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(54) **Title**: LED CONTROL CIRCUIT, LED ILLUMINATING DEVICE AND SHORT CIRCUIT PROTECTION METHOD

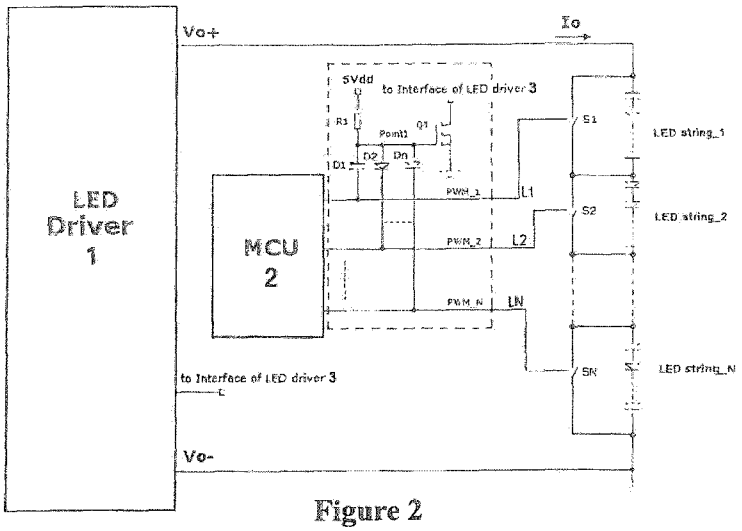


Figure 2

(57) **Abstract**: The present invention relates to An LED control circuit, comprising an LED driver (1), a microcontroller (2) and a plurality of serially connected load groups (LED string_1, LED string_N), the LED driver (1) supplies a driving current to a plurality of serially connected load groups (LED string_1,.... LED string_ N); and the microcontroller (2) send respective pulse width modulation signals (PWM_1, PWM_N) to control the switches (S1, SN) via control lines (L1, LN); and the plurality of switches (S1, SN) each connected in parallel with respective load group, characterized by further comprising a short protection circuit that collects the pulse width modulation signals (PWM_1,..., PWM_N) from respective control lines, and outputs a signal to an interface (3) of the LED driver to turn off the LED driver (1) so as to stop outputting the driving current, if all of the pulse width modulation signals are in high level.

WO 2013/053522 A1

Description

LED Control Circuit, LED Illuminating device and Short Circuit Protection Method

Technical Field

The present invention relates to the LED driving field, and specifically, to an LED control circuit, an LED illuminating device and a short circuit protection method.

Background Art

At present, color mixing concept is widely used to obtain white light with expected CCT (color temperature) and CRI (color rendering index) and color. At the same time, it demands a higher requirement on electronic driver design. The electronic driver should be able to drive multiple LED strings.

In the prior art, a solution for driving multiple LED strings is as shown in Figure 1. The advantage of the solution is that it only needs one DC/DC convertor for the whole strings. However, in a traditional solution, the number of DC/DC convertors is the same as the number of LED strings. As shown in Figure 1, there are N channels of LED strings in the solution, from LED string_1 to LED string_N. Multiple PWM signals, from PWM_1 to PWM_N, are outputted from MCU (viz. microcontroller) to control the current of LED string_1 to LED string_N in PWM mode. But there is a problem with such a solution, viz. when all the PWM signals are in high level, all the switches will turn on and short the whole LED strings, which thereby will lead to a short circuit and cause failure of LED driver.

Summary of the invention

The object of the present invention lies in providing an LED control circuit which can overcome the defects in the prior art and possesses the advantages of high security and fast response.

The object of the present invention is realized by such an LED control circuit: an LED control circuit, comprising an LED driver, a microcontroller and a plurality of serially connected load groups, the LED driver supplies a driving current to a plurality of serially connected load groups; and the microcontroller send respective pulse width modulation signals to control the switches via control lines; and the plurality of switches each connected in parallel with respective load group, characterized by further comprising a short protection circuit that collects the pulse width modulation signals from respective control lines, and outputs a signal to an interface of the LED driver to turn off the LED driver so as to stop outputting the driving current, if all of the pulse width modulation signals are in high level.

In one case, an active level of interface of the LED driver is high level. The following three embodiments can be provided for the case where the interface of the LED driver is active for high level.

According to the first preferred embodiment, the short protection circuit comprises a diode network having a plurality of diodes, wherein Cathode of the diodes are connected to respective control lines, and Anode of the diodes are connected with a power supply through a dropping resistor, and the Anode is connected to the interface of the LED driver. The advantage of the first embodiment is that the circuit is sim-

plified, and the high level for controlling the LED driver can be realized just through a diode network.

According to the second preferred embodiment, the short protection circuit comprises a first transistor network having a plurality of first transistors, and a second transistor, wherein control electrodes of the first transistors are connected to respective control lines through respective first control electrode resistors, reference electrodes of the first transistors are connected to the power supply, working electrodes of the first transistors are a common working electrode which is connected to a reference potential through a common working electrode resistor, a control electrode of the second transistor is connected to the common working electrode of the first transistors through a second control electrode resistor, a reference electrode of the second transistor is connected to the reference potential, a working electrode of the second transistor is supplied with power by the power supply through a second working electrode resistor, and the working electrode of the second transistor is connected to the interface of the LED driver. The second embodiment can also achieve short circuit protection.

According to the third preferred embodiment, the short protection circuit comprises a first transistor network having a plurality of first transistors, and a second transistor network having a plurality of second transistors, wherein control electrodes of the first transistors are connected to respective control lines through respective first control electrode resistors, working electrodes of the first transistors are connected to the power supply through respective first working electrode resistors, and reference electrodes of the first transistors are connected to a reference potential, control electrodes of the second transistors are connected to

the working electrodes of the first transistors, working electrodes of the second transistors are a common working electrode which is connected to the power supply through a second common working electrode resistor, and reference electrodes of the second transistors are connected to the reference potential, and the common working electrode of the second transistors is connected to the interface of the LED driver. The advantage of this embodiment is that reversed-phase of pulse width modulation signals can be realized using the first transistor network and logic "NOR" function can be realized using the second transistor network. The third embodiment can also accomplish the short circuit protection function.

In the case where an active level of interface of the LED driver is low level, three embodiments can also be provided as follows.

The fourth embodiment according the present invention corresponds to the first embodiment. The difference between the two embodiments lies in that, in the fourth embodiment, in order to adapt to the case where the interface of the LED driver is active for low level, a further transistor is added, besides the diode network. The specific solution of the fourth embodiment is: the short protection circuit comprises a diode network having a plurality of diodes, and a transistor, wherein Cathode of the diodes are connected to respective control lines, and Anode of the diodes are connected with a power supply through a dropping resistor, the Anode are connected to a control electrode of the transistor, a working electrode of the transistor is connected to the interface of the LED driver, and a reference electrode of the transistor is connected to the reference potential. This embodiment also has the advantage that the circuit is simpli-

fied.

The fifth embodiment according the present invention corresponds to the second embodiment. The difference between the two embodiments lies in that, in the fifth embodiment, in order to adapt to the case where the interface of the LED driver is active for low level, the second transistor is omitted. The specific solution of the fifth embodiment is: the short protection circuit comprises a first transistor network having a plurality of first transistors, wherein control electrodes of the first transistors are connected to respective control lines through respective first control electrode resistors, reference electrodes of the first transistors are connected to the power supply, working electrodes of the first transistors are a common working electrode which is connected to the reference potential through a common working electrode resistor, and the common working electrode of the first transistors is connected to the interface of the LED driver. The fifth embodiment can also accomplish the short circuit protection function.

The sixth embodiment according the present invention corresponds to the third embodiment. The difference between the two embodiments lies in that, in the sixth embodiment, in order to adapt to the case where the interface of the LED driver is active for low level, a further third transistor is added, besides the first transistor network and the second transistor network. The specific solution of the sixth embodiment is: the short protection circuit comprises a first transistor network having a plurality of first transistors, a second transistor network having a plurality of second transistors, and a third transistor, wherein control electrodes of the first transistors are connected to respective control lines through respective first control electrode resistors,

working electrodes of the first transistors are connected to the power supply through respective first working electrode resistors, and reference electrodes of the first transistors are connected to the reference potential, control electrodes of the second transistors are connected to the working electrodes of the first transistors, working electrodes of the second transistors are a common working electrode which is connected to the power supply through a second common working electrode resistor, and reference electrodes of the second transistors are connected to the reference potential, a control electrode of the third transistor is connected to the common working electrode of the second transistors, a working electrode of the third transistor is connected to the interface of the LED driver, and a reference electrode of the third transistor is connected to the reference potential. The advantage of this embodiment is that reversed-phase of pulse width modulation signals can be realized using the first transistor network, logic "NOR" function can be realized using the second transistor network, and another reversed-phase can be realized using the third transistor. The sixth embodiment can also accomplish the short circuit protection function.

The present invention further relates to an LED illuminating device comprising an LED control circuit having the above characteristics.

The present invention also relates to a short circuit protection method characterized by comprising the steps of: a) collecting respective pulse width modulation signals from control lines connected between a microcontroller and a plurality of switches each connected in parallel with respective load group, and b) outputting to an interface of an LED driver a signal causing the LED driver to be turned off so as

to stop supplying a driving current to the load groups, if all of the pulse width modulation signals are in high level; otherwise, the LED driver supplying a driving current to the load groups, such that the security of the control circuit can be enhanced and fast response can be achieved.

The LED control circuit and the short circuit protection method according to the present invention possess the advantages of high security and fast response.

Brief Description of the Drawings

In the drawings, similar reference signs in different views usually refer to the same part. In the following description, various embodiments of the present invention are described with reference to the following drawings. In the drawings,

Fig. 1 shows an LED control circuit in the prior art;

Fig. 2 shows the first and fourth embodiments of the LED control circuit according to the present invention;

Fig. 3 shows the timing sequence diagram of each signal of the LED control circuit in Fig. 2;

Fig. 4 shows the second and fifth embodiments of the LED control circuit according to the present invention;

Fig. 5 shows the third and sixth embodiments of the LED control circuit according to the present invention; and

Fig. 6 shows a flowchart of the short circuit protection method according to the present invention.

Detailed Description of the Embodiments

Fig. 2 shows the first and fourth embodiments of the LED control circuit according to the present invention. The LED control circuit according to the present invention comprises an LED driver 1, a microcontroller 2, and a plurality of serially connected load groups LED string_1, …, LED string_N. The plurality of serially connected load groups LED string_1, …, LED string_N are connected to the two outputs of the LED driver 1 to receive a driving current Io from the LED driver 1. A plurality of switches S1, …, SN are provided, each switch being connected in parallel with respective one of load groups LED string_1, …, LED string_N. The microcontroller MCU2 transmits, through respective control lines L1, …, LN, respective pulse width modulation signals PWM_1, …, PWM_N to control the switches S1, …, SN, so as to short or connect respective load groups.

A short protection circuit is provided according to the present invention. The short protection circuit collects from each of the control lines L1, …, LN the pulse width modulation signals PWM_1, …, PWM_N, and outputs, when all of the pulse width modulation signals are in high level, a signal to an interface 3 of the LED driver to cause the LED driver to be turned off so as to stop outputting the driving current. However, when one of the pulse width modulation signals is in low level, the LED driver outputs a driving current normally.

In the first and fourth embodiments, the short protection circuit comprises a diode network having a plurality of diodes D1, …, Dn, or comprises a diode network having a plurality of diodes D1, …, Dn, and a transistor, so as to match the case where the interface 3 of the LED driver is active for high level and the case where the interface 3 of the LED

driver is active for low level, respectively. In the case where the interface 3 of the LED driver is active for high level, Cathode of the diodes are connected to respective control lines L1, …, LN for collecting the pulse width modulation signals PWM_1, …, PWM_N, and Anode of the diodes are a common Anode which is connected with a power supply Vdd through a dropping resistor R1. The common Anode is connected to the interface 3 of the LED driver in order to output a signal, a signal can be collected from Point 1 as shown in the figure. In the case where the interface of the LED driver is active for low level, an additional transistor Q1 is needed, a control electrode of the transistor Q1 is connected to the common Anode, a working electrode of the transistor Q1 is connected to the interface of the LED driver, and a reference electrode of the transistor Q1 is connected to the reference potential. The common Anode is connected to a control electrode of the transistor Q1, a working electrode of the transistor is connected to the interface of the LED driver, and a reference electrode of the transistor is connected to the reference potential.

Fig. 3 shows the timing sequence diagram of each signal of the LED control circuit in Fig. 2, in the case where the interface of the LED driver is active for low level. It can be seen from the figure that, for example, the waveforms of the pulse width modulation signals PWM_1, …, PWM_N are respectively shown by CH1, …, CHn, the waveform of the control electrode of the transistor Q1, viz. the waveform at Point 1, is as shown by CHn+1, and the waveform of the driving current Io outputted from the LED driver is as shown by CHn+2. It can be seen that, for the waveforms during t0-t1, t2-t3, and t4-t5, all the PWM signals are in high levels, which will short the whole LED strings, viz. the load groups LED string_1, …, LED string_N, but the logic voltage at the con-

trol electrode of the transistor Q1, viz. on Point 1, turns to be high level, which thereby turns off the LED driver to prevent damages caused by short circuit of load groups.

Fig. 4 shows the second and fifth embodiments of the LED control circuit according to the present invention. In the second and fifth embodiments, the short protection circuit comprises a first transistor network having a plurality of first transistors Q1', …, Qn', and a second transistor Qn+1', or merely comprises a first transistor network having a plurality of first transistors Q1', …, Qn', so as to match the case where the interface 3 of the LED driver is active for high level and the case where the interface 3 of the LED driver is active for low level, respectively. In the case where the interface 3 of the LED driver is active for high level, control electrodes of the first transistors Q1', …, Qn' are connected to respective control lines L1, …, LN through respective first control electrode resistors R1', …, Rn', reference electrodes of the first transistors Q1', …, Qn' are connected to the power supply Vdd, working electrodes of the first transistors are a common working electrode which is connected to a reference potential through a common working electrode resistor Rn+1', a control electrode of the second transistor Qn+1' is connected to the common working electrode of the first transistors through a second control electrode resistor Rn+2', a reference electrode of the second transistor Qn+1' is connected to the reference potential, a working electrode of the second transistor Qn+1' is supplied with power by the power supply Vdd through a second working electrode resistor Rn+3', and the common working electrode of the first transistors Q1', …, Qn' is connected to the interface 3 of the LED driver, a signal can be collected from Point 2 as shown in the figure. In the case where the interface 3 of the LED driver is active for low level, the second transistor Qn+1',

the second control electrode resistor Rn+2', and the second working electrode resistor Rn+3' are not needed; and in this case, the common working electrode of the first transistors Q1', …, Qn' is connected to the interface 3 of the LED driver, a signal can be collected from Point 1 as shown in the figure.

Fig. 5 shows the third and sixth embodiments of the LED control circuit according to the present invention. In the third and sixth embodiments, the short protection circuit comprises a first transistor network having a plurality of first transistors Q1'', …, Qn'', and a second transistor network having a plurality of second transistors Qn+1'', …, Q2n'', or comprises a first transistor network having a plurality of first transistors Q1'', …, Qn'', a second transistor network having a plurality of second transistors Qn+1'', …, Q2n'', and a third transistor, so as to match the case where the interface 3 of the LED driver is active for high level and the case where the interface 3 of the LED driver is active for low level, respectively. In the case where the interface 3 of the LED driver is active for high level, control electrodes of the first transistors Q1'', …, Qn'' are connected to respective control lines L1, …, LN through respective first control electrode resistors R1'', …, Rn'', working electrodes of the first transistors Q1'', …, Qn'' are connected to the power supply Vdd through respective first working electrode resistors Rn+1'', …, R2n'', and reference electrodes of the first transistors Q1'', …, Qn'' are connected to the reference potential, control electrodes of the second transistors Qn+1'', …, Q2n'' are connected to respective working electrodes of the first transistors, working electrodes of the second transistors Qn+1'', …, Q2n'' are a common working electrode which is connected to the power supply Vdd through a second common working electrode resistor

R2n+1'', and reference electrodes of the second transistors Qn+1'', …, Q2n'' are connected to the reference potential, and the common working electrode of the second transistors Qn+1'', …, Q2n'' is connected to the interface 3 of the LED driver, a signal can be collected from Point 1 as shown in the figure. In the case where the interface 3 of the LED driver is active for low level, an additional third transistor Q2n+1'' is needed to reach another reversed-phase, in this case, a control electrode of the third transistor Q2n+1'' is connected to the common working electrode of the second transistors Qn+1'', …, Q2n'', a working electrode of the third transistor Q2n+1'' is connected to the interface 3 of the LED driver, and a reference electrode of the third transistor Q2n+1'' is connected to the reference potential. In the all embodiments of present invention, the transistor can be MOS transistor or triode transistor, for example an N-MOS transistor or an N-P-N triode transistor.

Fig. 6 shows a flowchart of the short circuit protection method according to the present invention. The short circuit protection method comprises a) collecting respective pulse width modulation signals from control lines (L1, …, LN) connected between a microcontroller and a plurality of switches each connected in parallel with respective load group, and b) outputting to an LED driver a signal causing the LED driver to be turned off so as to stop supplying a driving current to the load groups, if all of the pulse width modulation signals are in high level; otherwise, the LED driver supplying a driving current to the load groups.

What is respective to the above six embodiments, in step b), a high level signal for the interface of the LED driver is generated using a diode network having a plurality of diodes D1, …, Dn, or a low level signal for the interface of the LED

driver is generated using the diode network and a transistor; in step b), a low level signal for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors Q1', …, Qn', or a high level signal for the interface of the LED driver is generated using the first transistor network and a second transistor; in step b), a high level signal for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors Q1'', …, Qn'', and a second transistor network having a plurality of second transistors Qn+1'', …, Q2n'', or a low level signal for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors Q1'', …, Qn'', a second transistor network having a plurality of second transistors Qn+1'', …, Q2n'', and a third transistor Q2n+1''.

List of reference signs

1	LED driver
2	microcontroller
3	interface of the LED driver
LED string_1, …, LED string_N	load groups
S1, …, SN	switches
L1, …, LN	control lines
PWM_1, …, PWM_N	pulse width modulation signals
Vdd	power supply
D1, …, Dn	diodes
R1	droping resistor
Q1	transistor
Q1', …, Qn'	first transistors
Qn+1'	second transistor
R1', …, Rn'	first control electrode resistors
Rn+1'	common working electrode resistor
Rn+2'	second control electrode resistor
Rn+3'	second working electrode resistor

Q1'', …, Qn'' first transistors

Qn+1'', …, Q2n'' second transistors

R1'', …, Rn'' first control electrode resistors

Rn+1'', …, R2n'' first working electrode resistors

R2n+1'' second common working electrode resistor

Qn+1'', …, Q2n'' second transistors

Q2n+1'' third transistor

Patent claims

1. An LED control circuit, comprising an LED driver (1), a microcontroller (2) and a plurality of serially connected load groups (LED string_1, …, LED string_N), the LED driver (1) supplies a driving current to a plurality of serially connected load groups (LED string_1,…. LED string_ N); and the microcontroller (2) send respective pulse width modulation signals (PWM_1, …, PWM_N) to control the switches (S1, …, SN) via control lines (L1, …, LN); and the plurality of switches (S1, …, SN) each connected in parallel with respective load group, characterized by further comprising a short protection circuit that collects the pulse width modulation signals (PWM_1, …, PWM_N) from respective control lines, and outputs a signal to an interface (3) of the LED driver to turn off the LED driver (1) so as to stop outputting the driving current, if all of the pulse width modulation signals are in high level.

2. The LED control circuit according to Claim 1, characterized in that, an active level of interface (3) of the LED driver is high level.

3. The LED control circuit according to Claim 2, characterized in that, the short protection circuit comprises a diode network having a plurality of diodes (D1, …, Dn), wherein Cathode of the diodes are connected to respective control lines (L1, …, LN), and Anode of the diodes are connected with a power supply (Vdd) through a dropping resistor (R1), and the common Anode is connected to the interface (3) of the LED driver.

4. The LED control circuit according to Claim 2, character-

ized in that, the short protection circuit comprises a first transistor network having a plurality of first transistors (Q1', …, Qn'), and a second transistor (Qn+1'), wherein control electrodes of the first transistors (Q1', …, Qn') are connected to respective control lines (L1, …, LN) through respective first control electrode resistors (R1', …, Rn'), reference electrodes of the first transistors are connected to the power supply (Vdd), working electrodes of the first transistors are a common working electrode which is connected to a reference potential through a common working electrode resistor (Rn+1'), a control electrode of the second transistor is connected to the common working electrode of the first transistors through a second control electrode resistor (Rn+2'), a reference electrode of the second transistor (Qn+1') is connected to the reference potential, a working electrode of the second transistor (Qn+1') is supplied with power by the power supply (Vdd) through a second working electrode resistor (Rn+3'), and the working electrode of the second transistor is connected to the interface (3) of the LED driver.

5. The LED control circuit according to Claim 2, characterized in that, the short protection circuit comprises a first transistor network having a plurality of first transistors (Q1'', …, Qn''), and a second transistor network having a plurality of second transistors (Qn+1'', …, Q2n''), wherein control electrodes of the first transistors (Q1'', …, Qn'') are connected to respective control lines (L1, …, LN) through respective first control electrode resistors (R1'', …, Rn''), working electrodes of the first transistors (Q1'', …, Qn'') are connected to the power supply (Vdd) through respective first working electrode resistors (Rn+1'', …, R2n''), and reference electrodes of the first transistors (Q1'', …, Qn'') are connected to a reference potential, control electrodes of

the second transistors (Qn+1'', …, Q2n'') are connected to the working electrodes of the respective first transistors, working electrodes of the second transistors (Qn+1'', …, Q2n'') are a common working electrode which is connected to the power supply (Vdd) through a second common working electrode resistor (R2n+1''), and reference electrodes of the second transistors (Qn+1'', …, Q2n'') are connected to the reference potential, and the common working electrode of the second transistors (Qn+1'', …, Q2n'') is connected to the interface (3) of the LED driver.

6. The LED control circuit according to Claim 1, characterized in that, an active level of interface (3) of the LED driver is low level.

7. The LED control circuit according to Claim 6, characterized in that, the short protection circuit comprises a diode network having a plurality of diodes (D1, …, Dn), and a transistor (Q1), wherein Cathode of the diodes are connected to respective control lines (L1, …, LN), and Anode of the diodes respectively is connected with a power supply (Vdd) through a dropping resistor (R1), the Anode are connected to a control electrode of the transistor (Q1), a working electrode of the transistor is connected to the interface (3) of the LED driver, and a reference electrode of the transistor is connected to the reference potential.

8. The LED control circuit according to Claim 6, characterized in that, the short protection circuit comprises a first transistor network having a plurality of first transistors, wherein control electrodes of the first transistors (Q1', …, Qn') are connected to respective control lines (L1, …, LN) through respective first control electrode resistors (R1', …, Rn'), reference electrodes of the first transistors are con-

nected to the power supply (Vdd), working electrodes of the first transistors are a common working electrode which is connected to the reference potential through a common working electrode resistor (Rn+1'), and the common working electrode of the first transistors is connected to the interface (3) of the LED driver.

9. The LED control circuit according to Claim 6, characterized in that, the short protection circuit comprises a first transistor network having a plurality of first transistors (Q1'', …, Qn''), a second transistor network having a plurality of second transistors (Qn+1'', …, Q2n''), and a third transistor (Q2n+1''), wherein control electrodes of the first transistors are connected to respective control lines (L1, …, LN) through respective first control electrode resistors (R1'', …, Rn''), working electrodes of the first transistors are connected to the power supply (Vdd) through respective first working electrode resistors (Rn+1'', …, R2n''), and reference electrodes of the first transistors are connected to the reference potential, control electrodes of the second transistors (Qn+1'', …, Q2n'') are connected to the working electrodes of the respective first transistors, working electrodes of the second transistors (Qn+1'', …, Q2n'') are a common working electrode which is connected to the power supply (Vdd) through a second common working electrode resistor (R2n+1''), and reference electrodes of the second transistors (Qn+1'', …, Q2n'') are connected to the reference potential, a control electrode of the third transistor (Q2n+1'') is connected to the common working electrode of the second transistors (Qn+1'', …, Q2n''), a working electrode of the third transistor (Q2n+1'') is connected to the interface (3) of the LED driver, and a reference electrode of the third transistor (Q2n+1'') is connected to the reference potential.

10. An LED illuminating device comprising an LED control circuit according to any of Claims 1-9.

11. A short circuit protection method, characterized by comprising the steps of:

a) collecting respective pulse width modulation signals (PWM_1, …, PWM_N) from control lines (L1, …, LN) connected between a microcontroller (2) and a plurality of switches (S1, …, SN) each connected in parallel with respective load groups (LED string_1, …, LED string_N), and

b) outputting to an interface of an LED driver a signal causing the LED driver to be turned off so as to stop supplying a driving current to the load groups, if all of the pulse width modulation signals (PWM_1, …, PWM_N) are in high level.

12. The short circuit protection method according to Claim 11, characterized in that, in step b), a high level signal for the interface of the LED driver is generated using a diode network having a plurality of diodes (D1, …, Dn), or a low level signal for the interface of the LED driver is generated using the diode network and a transistor.

13. The short circuit protection method according to Claim 11, characterized in that, in step b), a low level signal for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors (Q1', …, Qn'), or a high level signal for the interface of the LED driver is generated using the first transistor network and a second transistor.

14. The short circuit protection method according to Claim 11, characterized in that, in step b), a high level signal

for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors (Q1'', …, Qn''), and a second transistor network having a plurality of second transistors (Qn+1'', …, Q2n''), or a low level signal for the interface of the LED driver is generated using a first transistor network having a plurality of first transistors (Q1'', …, Qn''), a second transistor network having a plurality of second transistors (Qn+1'', …, Q2n''), and a third transistor (Q2n+1'').

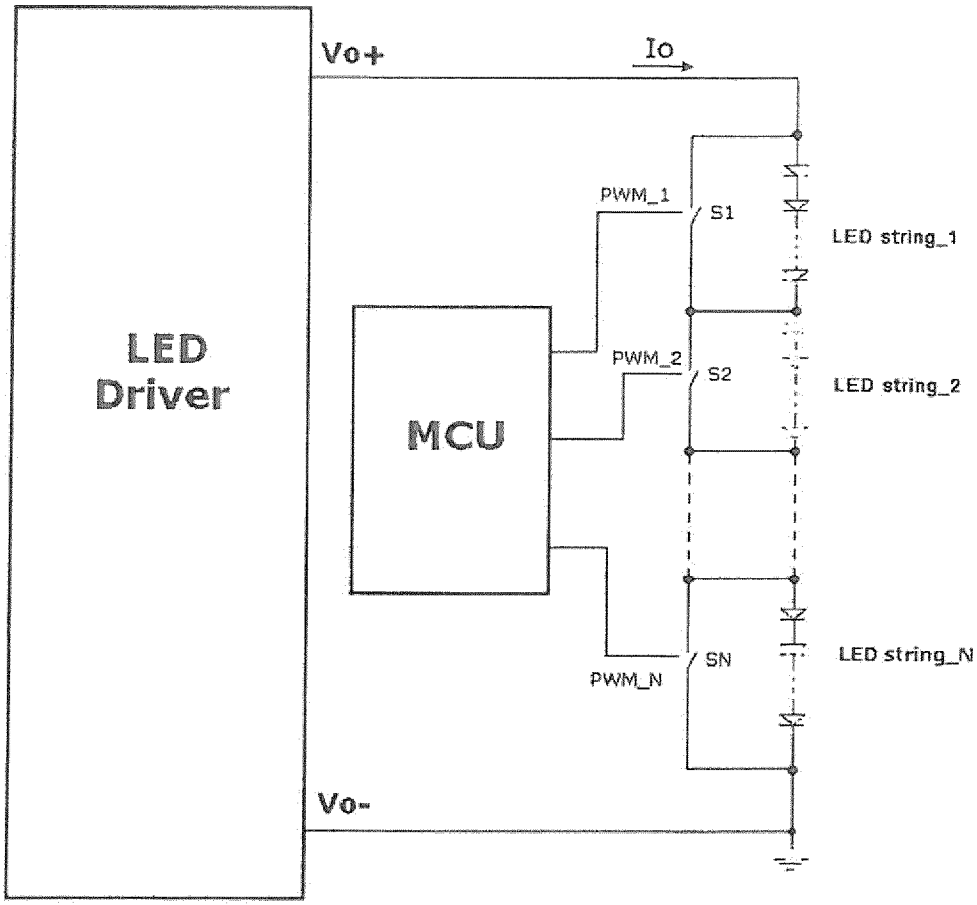

LED
Driver
Vo+
Io
PWM_1
S1
LED string_1
MCU
PWM_2
S2
LED string_2
PWM_N
SN
LED string_N
Vo-

Figure 1

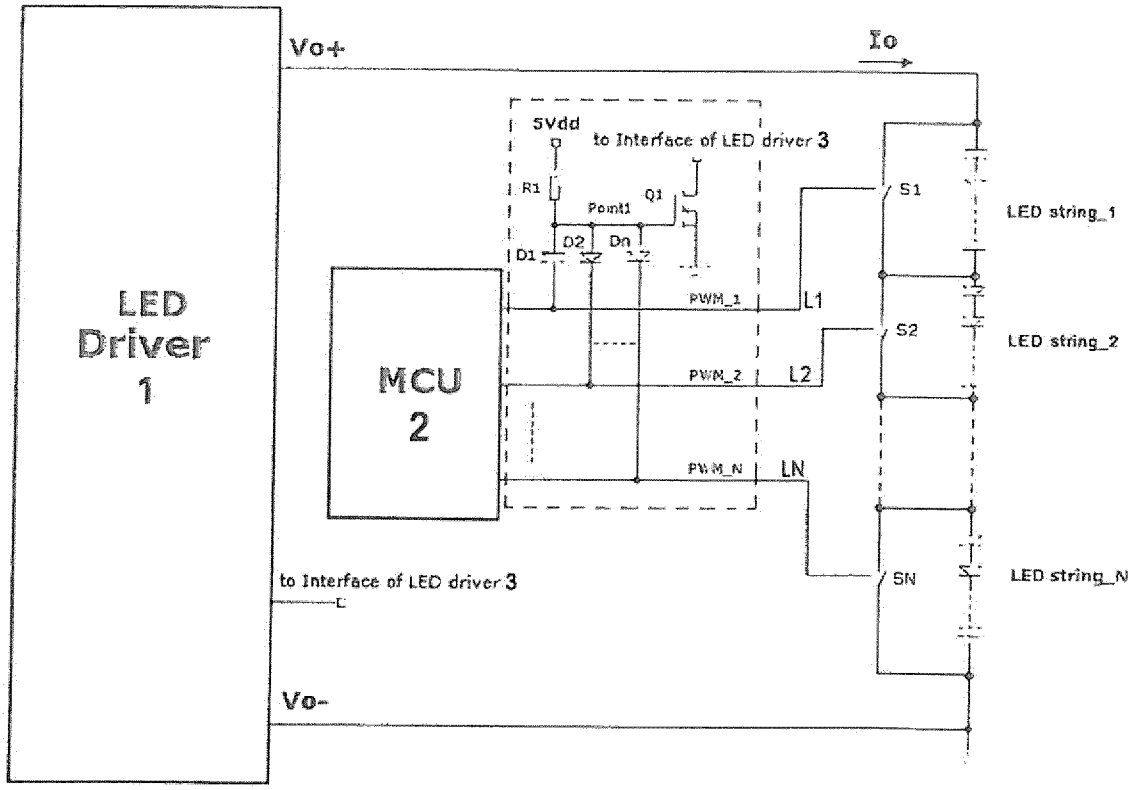

LED
Driver
1
MCU
2
Vo+
Io
5Vdd
to Interface of LED driver 3
R1
Q1
Point1
D1
D2
Dn
PWM_1
PWM_2
PWM_N
L1
L2
LN
S1
S2
SN
LED string_1
LED string_2
LED string_N
to Interface of LED driver 3
Vo-

Figure 2

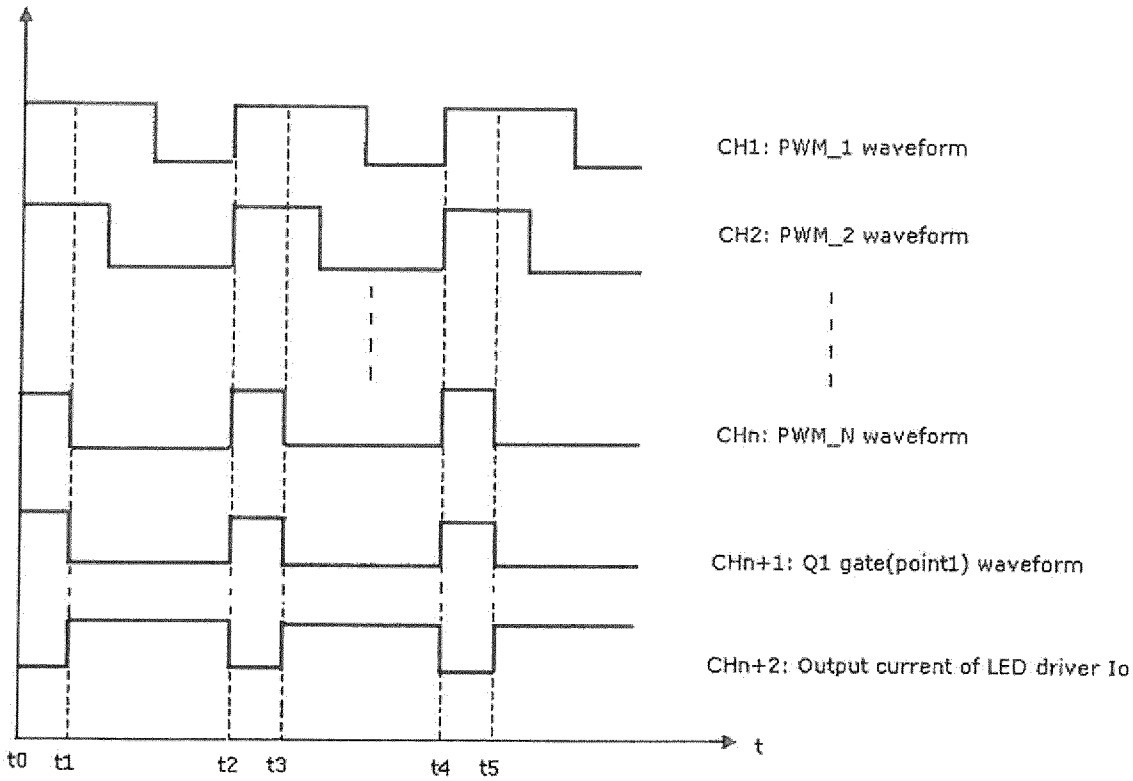

CH1: PWM_1 waveform
CH2: PWM_2 waveform
CHn: PWM_N waveform
CHn+1: Q1 gate(point1) waveform
CHn+2: Output current of LED driver Io
t
t0
t1
t2
t3
t4
t5

Figure 3

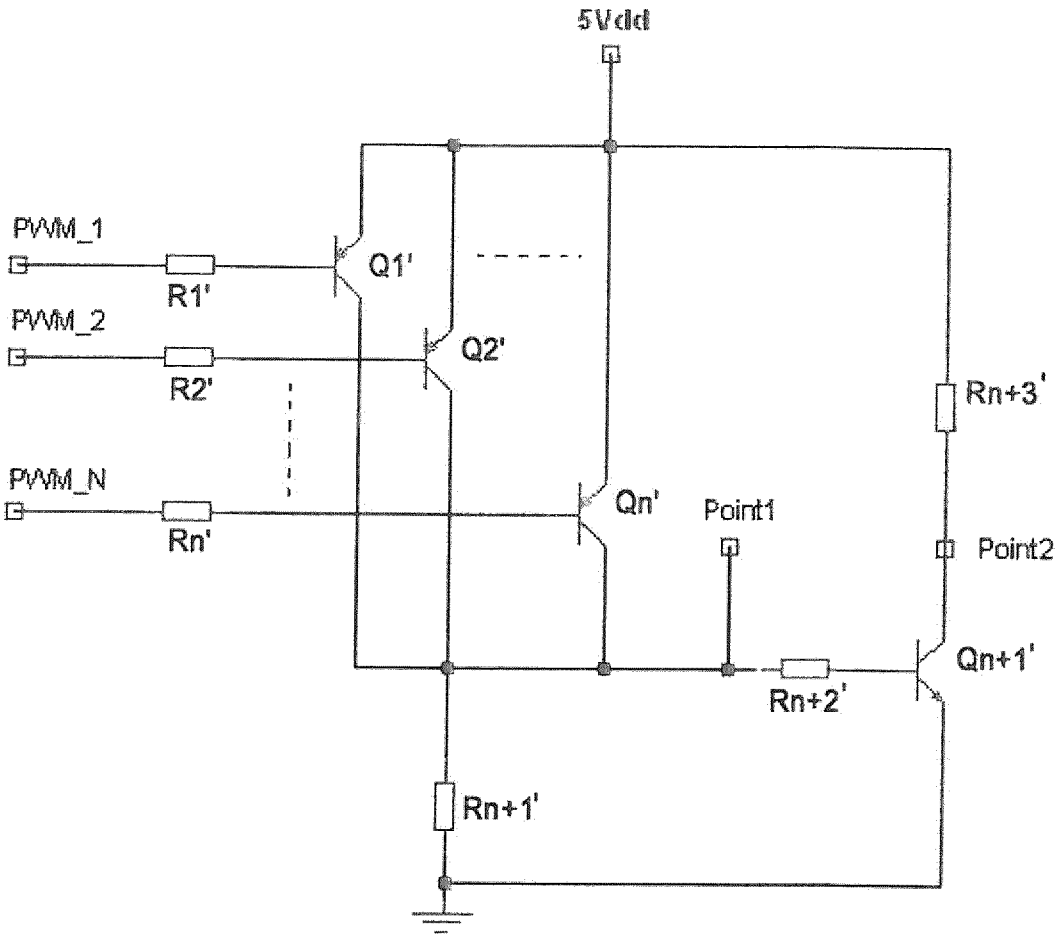

5Vdd
PWM_1
R1'
Q1'
PWM_2
R2'
Q2'
PWM_N
Rn'
Qn'
Point1
Point2
Rn+3'
Qn+1'
Rn+2'
Rn+1'

Figure 4

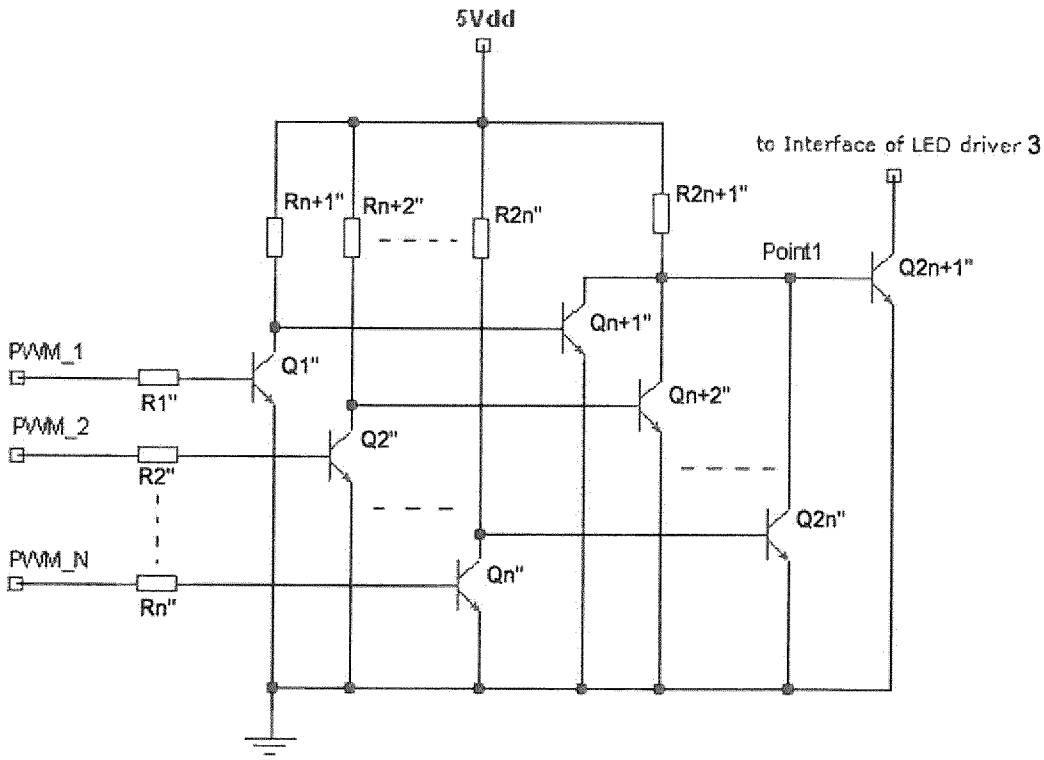


Figure 5

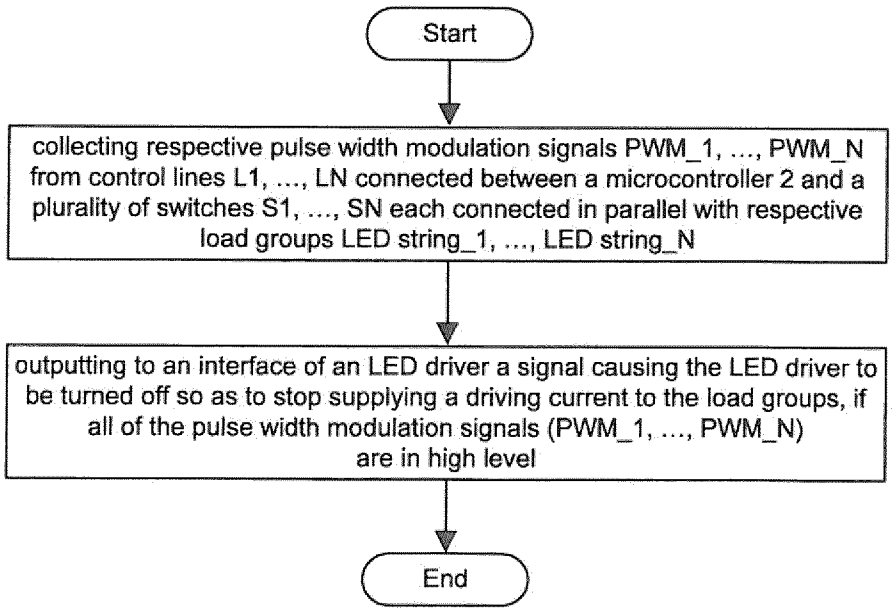


Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/066432

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B33/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/303452 A1 (VAN ERP JOSEPHUS ADRIANUS MARIA [NL]) 11 December 2008 (2008-12-11) paragraphs [0020] - [0022], [0030] - [0041]; figures 4,5	1,2,10, 11
X	US 4 743 897 A (PEREZ RICARDO [BE]) 10 May 1988 (1988-05-10) column 2, line 49 - column 3, line 58; figure 1	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 2012	23/10/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Waters, Duncan

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/066432

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