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

(11) EP 2 600 694 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.06.2013 Bulletin 2013/23

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

(21) Application number: **11191353.9**

(22) Date of filing: **30.11.2011**

(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

(71) Applicant: **Vossloh-Schwabe Deutschland GmbH**
73660 Urbach (DE)

(72) Inventors:
- **Bachl, Bernhard**
  73642 Welzheim (DE)
- **Sulek, Jozef**
  026 01 Dolný Kubin (SK)

(74) Representative: **Rüger, Barthelt & Abel**
Webergasse 3
73728 Esslingen (DE)

(54) LED driver circuit with constant power safe operating area

(57) A drive circuit (20) is disclosed for powering an LED chain 11 even if the chain presents an unusual high forward voltage drop. This may be due to extraordinary low temperature, connecting more LEDs in the chain, aging or the like. It is considered to raise the DC voltage for powering the LEDs at least if those unusual high voltage drop conditions occur. If so, however, the LED current otherwise kept constant will be reduced in that second mode of operation. The DC voltage source (23) can be designed for a maximum power which is equal to a constant power in the second mode II of operation. Preferably, the reduction of the LED current is such that the power applied to the LEDs will be kept at a given constant value.

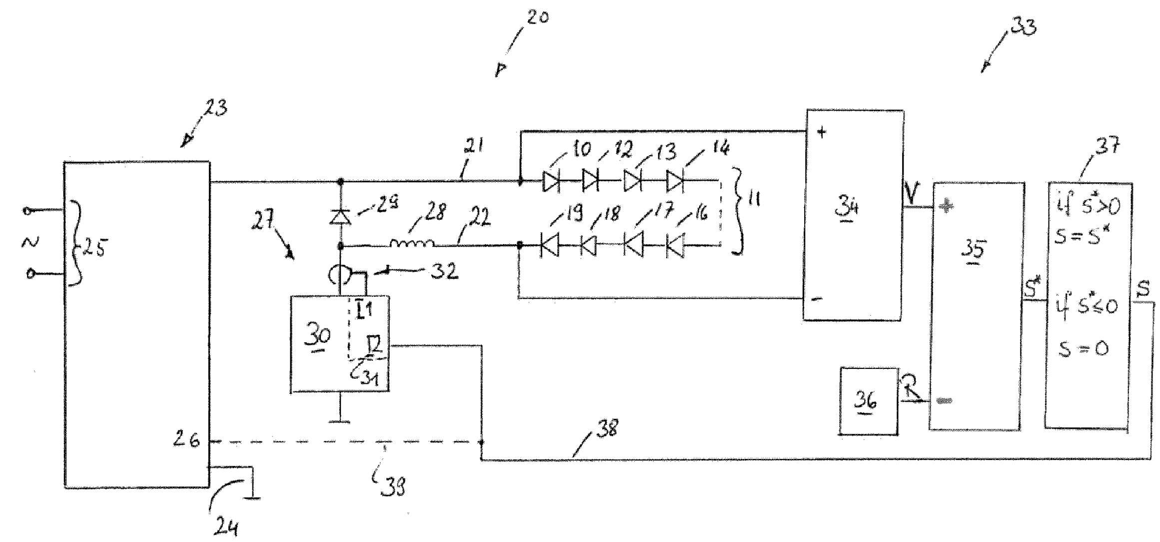

Fig. 1

EP 2 600 694 A1

Description

[0001] The invention relates generally to a driver circuitry for driving one or several LEDs and in particular to a driver circuitry for driving one or several LEDs for lighting purposes and/or for high power signalling purposes.

[0002] Driving circuits are known for providing current to LEDs by using switches and inductors which are periodically charged from a DC source and discharged to LEDs for providing current to them. Basically it is known to control the power supplied to the LEDs. WO 2010/118944 A1 discloses a circuitry of the switched inductor type in which the duty cycle of the switch is regulated for controlling the power to the LED. For doing so a signal representing the mean value of the LED current will be compared with a reference value and the duty cycle of the switch will be adjusted accordingly. Alternatively, the signal can be derived from the voltage across the LED.

[0003] While it is basically known to regulate the LED current according to the LED voltage or a given reference value, problems may arise if the LEDs are exposed to very low temperatures. The forward voltage of the LEDs increases very much if the LED is exposed to temperatures far below 0°C. The forward voltage may increase such that it reaches or even exceeds the voltage of the DC source the LED current is derived from. As a result it may be that the supply circuitry is not able to power the LEDs under those conditions. If so the LEDs do not light. If this occurs, dangerous situations may result. Increasing the DC voltage, however, can destroy the (very) cold LEDs even if the LED current is limited or kept constant at the rated current.

[0004] It is an object of the present invention to overcome at least one of the problems mentioned before.

[0005] The inventive LED power supply is basically adapted to supply LED current even if the forward voltage of the LEDs is heavily increased e.g. because of low temperatures. It may have an increased internal voltage DC source having a voltage which is higher than the, under worst conditions, largest expectable forward voltage of the LED or chain of LEDs connected to the supply. Even a safety margin may be present so that the DC voltage may be some volts above the highest expectable forward voltage.

[0006] The invention provides that the driver circuit comprises a converter circuit of any usable type. Preferably a buck-type converter is used for supplying current to the LED or chain of LEDs. The converter circuit can be operated in any suitable way, e.g. in a continuous current mode in which the switch is closed before the freewheeling current of the inductor reached zero. It may also be operated in different modes, e.g. the critical mode in which the switch is closed just when the freewheeling current of the inductor reaches Zero. Alternatively, it may be driven in an intermittent mode in which the switch is closed after a small amount of time in which the current remained zero. No matter what mode is used for operating the converter circuitry it may assume two different operational modes. A first mode is used during regular operation if the forward voltage of the LED or chain of LEDs is within an expected normal range. The converter circuit supplies current having a defined mean value to the LEDs in this first mode of operation. Alternatively the converter circuit may supply current having a defined root mean square value (RMS) to the LEDs in this first mode of operation. Furthermore the converter circuit may supply current having any other defined characteristic to the LEDs in this first mode of operation, as there is the peak value or the like.

[0007] The converter circuit may assume a second mode of operation if the forward voltage of the LED or chain of LEDs exceeds a given value. The second mode of operation is defined by supplying a reduced current to the LED or chain of LEDs. By using a reduced LED current in the second mode of operation, a safe operating mode is established. This extends the useful temperature range in which the LEDs may be operated. The LED current may be adjusted such that the LEDs will be safely heated up until reaching sufficient operating temperature and sufficiently low forward voltage. The converter circuit will switch into the first mode of operation if the forward voltage falls below a given reference value.

[0008] In a preferred embodiment the first mode of operation is a constant current operating mode while the second mode of operation may be a constant power operating mode in the sense explained above. The more the forward voltage exceeds the given reference value the lower will be the LED current. It is noted, however, that the second mode of operation may use different approaches. It is possible, for example, to supply a reduced fixed current to the LEDs which, in the second mode of operation, is considerably lower than the current in the first mode of operation.

[0009] In all embodiments it is possible to vary the DC source voltage internally provided for powering and supplying the buck converter. Preferably, the DC voltage is set to a first lower value for operating the driver circuit in the first mode of operation. Further it is preferred to set the DC source to a second higher value for operating the driver circuit in the second mode of operation. The transition may be done stepwise in one single larger or several smaller steps and in a continuous ramping transition process as well. It is also possible to raise the voltage of the DC source in a fixed relation to the LED forward voltage in the second mode of operation. So it is possible to keep constant the difference between the DC source voltage and the LED forward voltage. It is at least possible to keep positive the difference between the DC source voltage and the LED forward voltage.

[0010] Further advantages and aspects of the invention are to be taken from the drawings, the description and dependent claims.

[0011] Embodiments of the invention are to be taken from the drawings in which:

Figure 1 discloses the overall structure of the inventive driver circuit;

Figure 2 illustrates a signal indicating the voltage across the LED or chain of LEDs, reference signal and their difference.

Figure 3 illustrates a signal indicating the voltage across the LED or chain of LEDs if the voltage exceeds a given reference value;

Figure 4 illustrates the current through the LED or chain of LEDS in two different modes of operation of the driver circuit;

Figure 5 illustrates the current through the LEDs similar to Figure 3 according to another embodiment;

Figure 6 illustrates the basic structure of the inventive buck converter using a current signal for controlling the converter;

Figure 7 illustrates the buck converter of Figure 6 in more details; and

Figure 8 illustrates an alternative embodiment of the buck converter of Figure 6.

[0012] Referring to Figure 1 at least one LED 10, preferably however, a chain 11 of LEDs 10, 12, 13, 14, 16, 17, 18, 19 connected in series one to another is powered by an inventive driver circuit 20. The LEDs 10 to 19 of the chain 11 may be used to light outside areas or any other sites which are prone to highly varying temperatures as there are warehouses, cooled stores, lights on ships, aircrafts, stacks, wind turbines, cars, motorcycles, bicycles or the like. It is noted, however, that the invention is not restricted to applications mentioned before. To the contrary, it can be applied to all lighting or signalling applications for indoor and/or outdoor use.

[0013] The chain 11 is powered by the driver circuit 20, which supplies current to the LED chain 11 through lines 21 and 22. The voltage between the two lines 21, 22 is defined by the sum of the forward voltages of all LEDs 10 to 19 of the chain 11. In particular, for powerful lighting applications the number of LEDs may be that high that the total forward voltage may exceed 200 volts (e.g. 240 V). It is noted that further chains of LEDs may be connected in parallel to chain 11. Also groups of LEDs may be connected in parallel one to another. That, however, does not change anything to the forward voltage which also in those cases may be relatively high and increase with lower temperatures or for other reasons.

[0014] The driver circuit 20 comprises a DC power source 23, which provides DC voltage on line 21. The other end of the DC voltage source 23 is grounded at 24. DC voltage source 23 may provide a fixed DC voltage which is well above the forward voltage of the chain 11 under all circumstances. This is in particular true if the forward voltage of the LEDs is varying due to external facts like temperature, aging or the like. However, as an alternative concept in all embodiments disclosed and described above and/or below, the DC voltage source 23 may produce a variable voltage which may be low but still exceeding the forward voltage of the chain 11 if the forward voltage has a first lower value, and which DC voltage is rather high if the forward voltage of the chain 11 is increased for one reason or another. So it can always be made sure that the DC voltage at line 21 exceeds the forward voltage of the chain 11 by all means.

[0015] The DC voltage source 23 may be of any suitable type. Preferably, it is powered by the mains supply or any other source, which can be AC or DC of higher or lower voltage. For connecting with the mains, DC source 23 comprises a mains input 25. Any usable power factor correction circuit (PFC) may be used for generating DC power from the alternating mains voltage. The power factor correction circuit may be from the isolating type if desired. It may comprise a rectifier unit and a step-up converter connected thereto. It may be of the fixed output voltage type. Alternatively, it may comprise a control input 26 for receiving a signal S and will adjust the output DC voltage accordingly.

[0016] The current for powering the LED chain 11 is supplied by a buck converter 27 drawing current from line 21 through the series connection of the LED chain 11 and an inductor 28. The inductor 28 may be connected to line 22 as illustrated in Figure 1 or be connected to line 21, alternatively. It may as well be split into two inductors connected to lines 21 and 22, accordingly. A diode 29 provides a freewheeling part for the LED current I_{LED} and closes a conductive loop. The buck converter 27 further comprises a switch arrangement 30 comprising a switch for providing a conductive path from line 22 to the ground 24. Further it comprises a drive circuit 31 for controlled closing and opening the switch. The drive circuit 31 of the switching arrangement 30 comprises at least one input I1, which is connected to a current sensing means 32, which is adapted to sense at least a portion of the current I_{LED} flowing through the LED chain 11. Current sensing means 32 may be placed at any suitable branch or node of the circuit.

[0017] The controller 31 comprises another input I2 for receiving a signal S indicating the forward voltage present at the chain 11.

[0018] The inventive drive circuit 20 comprises a mode selector unit 33, which is connected to the LED chain 11 and the control input 12. The mode selector unit 33 comprises a differential amplifier unit 34 the inputs of which are connected to both ends of the chain 11 e.g. to lines 21 and 22. The output of the differential amplifier unit 34 is connected to a block 35 which is differential amplifier, for subtraction the reference signal R provided by a block 36 from the output signal V provided by a block 34. The output signal of the block 35 is a signal S* which is supplied to a block 37. Logic block 37 passes the signal S* to its output were it appears as signal S. If the signal S*, however, is smaller as, or equal to, zero the output signal S will be zero too. The signal S is supplied to the control input I2 via line 38 and optionally to control input 26, if present.

[0019] In operation, DC voltage source 23 provides a fairly high voltage of approximately 460 V (DC) or any other suitable value. It is assumed that the forward voltage of the LED chain 11 is well below that value. The forward voltage may be for example 240 V. The driver circuit 20 assumes a first mode I of operation, which is a current controlled mode of operation. The forward voltage across the LED chain 11 is sensed by the differential amplifier unit 34, which presents a respective signal to one input of block 35. Block 35 subtract the reference value R of block 36 from output signal V provided by a block 34. If the output of differential amplifier 34 is smaller than the reference value supplied by block 36 the signal S* is below Zero. If, however, the output of the differential amplifier 34 exceeds the reference value provided by the block 36, the signal S* will be positive and the block 37 will set the signal S equal to S*.

[0020] In normal operation the forward voltage across the chain 11 is below a certain limit. The signal V at the output of the differential amplifier 34 is smaller than the reference signal R. Consequently no signal S is present on line 38. In terms of block 37 the signal S is zero. This state characterizes the first mode I of operation. The controller 31 does not receive a significant control signal from block 37. The only thing controller 31 does, is controlling the switch of the buck converter 27 in any suitable way for keeping the average value (or any other feature defining the strength of the current) of the LED current I_{LED} flowing through lines 21 and 22 equal to a desired constant value. Consequently, the first mode I of operation is a current controlled mode. The strength of the current is not dependent in any way from the forward voltage when being in that first mode I of operation. It is noted that the current flowing through the chain 11 is ramping up and down and may be even zero, periodically. However, the mean value thereof is kept constant.

[0021] If however, for what reason ever, the forward voltage across the chain 11 exceeds a given value, the driver circuit 20 assumes a second mode II of operation. The increase of the forward voltage may be due to very low temperature or other reasons. Block 35 will now find the output signal V exceeding the reference value R and present a positive interim signal S* at its output. Consequently, the block 37 presents a positive signal S which is fed to the control input I2 line 38. The result being that the buck converter 27 reduces the current fed to the lamp circuit, which is formed by the chain 11 and the inductor 28. The reduction of the current is preferably tuned such that the product of the mean current through the chain 11 and the mean forward voltage is kept to constant desired value.

[0022] Figure 2 illustrates a signal V provided by a block 34 indicating the voltage across the LED or chain of LEDs, reference signal R provided by a block 36 and their difference S*.

[0023] For illustrating the two different modes of operation reference is made to Figure 3. While the signal S remains zero (or inactive in any other way) if the forward voltage U_{LED} is below a critical value R* the constant current mode e.g. the first mode I of operation is taken. If however the forward voltage U_{LED} exceeds the given value R* the constant current operational mode e.g. the second mode II of operation is assumed.

[0024] Figure 4 illustrates the dependency of the LED current I_{LED} and the forward voltage U_{LED}. Depending on whether the forward voltage U_{LED} exceeds a set value R* the first constant current mode of operation or the second constant power mode of operation is assumed. (The output R of the block 36 defines a reference value for the signal V which is related to the forward voltage. The reference value R* however compares directly to the forward voltage.)

[0025] It is noted that numerous modifications can be made on the invention. Figure 5 illustrates the behaviour of the LED current I_{LED} dependent from the forward voltage U_{LED} with dramatically reduced power in the second mode II of operation. While the first mode I of operation is equal to the first modes described before the second mode II* reduces the current more than described before. Consequently, the power supplied to the LED chain 11 will stay below limits and not be constant which, however, may be tolerable or even favourable.

[0026] If, in a modified embodiment, the line 39 is present according to Figure 1 another modification of the operation is possible. In this case the DC voltage source 23 will keep the DC voltage at line 21 to a somewhat lower value as long as signal S is zero. It will switch the DC voltage to a somewhat higher value at line 21 if the signal S is present and above zero. Alternatively, it is possible to raise the DC voltage at line 21 in proportion to, or otherwise dependent of, signal S on line 39. So it is made sure that the voltage at line 21 is always above the forward voltage U_{LED} across the chain 11, no matter whether the LEDs are very hot or very cold. On the other hand, it is made sure that the voltage of the DC source 23 minus the voltage across the chain 11 will not exceed a set value of e.g. 20V or 30V in any operating state. Thus it is possible to use relatively small inductors and a relatively narrow range of duty cycles and frequencies in the switch arrangement 30.

[0027] Figure 6 illustrates the basic structure of the inventive driver circuit 20 using a current i signal for representing the signal S. The current i signal is fed to a current sensing shunt 40 which is used as the current sensing means 32. Both, the current i signal and the LED current I_{LED} are fed through the shunt 40 which is connected to a signal input IS of the buck converter 27. The signal input IS replaces inputs I1 and I2 of the switching arrangement 30 of figure 1. Further blocks 34, 35 and 37 are unified to one single block in figure 6. Block 42 of figure 6 transforms the voltage signal into a current signal.

[0028] In the first mode I of operation the current i signal is zero. Consequently, the shunt 40 senses just the LED current I_{LED}. The driver circuit 20 is in the current control mode.

[0029] If the current i signal is positive the current i signal adds to the LED current I_{LED} so that the buck converter tries to keep constant the sum of the LED current I_{LED} and the current i signal. Consequently, it reduces the LED current I_{LED}.

[0030] Figure 7 illustrates a somewhat modified embodiment of the driver circuit 20 of figure 6. The buck converter 27 uses a switch 41 connected in series with the shunt 40. The voltage dropping on the shunt 40 is supplied to the control input IS via a resistor R1. The current i signal is supplied to the same control input IS via a resistor R2. Transforming the signal S into a current i signal is done by U/I converter 42. It uses an operational amplifier in a basically known application.

[0031] Operational amplifier OPA 1 is rail-to-rail input/output type with single supply voltage which provides on the output OPA 1 the signal S.

[0032] Similarly, the blocks 34, 35 and 37 are built using at least one operational amplifier in a known wiring.

[0033] As can be seen, two currents are fed into the input IS which currents are the current i signal and another current defined by the voltage across the shunt 40 and the resistor R1. The latter characterizes the LED current. If the current i is zero, the controller 31 will operate the switch 41 in a way for keeping the LED current I_{LED} constant. If, however, the current i adds to the current flowing through the resistor R2 the controller 41 will reduce the current flowing through the LED chain 11. Preferably, the reduction is adjusted such that the power supplied to the LED chain 11 will be kept constant.

[0034] The same is true for the modified buck converter illustrated in figure 8. The only difference is to be found in the wiring of the LED chain 11, the diode 29, the inductor 28 and the switch 41. However, the description given to Figure 1 to 7 totally applies to the modified buck converter of Figure 7 in regard to the structural description and to the functional description as well.

[0035] A drive circuit 20 is disclosed for powering an LED chain 11 even if the chain presents an unusual high forward voltage drop. This may be due to extraordinary low temperature, connecting more LEDs in the chain, aging or the like. It is considered to raise the DC voltage for powering the LEDs at least if those unusual high voltage drop conditions occur. If so, however, the LED current otherwise kept constant will be reduced in that second mode II of operation. Preferably, the reduction of the LED current is such that the power applied to the LEDs will be kept at a given constant value.

Parts List:

[0036]

10	LED
11	chain of LEDs
12 — 19	LEDs
20	Driver Circuit
21	Line
22	Line
23	DC Voltage Source
24	Ground
25	Mains Input
26	Control Input
27	Buck Converter
28	Inductor
29	Diode
30	Switching Arrangement
31	Controller
32	Current Sensig Means
i1	Current Sensing Input
i2	Control Input
is	Current Sensing Input
33	Mode Selecting Unit
34	Differential Amplifier Unit 1
35	Differential Amplifier Unit 2
36	Reference Value Block
37	Block
38	Line
39	Line
40	Shunt
41	Switch
42	V/I Converter

Claims

1. Driver circuit (20) for driving an LED (10) or a chain of LEDs (11) for signalling or lighting purposes comprising:

   a converter circuit (27) adapted to supply to the LED (10) or chain (11) of LEDs i) constant current in a first mode (I) of operation and ii) decreased current in a second mode (II) of operation;
   a mode selecting unit (33) for producing a signal (i, s) indicating the voltage (U_{LED}) across the LED (10) or chain (11) of LEDs if the voltage (U_{LED}) or a signal (V) derived therefrom exceeds a given reference value (R);
   the converter circuit (27) comprising an input (i2, is) being connected to the sensing circuit (34) for receiving the signal (i, s), wherein the converter circuit (27) is operated in the first mode (I) of operation, if the signal (i, s) indicates the voltage (U_{LED}) or the signal (V) derived therefrom being below the given reference value (R), and wherein the converter circuit (27) is operated in the second mode (II) of operation, if the signal (i, s) indicates the voltage (U_{LED}) or the signal (V) derived therefrom being above the given reference value (R).

2. Driver circuit according to claim 1, wherein the mode selecting unit (33) comprises a differential amplifier (34, OPA1) having a first input (+) connected to anode of the LED (10) or chain (11) of LEDs and having another input (-) connected to cathode of the LED (10) or chain (11) of LEDs.

3. Driver circuit according to one of the preceding claims, wherein the mode selecting unit (33) comprises a differential amplifier (35) having at least one input for receiving a signal (V) which is proportional to the voltage across the LED (10) or chain (11) of LEDs and another input for receiving the reference signal (R).

4. Driver circuit according to one of the preceding claims, wherein a module (37) is provided for setting the signal (i, s) to zero if the voltage across the LED (10) or chain (11) of LEDs or the signal (V) derived therefrom does not exceed the given value (R).

5. Driver circuit according to one of the preceding claims, wherein a module (37) is provided for setting the signal (i, s) to a positive nonzero value, if the voltage across the LED (10) or chain (11) of LEDs or the signal (V) derived therefrom does exceed the given value (R).

6. Driver circuit according to one of the preceding claims, wherein a module (37) is provided for setting the signal (i, s) to a value, which is proportional to the difference between the voltage across the LED (10) or chain (11) of LEDs or the signal (V) derived therefrom, and the given reference value (R), if the voltage across the LED (10) or chain (11) of LEDs or the signal (V) derived therefrom does exceed the given value.

7. Driver circuit according to one of the preceding claims, wherein the signal (s) is an electrical current (i).

8. Driver circuit according to one of the preceding claims, wherein the converter circuit (27) comprises a current sensing input (is) connected to a shunt (40) the LED (10) or chain (11) of LEDs current is fed to.

9. Driver circuit according to claims 7 and 8, wherein the signal (i, s) is fed to the current sensing input (i2, is) whereby the signal (i) current adds to a signal caused by the LED current (I_{LED}).

10. Driver circuit according to one of the preceding claims, wherein the decreased current (I_{LED}) is adjusted such that any power produced by the LED (10) or chain (11) of LEDs will not exceed a set maximum power in any operating state.

11. Driver circuit according to one of the preceding claims, wherein the supply circuit (20), in the second mode (II) of operation, supplies constant power to the LED (10) or chain (11) of LEDs.

12. Method for driving an LED (10) or a chain (11) of LED for lighting and signalling purposes comprising:

   sensing the voltage across the LED (10) or chain (11) of LEDs,
   supplying to at least one LED (10) or chain (11) of LEDs constant current (I_{LED}) if the voltage (U_{LED}) or a signal (V) derived therefrom is below a given reference value (R),
   supplying to at least one LED (10) or chain (11) of LEDs decreased current (I_{LED}) if the voltage (U_{LED}) or a signal (V) derived therefrom is above the given reference value (R).

13. Method according to claim 12, **characterized by** providing a signal (s) which is neutral if the voltage (U_{LED}) across the LED (10) or chain (11) of LEDs or a signal (V) derived therefrom is below the reference value (R) and which is different from zero and proportional to Voltage (U_{LED}) across the LED (10) or chain (11) of LEDs if the Voltage (U_{LED}) across the LED (10) or chain (11) of LEDs or a signal (V) derived therefrom is above the reference value (R), and adding the signal (s) to another signal derived from

the current flowing through the LED (10) or chain (11) of LEDs.

14. Method according to claim 12, **characterized by** providing a current (i) which is zero if the voltage (U_{LED}) across the LED (10) or chain (11) of LEDs or a signal (V) derived therefrom is below the reference value (R) and which is different from zero and proportional to Voltage (U_{LED}) across the LED (10) or chain (11) of LEDs if the Voltage (U_{LED}) across the LED (10) or chain (11) of LEDs or a signal (V) derived therefrom is above the reference value (R), and adding the current (i) to another current derived from a voltage caused by a current flowing through a shunt (40) and characterizing the current (I_{LED}) flowing through the LED (10) or chain (11) of LEDs.

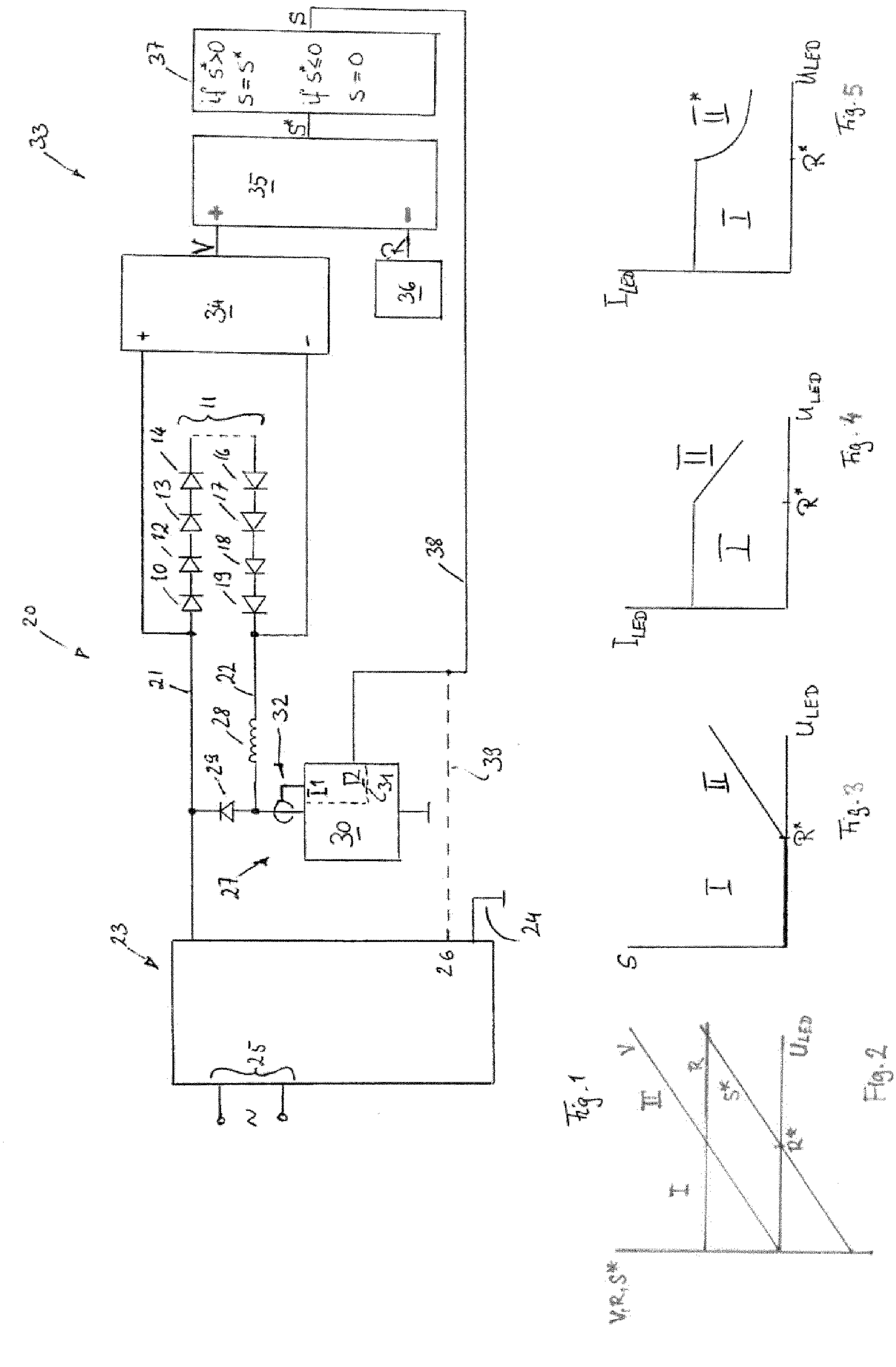
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
if S* > 0
S = S*
if S* ≤ 0
S = 0
V
R
S*
S
R*
I
II
II*
ILED
ULED
V,R,S*
10
11
12
13
14
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39

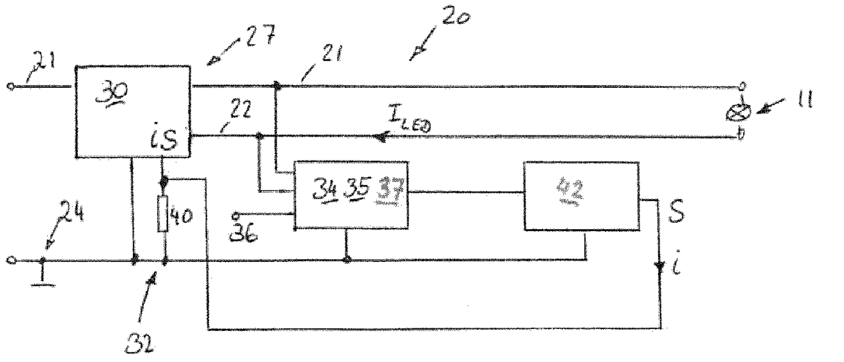

Fig. 6

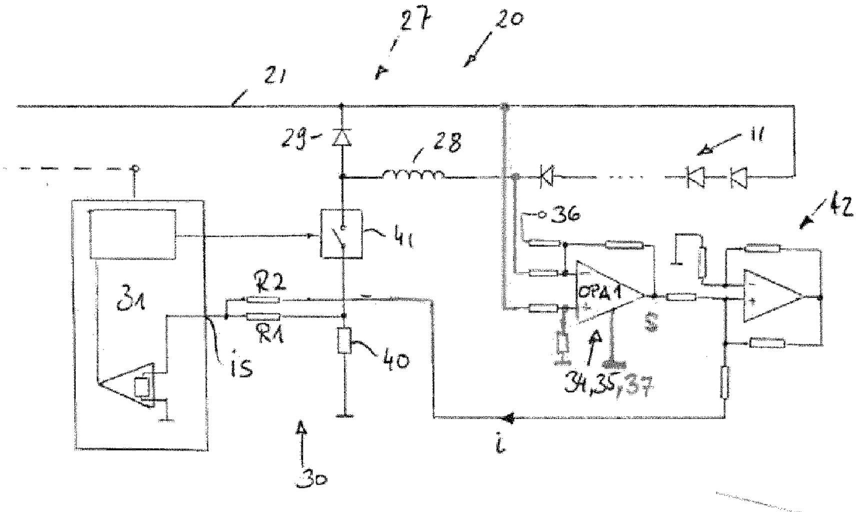

Fig. 7

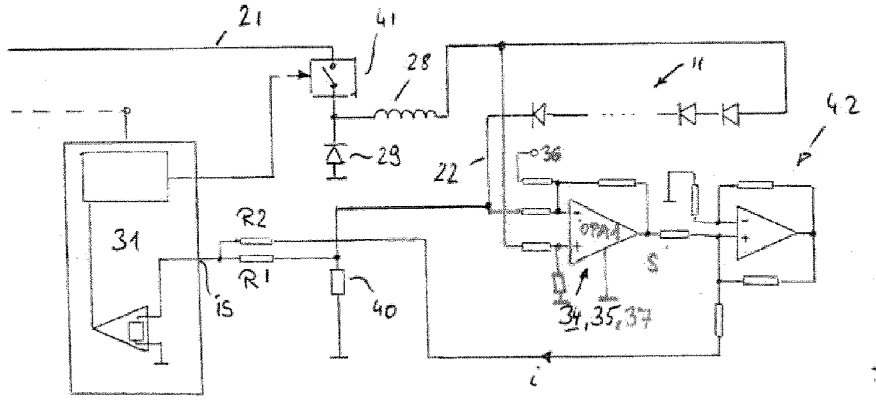

Fig. 8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 11 19 1353

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2004/155844 A1 (STOPA JAMES L [US]) 12 August 2004 (2004-08-12) * paragraph [0052] - paragraph [0055]; figures 1,9A *	1,12	INV. H05B33/08
A	US 2011/254530 A1 (HULETT JEFFERY NEIL [US]) 20 October 2011 (2011-10-20) * paragraph [0052]; figure 6 *	1,12	
A	EP 0 482 520 A1 (FUJITSU LTD [JP]) 29 April 1992 (1992-04-29) * abstract; figures 2,3 *	1,12	
A	WO 2010/025450 A2 (CIRRUS LOGIC INC [US]; MELANSON JOHN LAURENCE [US]) 4 March 2010 (2010-03-04) * paragraph [0028] - paragraph [0029]; figure 6 *	1,12	

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 April 2012	Brown, Julian

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 19 1353

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.

19-04-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004155844 A1	12-08-2004	NONE	
US 2011254530 A1	20-10-2011	US 2011254530 A1	20-10-2011
		WO 2011130535 A1	20-10-2011
EP 0482520 A1	29-04-1992	DE 69107276 D1	23-03-1995
		DE 69107276 T2	20-07-1995
		EP 0482520 A1	29-04-1992
		JP 4157771 A	29-05-1992
		US 5341086 A	23-08-1994
WO 2010025450 A2	04-03-2010	CN 102282912 A	14-12-2011
		GB 2474994 A	04-05-2011
		WO 2010025450 A2	04-03-2010

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2010118944 A1 **[0002]**