(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 3 079 445 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.10.2016 Bulletin 2016/41

(51) Int Cl.:
H05B 33/08 *(2006.01)*

(21) Application number: **15162552.2**

(22) Date of filing: **07.04.2015**

(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:
MA

(71) Applicant: **Helvar Oy Ab**
03600 Karkkila (FI)

(72) Inventor: **Moilanen, Aku**
03600 Karkkila (FI)

(74) Representative: **Berggren Oy Ab**
P.O. Box 16
Eteläinen Rautatiekatu 10A
00101 Helsinki (FI)

(54) METHOD AND ARRANGEMENT FOR SETTING THE OUTPUT CURRENT OF A LED DRIVER

(57) A driver device is presented for providing output current for one or more light-emitting semiconductor devices. The driver device comprises a processor and a connector coupled to said processor. The processor is configured to store a reference value for use in limiting said output current, said reference value being dependent on what is connected to said connector, and to use the stored reference value in the absence of any component from said connector.

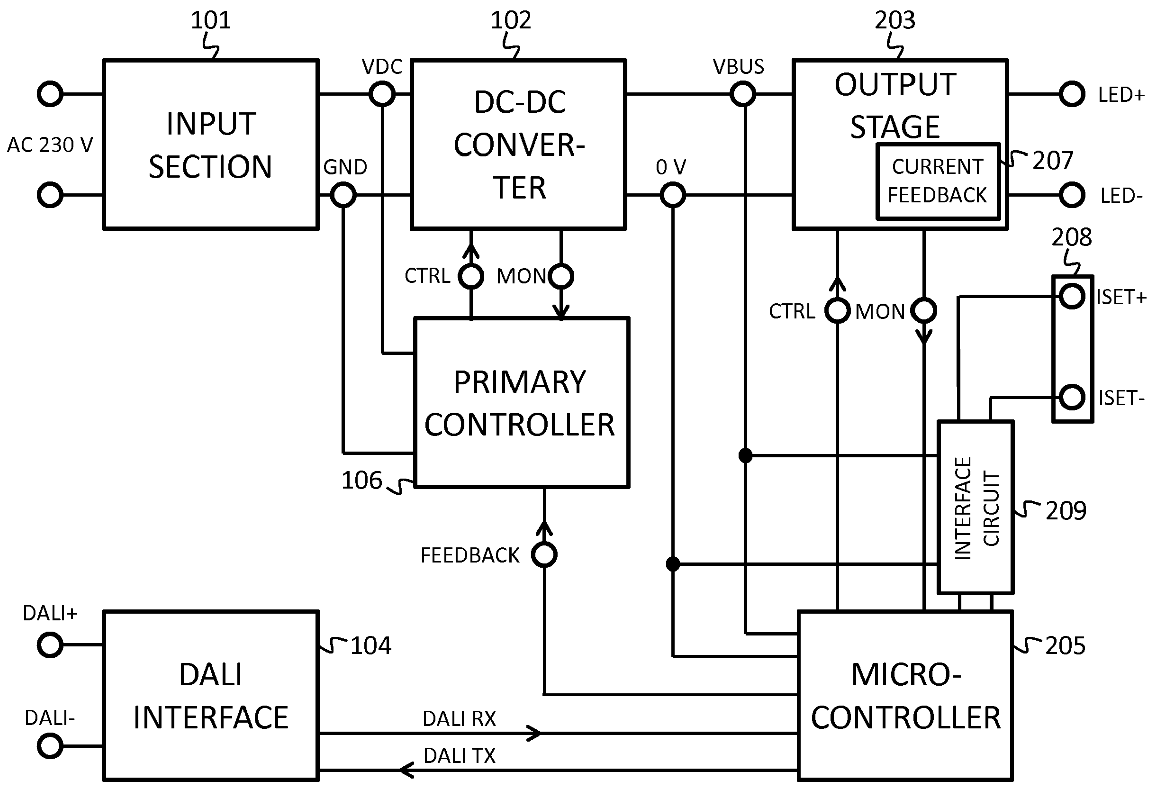


Fig. 2

EP 3 079 445 A1

Description

FIELD OF THE INVENTION

[0001] The example embodiments of the present invention relate to the control of a driver device for operating one or more light-emitting semiconductor devices, such as light emitting diodes (LEDs), at a predefined current. In particular, one or more example embodiments of the present invention relate to setting the value of the predefined output current in a simple and effective manner.

BACKGROUND OF THE INVENTION

[0002] Light fixtures that rely on light emitting semiconductor devices such as light emitting diodes (LEDs) as the source of light typically comprise a driver device, the task of which is to convert input power to output current and voltage of suitable magnitude so that the light radiated by the light emitting semiconductor devices has desired brightness, color temperature, and/or possible other characteristics. In the following the acronym LED is used in a broad sense that covers all kinds of light emitting semiconductor devices, such as traditional LEDs, organic LEDs (OLEDs), laser diodes, and the like.

[0003] A key operating factor of LEDs is the output current of the driver device. The driver manufacturer typically dimensions the driver electronics according to output power, which can then be utilized at various output voltage and current combinations. For example if the output power of the driver is 30 watts, a luminaire manufacturer may decide to take out 350 mA at 85 V, or 700 mA at 42 V, or 1050 mA at 28 V.

[0004] A widely used way in which the output current is set involves a passive component, typically a resistor, connected to a dedicated two-pole connector at the output side of the driver device. The resistor is frequently referred to as the Rset or Iset resistor, and it becomes part of an analog current feedback coupling that defines, how large the output current can become before the driver device starts limiting it for example by ending a conduction period of the power switch in a switched-mode power supply. The driver device allows its output voltage to freely assume a value that matches the sum of the threshold voltages of LEDs coupled in series between the output nodes, as long as said sum is within a range of allowable output voltages.

[0005] Fig. 1 illustrates a driver device in which an Rset or Iset resistor can be used. An input section 101 is adapted to be coupled to a mains grid, for example 230 volts AC at 50 Hz. The input section 101 typically contains passive filtering components as well as a rectifier bridge, and is adapted to produce an internal DC voltage between the lines marked VDC and GND. This internal DC voltage goes into a DC-DC converter section 102, which typically comprises one or two switched-mode power supply stages and is adapted to produce another internal DC voltage between the lines marked VBUS and 0V. The last-mentioned voltage, which is commonly called the bus voltage, goes into one or more output stages, of which section 103 is shown in fig. 1. Its output nodes are marked LED+ and LED- to signify that a LED chain can be coupled therebetween.

[0006] The driver device of fig. 1 is controllable, so it comprises a control interface section 104 adapted to be coupled to a control bus. In this example a DALI (Digital Addressable Lighting Interface) is shown as an example. The control interface section 104 is coupled to a secondary side controller 105 that receives control commands from the control bus and controls the operation of the driver device accordingly.

[0007] In order to properly control the operation of the DC-DC converter section 102 there is a primary controller 106 that belongs to the primary side of the driver device. Each of the controllers 105 and 106 may receive various measured values that are all schematically represented with a single line marked MON respectively. They may also send various controlling signals that are all schematically represented with a single line marked CTRL respectively. The Rset or Iset resistor is to be coupled between the nodes marked ISET+ and ISET-, and it becomes a part of a current feedback circuit 107 of the section 103.

[0008] It is also known to set the output current of a LED driver device through programming. As an example, the SimpleSet wireless programming solution of Koninklijke Philips N.V., the Netherlands, involves placing a near-field communications transceiver close to a LED driver device and using near-field communications with a corresponding transceiver in the LED driver device to set various operating parameters. SimpleSet and Philips are registered trademarks of Koninklijke Philips N.V.

[0009] The known ways of setting the output current are not without drawbacks. The use of Rset or Iset resistors requires the luminaire manufacturer to have thousands of suitable resistors in store, and to make someone install a selected resistor to each and every driver device that is used to make luminaires. Remote programming arrangements like SimpleSet require the luminaire manufacturer to invest in the associated instruments and train the manufacturing personnel to use them.

SUMMARY OF THE INVENTION

[0010] It is an objective of the present invention to provide a technique for setting the output current of a driver device in an advantageous way that is easily adaptable to mass production.

[0011] The objectives of the invention are achieved with a driver device and a method as defined by the respective independent claims.

[0012] According to a first example embodiment of the invention, there is provided a driver device for providing output current for one or more light-emitting semiconductor devices, the driver device comprising:

a processor, and

a connector coupled to said processor;

wherein said processor is configured to store a reference value for use in limiting said output current, said reference value being dependent on what is connected to said connector, and to use the stored reference value in the absence of any component from said connector.

[0013] According to another example embodiment of the invention, there is provided a method for setting the output current provided by a driver device for one or more light-emitting semiconductor devices, the method comprising:

making a processor in said driver device store a reference value for use in limiting said output current, said reference value being dependent on what is connected to a connector coupled to the processor, and use the stored reference value in the absence of any component from said connector.

[0014] According to another example embodiment of the invention, there is provided a computer program for setting the output current provided by a driver device for one or more light-emitting semiconductor devices, comprising machine-readable instructions stored on a non-volatile medium, said machine-readable instructions being configured to, when executed by a processor of said driver device, make the processor store a reference value for use in limiting said output current, said reference value being dependent on what is connected to a connector coupled to the processor, and use the stored reference value in the absence of any component from said connector.

[0015] The exemplifying embodiments of the invention presented in this patent application are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" and its derivatives are used in this patent application as an open limitation that does not exclude the existence of also unrecited features. The features described hereinafter are mutually freely combinable unless explicitly stated otherwise.

[0016] Some features of the invention are set forth in the appended claims. Aspects of the invention, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of some example embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Figure 1 schematically illustrates a driver device.

Figure 2 schematically illustrates a driver device.

Figure 3 schematically illustrates a method and a computer program.

Figure 4 schematically illustrates the concepts of a triggering time and holding time.

Figure 5 schematically illustrates an interface circuit.

Figure 6 schematically illustrates an output stage of a driver device.

Figure 7 schematically illustrates forming control signals for the output stage.

DETAILED DESCRIPTION

[0018] Fig. 2 illustrates a driver device for providing output current for one or more light-emitting semiconductor devices. The input section 101, its coupling to a mains grid, the DC-DC converter section 102, the primary controller 106, and the control interface section 104 may be similar to the correspondingly numbered parts in fig. 1. Their structure and operation have little significance to the present invention, for which reason they are not described here in more detail

[0019] The output stage 203 is coupled to receive the bus voltage produced by the DC-DC converter section 102 and configured to provide output current to a LED chain that will be coupled between the output nodes marked LED+ and LED- in fig. 2. The general designation "LED chain" is used to describe any number and any networked or meshed configuration of light-emitting semiconductor devices that can be coupled to receive the output current provided by the output stage 203.

[0020] In fig. 2 it is assumed that the output stage 203 comprises a current feedback circuit 207, but contrary to the arrangement of fig. 1 the structure and operation of the current feedback circuit 207 have been fixed by the manufacturer of the driver device and cannot be later changed with the addition of any external resistor or other component. The output stage 203 is configured to provide an output current of a nominal value to the LED chain; the nominal value is a maximum allowable continuous electric current value for which the LED chain is rated. At the time of writing this description it is customary to express the maximum allowable continuous electric current values of LEDs used for illumination as integral multiples of 350 mA, so (non-limiting) examples of nominal values are e.g. 350 mA, 700 mA, 1050 mA, and 1400 mA.

[0021] The driver device of fig. 2 comprises a processor 205 and a connector 208 coupled to the processor 205. In the arrangement of fig. 2 the coupling between the connector 208 and the processor 205 takes place through an interface circuit 209. In its simplest form the interface circuit 209 may consist of trivial connections between nodes of the connector 208 and corresponding pins of the processor 205, but also more elaborate interface circuits are possible, an example of which will be given later in this text.

[0022] The processor 205 may receive various measured values from the output stage 203 that are all schematically represented with a single line marked MON in fig. 2. The processor 205 may also send various controlling signals that are all schematically represented with a single line marked CTRL in fig. 2. In particular, the processor 205 is configured to store a reference value for use in limiting the output current provided by the output stage 203 so that the output current does not exceed a selected nominal value. The reference value is dependent on what is connected to the connector 208. The processor 205 is configured to use the stored reference value in limiting the output current in the absence of any component from the connector 208.

[0023] The purpose of the arrangement of the kind explained above is to enable a luminaire manufacturer or other user of the driver device to set the nominal value of the output current by temporarily connecting a setting component to the connector 208, and later removing it when the processor 205 has been made aware of an appropriate electric characteristic of the setting component. If the driver device comprises an outer cover, it is therefore advantageous if the connector 208 is accessible on the outside of the outer cover. The setting component can be for example a resistor, in which case said appropriate electric characteristic is the resistance of the resistor. The setting component can, however, be also something else, like a capacitor or inductor, in which case the appropriate electric characteristic is the capacitance of the capacitor or the inductance of the inductor. Simplest setting components like resistors, capacitors, and inductors have two pins, for which reason the connector 208 in its simplest form is a two-pole connector.

[0024] Fig. 3 is a flow diagram that can be read as a description of a method or as a description of a computer program comprising machine-readable instructions stored on a nonvolatile medium, said machine-readable instructions being configured to, when executed by a processor of the driver device, make the processor execute the corresponding method. The purpose of the method steps (and the corresponding machine-readable instructions) is to ensure that the setting of the nominal value of the output current is made smoothly and easily when desired, but that changes in the nominal value of the output current are not made accidentally when not intended. For this purpose it is advantageous to bind the setting of the nominal value of the output current to a predetermined time from switching on the processor.

[0025] In general, the processor 205 is configured to measure the value of an electric characteristic (e.g. resistance) of what (e.g. resistor) is connected to the connector 208 within a predetermined time from switching on the processor 205. Switching on the processor 205 typically takes place as a part of switching on the whole driver device, and the concept of "switching on" may be generalized to cover also resetting the processor 205, i.e. making it begin executing its operating program from the beginning even if its operating voltage is not interrupted in between. The processor 205 is configured to calculate a reference value, taking the measured value of said electric characteristic into account, and to store the calculated value. The processor 205 is further configured to use the calculated and stored reference value after said predetermined time from which on the processor 205 has expired.

[0026] Step 301 in fig. 3 corresponds to switching on (or resetting) the processor. It is assumed that the driver device should be operable for providing some output current also relatively quickly after switch-on, so step 302 in fig. 3 corresponds to temporarily using a reference value that has been previously stored in a nonvolatile memory that is available to the processor. For safety it may be advantageous to store in said nonvolatile memory a default reference value that corresponds to the smallest possible nominal value of the output current, so that immediately after switch-on only a relatively small output current is provided until the setting process has been executed.

[0027] Step 303 in fig. 3 corresponds to examining, whether a change occurs in what is connected to the connecter before the expiration of a predetermined duration of time, called here the triggering time. A positive finding at step 303 causes a transition to step 304, which in fig. 3 corresponds to measuring the value of an electric characteristic of what is connected to said connector. This means that the operator must switch on the driver device with no setting component initially connected, and connect the setting component to the connector before the triggering time expires. A suitable length of the triggering time may be in the order of some seconds or some tens of seconds, like 60 seconds. The processor 205 only executes the step of measuring the value of said electric characteristic as a response to detecting a change of what is connected to the connector 208 within a triggering time from switching on (or resetting) the processor. A negative finding at step 303 causes bypassing all following steps, as illustrated in fig. 3: the processor is configured to use a previously stored reference value if no change is detected in what is connected to the connector during the triggering time.

[0028] Step 305 in fig. 3 corresponds to calculating a reference value, taking the measured value of said electric characteristic into account. The term "calculating" should be understood in a wide sense, covering e.g. the application of a mathematical algorithm but also covering e.g. reading from a look-up table.

[0029] Step 306 in fig. 3 corresponds to checking, whether the setting component has remained in place in the connector at least for the duration of a predetermined time, called here the holding time. Requiring the setting component to remain in place, with the value of its appropriate electric characteristic essentially unchanged, for the duration of the holding time is an advantageous safety measure that may keep the processor from accidentally changing the nominal output current e.g. in cases where the operator unintendedly touches the connector 208 with a tool or wire during the triggering time. The processor is configured to execute, in accordance with step 307 in fig. 3, the step of storing the calculated reference value only as a response to the measured value of the electric characteristic staying essentially constant for the duration of the predetermined holding time. If a change is detected in what is connected to the connector 208 during the holding time, a transition from step 306 to step 308 occurs, meaning that the processor will continue using the previously stored reference value.

[0030] An alternative embodiment of the method could be implemented, in which a positive finding at step 306, i.e. an observed change in the measured value of the electric characteristic before the expiration of the holding time, would as a default lead back to step 304. In other words, if the processor noted that some change occurred before the end of the holding time, it would start a new measurement in the hope that this time the electric characteristic would remain the same throughout the (newly begun) holding time. If step 306 again resulted in a positive finding, a new return to step 304 could occur unless some predetermined timeout had expired or unless a predefined maximum number of attempted new measurements had been reached. Thus the processor would make repeated attempts of observing a constant electric characteristic for the duration of a whole holding period, and only if one did not occur even after a number of attempts, revert to using a previously stored value at step 308.

[0031] Fig. 4 illustrates an example of the concepts of triggering time and holding time after switching on the processor. If nothing is connected to the connector 208 when the processor is switched on, the resistance observed between the two poles of the connector is essentially infinite. If a resistor of resistance RSET is then connected between said poles of the connector 208 before the expiry of the triggering time, the observed resistance assumes the value RSET and remains there until the resistor is removed. The calculated reference value is then dependent on the resistance observed between the two poles of the connector. In order to make the processor store the calculated reference value, the resistor must not be removed before the holding time has expired. In fig. 4 it is assumed that the holding time is a time period of predetermined length that begins when the predetermined triggering time expires; in an alternative embodiment the holding time starts running immediately when the processor has noticed a change in what is connected to the connector during the triggering time.

[0032] Fig. 5 illustrates an example of an interface circuit 209 that can be used to couple the connector 208 to the processor 205. A resistor network is coupled between the operating voltage VDD and ground GND nodes of the processor 205, and a connection is made from the middle of the resistor network to a measurement pin of the processor 205. The two poles of the connector 208 are connected across one of the resistors in the resistor network. Since the operating voltage VDD can be assumed to remain constant, the voltage that the processor 205 observes between the measurement and ground depends on the resistance between the poles of the connector 208, i.e. on the value of a setting resistor that is connected to the connector 208.

[0033] Fig. 6 illustrates an example of an output stage 203, which in this case has the circuit topology of a buck converter, in which a power switch 604 is driven with a switch driver circuit 601. The switch driver circuit 601 may be an integrated circuit, for example the circuit MP24894 of Monolithic Power Systems, San Jose, California. The MP24894 has the particular feature that a voltage smaller than 0.3 V between its EN/DIM and GND pins disables the whole circuit, while a voltage greater than 0.3 V but lower than 2.7 V acts as an analog current control signal, changing the way in which the circuit responds to its own current feedback signal. Also other basic approaches to the design of the switch driver circuit are possible, as long as it can be made to react to the values at a control input so that the output current of the output stage can be changed.

[0034] The main current path in fig. 6 goes from a first input voltage node Vbus through a current sensing resistor 602 to the first output voltage node LED+, and from the second output voltage node LED- through an inductor 603 and a power switch 604 to the second input voltage node 0V. A freewheeling current path goes through the current sensing resistor 602 to the first output voltage node LED+, and from the second output voltage node LED- through the inductor 603 and a diode 605 back to the first end of the current sensing resistor 602. An input capacitor 606 is coupled between the first and second input voltage nodes, and an output capacitor 607 is coupled between the first and second output voltage nodes.

[0035] Couplings to the VIN and ISENSE inputs of the switch driver circuit 601 come from opposite ends of the current sensing resistor 602, and the DRV output of the switch driver circuit 601 is coupled to the gate of the MOSFET that acts as a power switch 604. The switch driver circuit 601 is configured to respond to voltages between 0.3 V and 2.7 V at its control input EN/DIM by allowing a potential difference across the current sensing resistor 602 to reach a value proportional to the voltage at the control input EN/DIM during each switching pulse.

[0036] Couplings from the VCC and GND connections of the switch driver circuit 601 are to the local ground potential (the 0V line), through a capacitor 608 from the first-mentioned and directly from the last-mentioned. The node that offers a coupling to the EN/DIM input of the switch driver circuit 601 is marked with the reference designator 609.

[0037] Fig. 7 illustrates an example of how control pulses can be formatted for coupling to the control input EN/DIM of the switch driver circuit. The arrangement of fig. 7 comprises a control pulse formatter 701 that is coupled to the control input EN/DIM of the switch driver circuit 601. The control pulse formatter 701 is configured to provide the control input EN/DIM with control pulses of variable amplitude that exceeds the first threshold (0.3 V), at a pulse width modulation frequency that is significantly smaller than the switching frequency applied at the power switch 604. The difference in frequencies would typically be in the order of decades.

[0038] Even if the amplitude of the control pulses may vary, also the smallest amplitude (i.e. the lowest voltage value) used for a control pulse exceeds the first threshold. Thus each control pulse acts as an enabling pulse of the overall operation of the switch driver circuit 601. In other words, the control pulses act as PWM control pulses to the switch driver circuit 601 regardless of any variation in their amplitude. The frequency and duty cycle of the control pulses will directly determine the frequency and duty cycle of repeatedly enabling and disabling the switch driver circuit 601, and therethrough repeatedly enabling and disabling the whole output stage of the driver device.

[0039] The amplitude of each control pulse sets, control pulse by control pulse, the value that the amplitude of the measured current is allowed to reach during each of those switching pulses that occur in the switched-mode power supply during that particular control pulse. The relatively large difference in frequency between the control pulses and switching pulses means that during an individual control pulse there may occur tens, hundreds, or even thousands of switching pulses. It is even possible that the amplitude of the control pulse is not constant but changes during the control pulse, in which case the allowed value of the measured current may vary in a similar way in the switched-mode power supply during that control pulse.

[0040] The control pulse formatter 701 of fig. 7 acts as a kind of multiplexer, in the sense that it receives two input signals (PWM and NOM) and outputs a common output signal that has characteristics derived from both input signals: the frequency and duty cycle of the pulsed output signal may follow directly the frequency and duty cycle of the PWM input signal, and the amplitude of the pulses in the output signal may follow directly the amplitude of the NOM input signal. Direct following is not a requirement: the control pulse formatter 701 may also implement scaling and/or mapping functions that derive the frequency, duty cycle, and amplitude of the output signal on the basis of some unequivocal rule(s).

[0041] Both the PWM input signal and the NOM input signal may come from the processor 205, and at least one of them may be formed in the processor on the basis of the reference value that was calculated and stored at steps 305 and 307 of fig. 3. For example, the processor may use the PWM input signal for dimming the LEDs and the NOM input signal for setting the nominal output current, or vice versa.

[0042] Changes and modifications to the embodiments described above are possible without departing from the scope of the appended claims. For example, in particular if some other switch driver circuit than the MP24894 is used, the processor may use a single PWM input to the switch driver circuit for dimming, and use a NOM signal proportional to the stored reference value to directly affect a current feedback circuit in the output stage. Directly affecting a current feedback circuit could mean for example biasing some node of the current feedback circuit to a potential that depends on the stored reference value.

Claims

1. A driver device for providing output current for one or more light-emitting semiconductor devices, the driver device comprising:

   a processor, and
   a connector coupled to said processor;
   wherein said processor is configured to store a reference value for use in limiting said output current, said reference value being dependent on what is connected to said connector, and to use the stored reference value in the absence of any component from said connector.

2. A driver device according to claim 1, wherein the driver device comprises an outer cover, and said connector is accessible on the outside of the outer cover.

3. A driver device according to claim 1 or 2, wherein the connector is a two-pole connector.

4. A driver device according to any of the preceding claims, wherein the processor is configured to:

   measure the value of an electric characteristic of what is connected to said connector within a predetermined time from switching on said processor,
   calculate said reference value taking the measured value of said electric characteristic into account, and store the calculated reference value, and
   use the calculated and stored reference value after said predetermined time has expired.

5. A driver device according to claim 4, wherein the processor is configured to:

   execute the step of measuring the value of said electric characteristic only as a response to detecting a change of what is connected to said connector within a triggering time from switching on said processor, and
   use a previously stored reference value if no change is detected in what is connected to said connector during said triggering time.

6. A driver device according to claim 4 or 5, wherein the processor is configured to:

execute the step of storing the calculated reference value only as a response to the measured value of said electric characteristic staying essentially constant for the duration of a predetermined holding time, and
use a previously stored reference value if a change is detected in what is connected to said connector during said holding time.

7. A driver device according to claim 6, wherein the processor is configured to
as a response to the measured value of said electric characteristic not staying essentially constant for the duration of the predetermined holding time, measure again the value of an electric characteristic of what is connected to said connector and calculate again said reference value taking the measured value of said electric characteristic into account, and execute the step of storing the calculated reference value only as a response to the measured value of said electric characteristic staying essentially constant for the duration of said predetermined holding time after said measuring again of said value.

8. A driver device according to any of the preceding claims, wherein said reference value is dependent on the resistance observed between two poles of the connector.

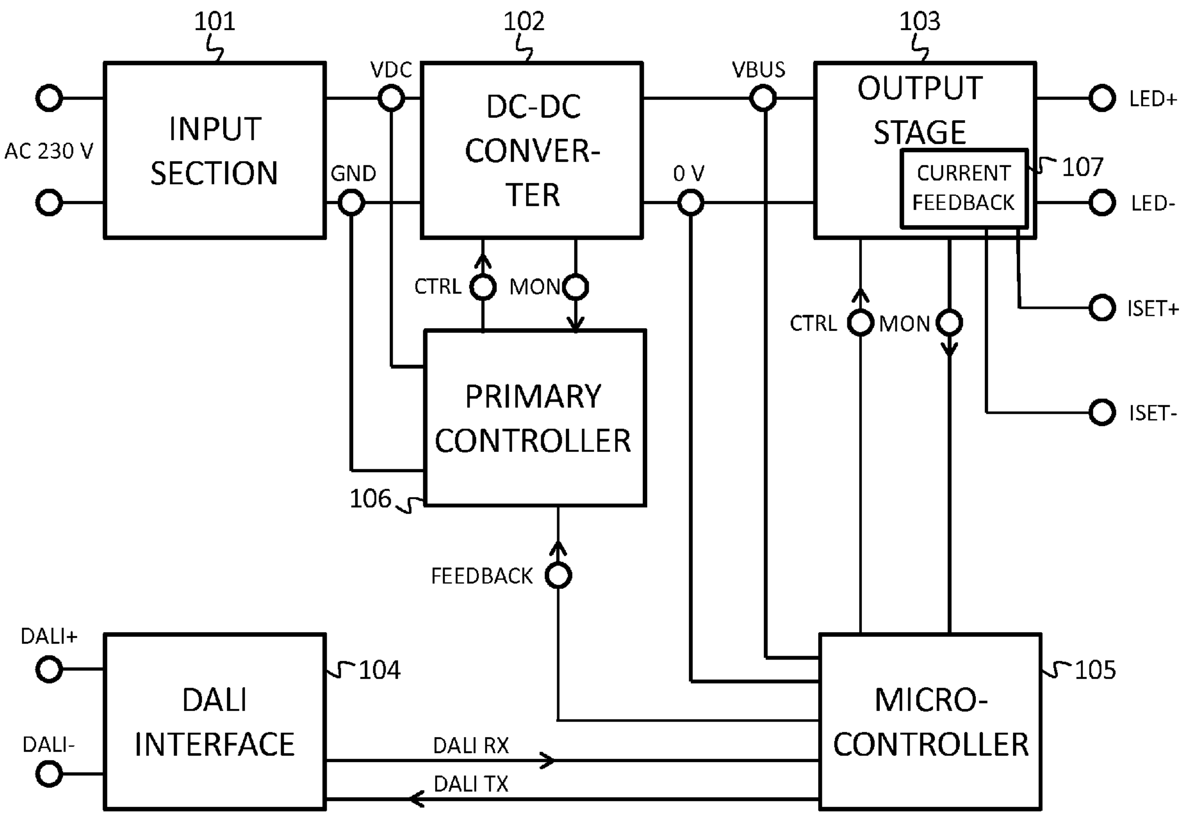
9. A method for setting the output current provided by a driver device for one or more light-emitting semiconductor devices, the method comprising:

making a processor in said driver device store a reference value for use in limiting said output current, said reference value being dependent on what is connected to a connector coupled to the processor, and use the stored reference value in the absence of any component from said connector.

10. A method according to claim 9, comprising:

switching on said processor,
during a predetermined triggering time, connecting a setting component to said connector, and after a predetermined holding time, removing said setting component from said connector.

11. A computer program for setting the output current provided by a driver device for one or more light-emitting semiconductor devices, comprising machine-readable instructions stored on a nonvolatile medium, said machine-readable instructions being configured to, when executed by a processor of said driver device, make the processor store a reference value for use in limiting said output current, said reference value being dependent on what is connected to a connector coupled to the processor, and use the stored reference value in the absence of any component from said connector.



101
102
103
AC 230 V
INPUT SECTION
VDC
GND
DC-DC CONVER-TER
VBUS
0 V
OUTPUT STAGE
CURRENT FEEDBACK
107
LED+
LED-
ISET+
ISET-
CTRL
MON
CTRL
MON
PRIMARY CONTROLLER
106
FEEDBACK
DALI+
DALI-
DALI INTERFACE
104
DALI RX
DALI TX
MICRO-CONTROLLER
105

Fig. 1

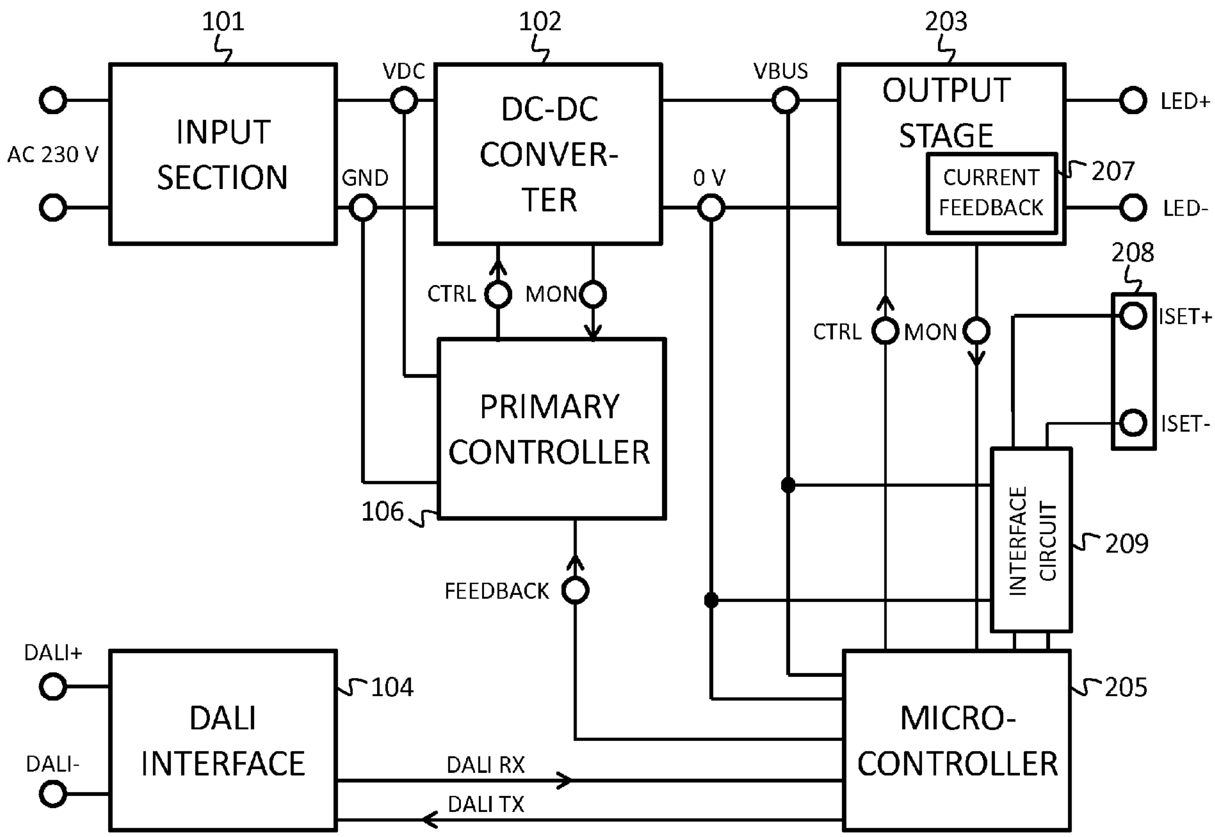

101
102
203
AC 230 V
INPUT SECTION
VDC
GND
DC-DC CONVER-TER
VBUS
0 V
OUTPUT STAGE
CURRENT FEEDBACK
207
LED+
LED-
208
ISET+
ISET-
CTRL
MON
PRIMARY CONTROLLER
106
CTRL
MON
INTERFACE CIRCUIT
209
FEEDBACK
DALI+
DALI-
DALI INTERFACE
104
DALI RX
DALI TX
MICRO-CONTROLLER
205

Fig. 2

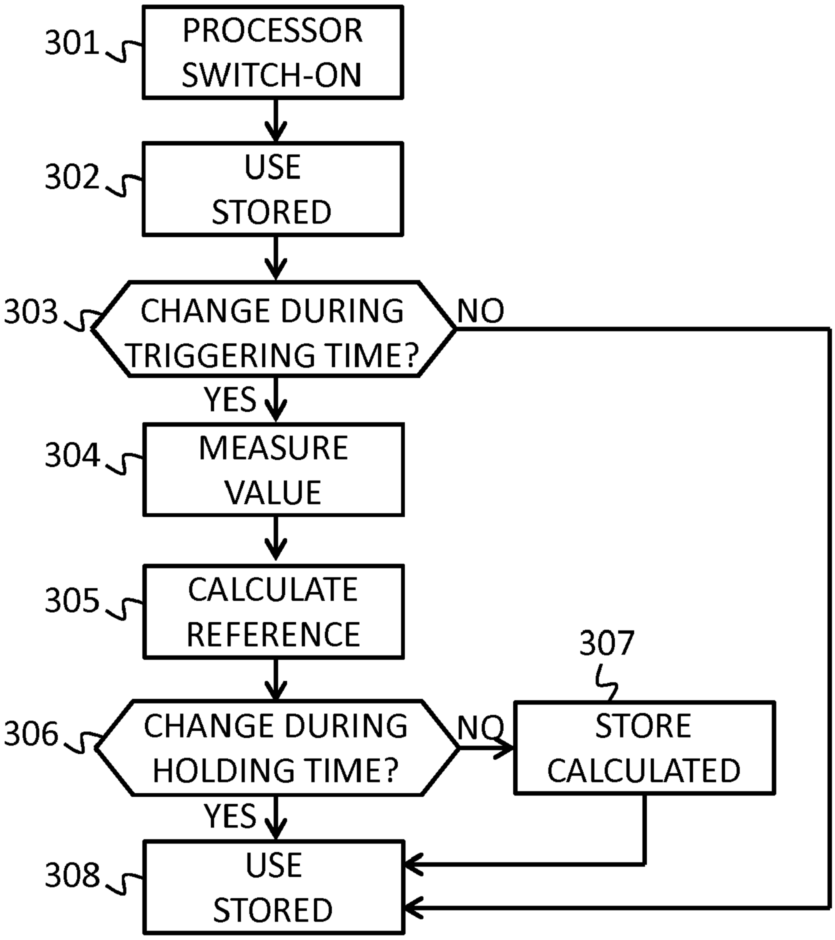

301
PROCESSOR SWITCH-ON
302
USE STORED
303
CHANGE DURING TRIGGERING TIME?
NO
YES
304
MEASURE VALUE
305
CALCULATE REFERENCE
307
306
CHANGE DURING HOLDING TIME?
NO
STORE CALCULATED
YES
308
USE STORED

Fig. 3

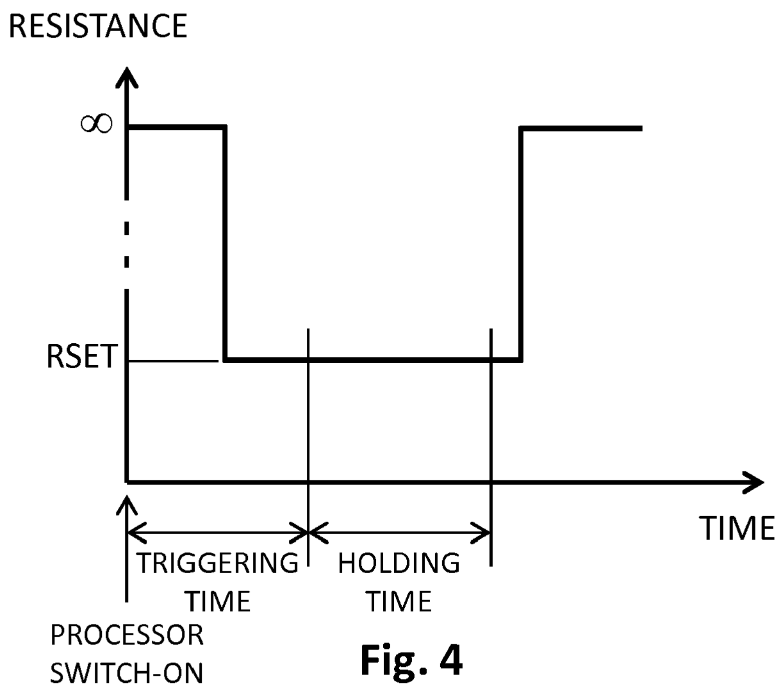

RESISTANCE
∞
RSET
TIME
TRIGGERING TIME
HOLDING TIME
PROCESSOR SWITCH-ON

Fig. 4

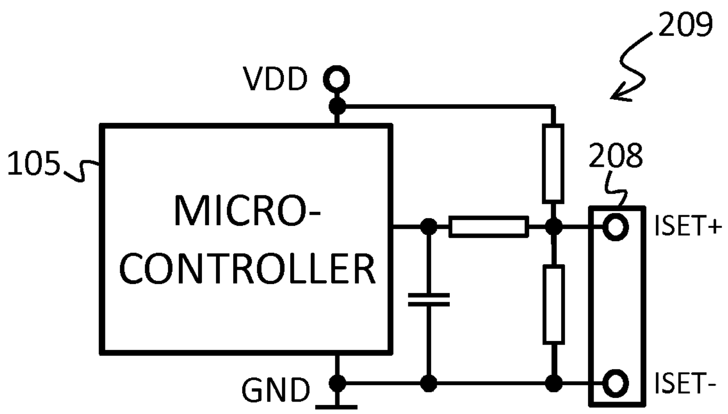

209
VDD
105
MICRO-CONTROLLER
208
ISET+
ISET-
GND

Fig. 5

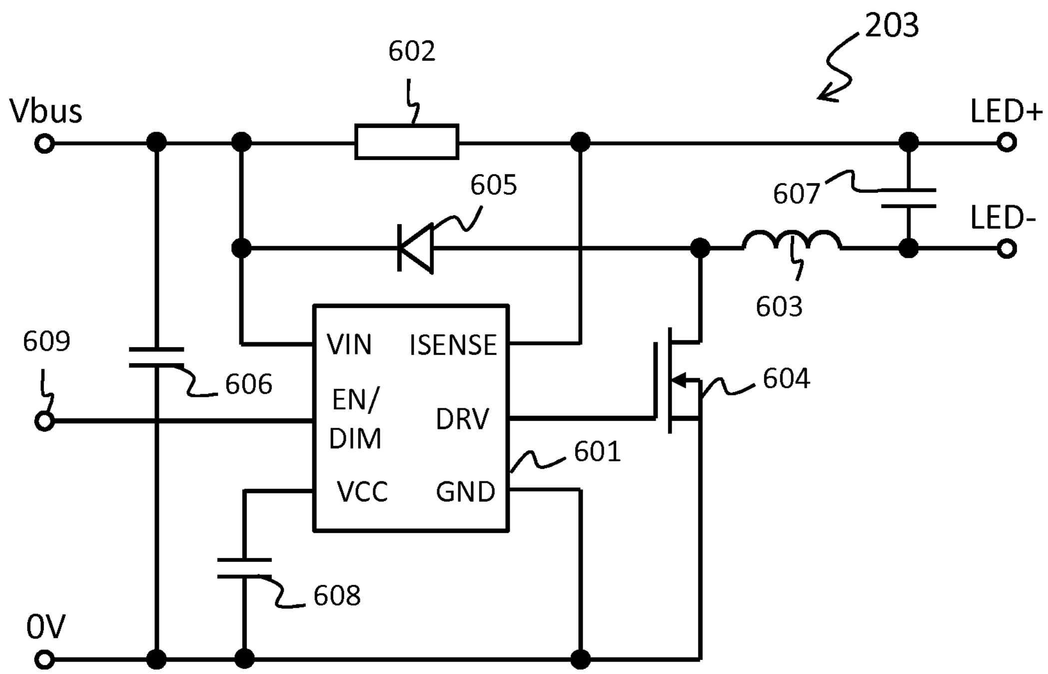

203
602
Vbus
LED+
605
607
LED-
603
609
606
VIN
ISENSE
EN/
DIM
DRV
604
601
VCC
GND
608
0V

Fig. 6

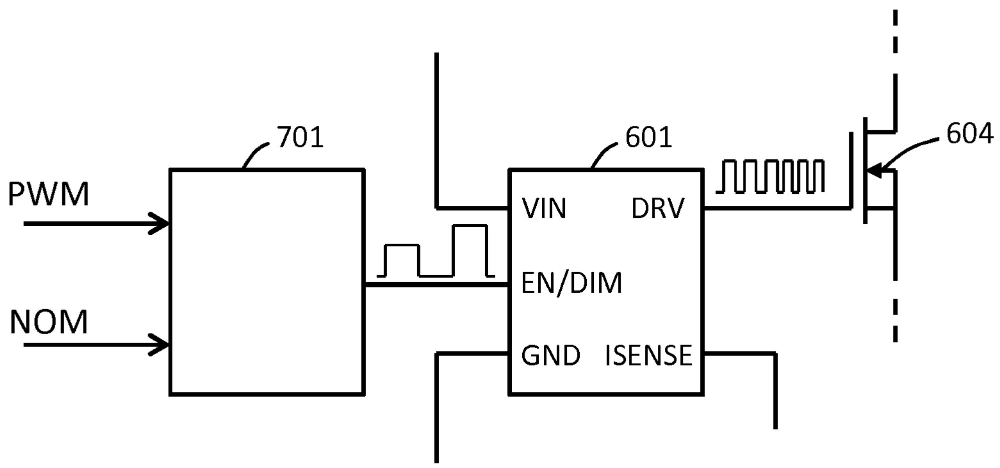

701
601
604
PWM
NOM
VIN
DRV
EN/DIM
GND
ISENSE

Fig. 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 15 16 2552

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2006/220625 A1 (CHAPUIS ALAIN [US]) 5 October 2006 (2006-10-05) * pages 2, 3; figures 2, 3 * -----	1-3,8,9, 11 4-7,10	INV. H05B33/08
X A	US 2012/187845 A1 (SAES MARC [NL] ET AL) 26 July 2012 (2012-07-26) * paragraphs [0095] - [0105] * -----	1-3,8,9, 11 4-7,10	
A	US 2006/226795 A1 (WALTER SCOTT D [US] ET AL) 12 October 2006 (2006-10-12) * paragraphs [0039] - [0041] * -----	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)
			H05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 October 2015	Morrish, Ian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 2552

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-10-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006220625 A1	05-10-2006	CN 101156123 A	02-04-2008
		EP 1866720 A1	19-12-2007
		KR 20070108279 A	08-11-2007
		US 2006220625 A1	05-10-2006
		WO 2006107426 A1	12-10-2006
US 2012187845 A1	26-07-2012	EP 2449854 A1	09-05-2012
		US 2012187845 A1	26-07-2012
		WO 2011002280 A1	06-01-2011
US 2006226795 A1	12-10-2006	AU 2006234972 A1	19-10-2006
		CA 2603640 A1	19-10-2006
		CN 101189917 A	28-05-2008
		EP 1867214 A1	19-12-2007
		JP 2008538053 A	02-10-2008
		US 2006226795 A1	12-10-2006
		WO 2006110340 A1	19-10-2006

EPO FORM P0459

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