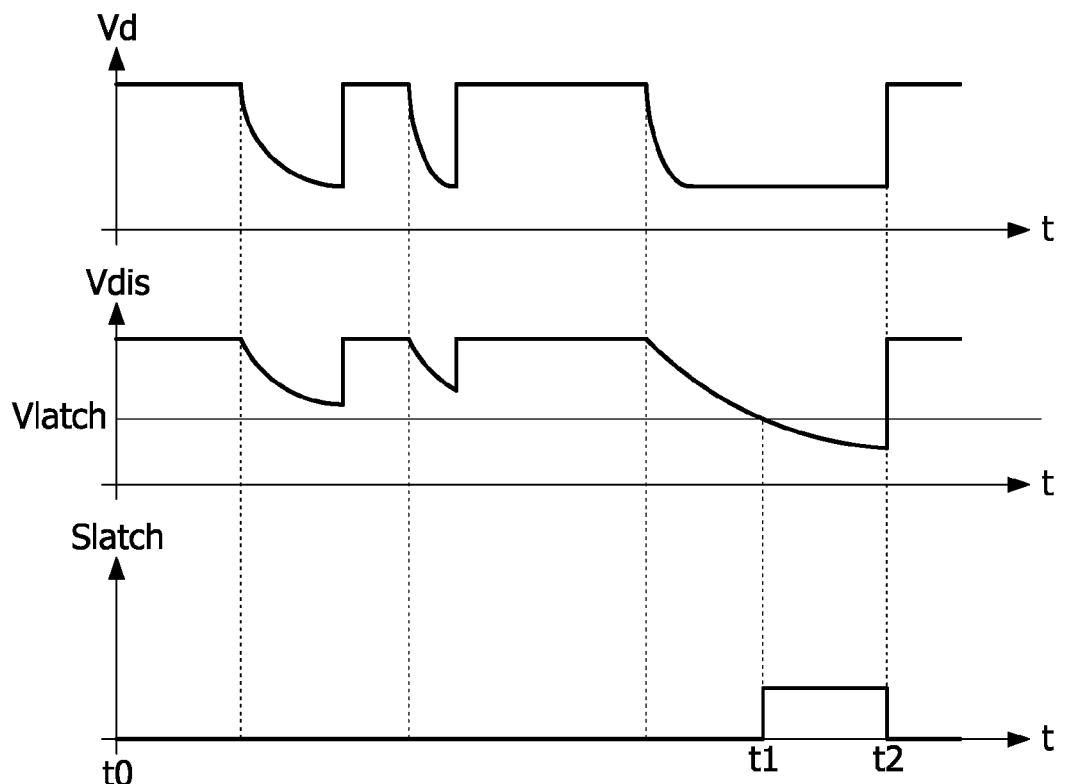


FIG.10



## EUROPEAN SEARCH REPORT

Application Number

EP 19 20 5525

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
10 X	WO 2015/145287 A1 (KONINKL PHILIPS NV [NL]) 1 October 2015 (2015-10-01) * page 1, paragraph 1; figures 1-6 * * page 3, paragraph 11 - page 4, paragraph 14 *	1,2,5-7, 14,15	INV. H05B47/185
15 Y	* page 10, paragraph 35 - page 29, paragraph 92 * -----	3,4,8, 12,13	
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