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(54) IMPROVED LED SHORT CIRCUIT AND OPEN LOAD DETECTION WITH A SINGLE CONTROLLER PIN

(57) The invention relates to an isolated LED driver (200) with open circuit and short-circuit at one pin, comprising: a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver (200), means for detecting the voltage (202) on the secondary side of the isolation stage and producing a voltage-representing signal, means for detecting the current (204) flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver (200), and producing a current-representing signal, and means combining for a current-representing signal, optionally the decoupled AC component of the current representing signal, with the voltage representing signal and feeding it to an input pin of the control unit.

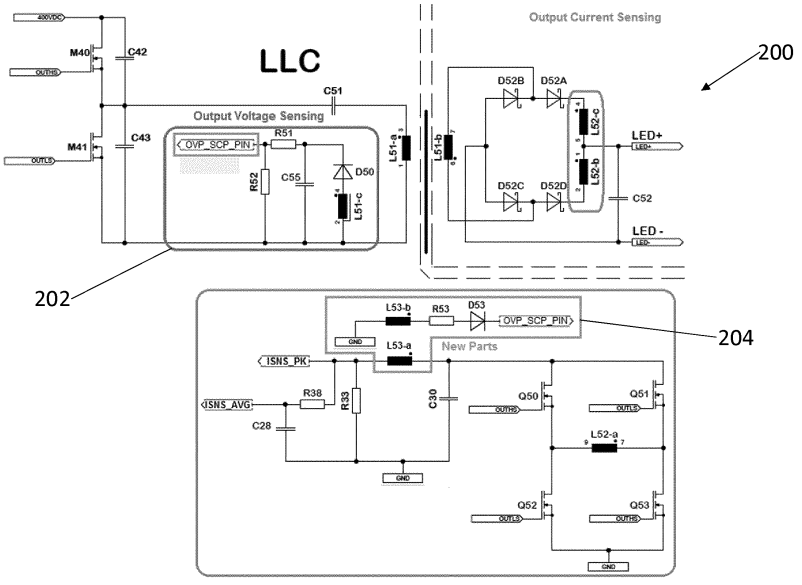

Fig. 2

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a switched isolated LED driver with a circuitry for detecting a short circuit and an open load condition on the secondary side of an isolation stage.

BACKGROUND OF THE INVENTION

[0002] In currently available LED gears, with e.g. a half-bridge LLC resonant circuit as at least one stage of a LED driver, the following two approaches are used to detect secondary side errors, namely short-circuit and over voltage conditions, as described in the following.

[0003] The first approach makes use of two separate controller (microcontroller or ASIC) pins, wherein one pin is used to evaluate the sensed output (LED) voltage e.g. to detect an open load condition when the secondary side voltage exceeds a given threshold. Another pin is used to evaluate the sensed output (LED) current. The first pin utilizes a comparator to detect over voltage (open load) conditions, the second pin utilizes a comparator to detect over current (short circuit) conditions. In Fig. 1, such a situation is shown, wherein the output voltage sensing module generates the voltage signal V_{SNS} which is given as input in a pin of a controller, while the output current sensing module generates the current signal I_{SNS_PK} which is given as input to another pin of the controller.

[0004] With this approach open load and short circuit can both be detected fast, because positive edges are used in both cases as detection criteria. As the sensing circuity uses peak hold circuits (namely, rectifier diode and filter capacitor) the sensed voltage can follow the real output voltage very fast in positive going direction. However, it follows slow in negative going direction as it takes some time for the filter capacitor to discharge.

[0005] The second approach makes use of only one controller pin, wherein only the output (LED) voltage is evaluated. Two comparators are used: one to detect over voltage (open load) conditions and one to detect under voltage (short circuit) conditions.

[0006] In this approach the reaction times (time until the error is detected) depend on the filtering of the sensed output voltage signal. If the sensed secondary side voltage of the LLC (output voltage) is fed to a peak hold circuit (namely, rectifier diode and filter capacitor), over voltage conditions can be detected very fast (because peak hold capacitor is charged immediately). However, under voltage (short circuit) conditions are detected delayed, because it takes some time for the peak hold capacitor to discharge. This leads to the problem that high output currents flow for several milliseconds that could probably destroy parts of the circuit.

[0007] In the case where an LED load open and short-circuit situation in a micro-controller based control circuit is detected by an ADC measurement of LED voltage, a slow response (about 10 to 100ms to detect) occurs. For precautionary measure under LED open condition, a Zener diode is connected across the LED load to prevent the further rise of LED voltage, before the micro-controller can act by shutting down the LED driver. For SELV products the voltage overshoot value requirement is quite tight and Zener diode as well as ADC tolerance becomes unacceptable. Further the short-circuit detection based on LED voltage detection needs to be fast enough before the current rises and causes a voltage drop across the short-circuit or low load voltage condition which can cause the sensed voltage above the detection threshold.

[0008] Furthermore, using a small size micro-controller poses a considerable challenge in wisely using the available pins (and associated analog and digital resources) by multi-tasking them to achieve all the advanced functionality or features of an, e.g., emergency LED driver, as it is the case when there is a quest to combine the sensing of LED open or short-circuit situation.

[0009] Thus, it is an objective to provide an improved LED driver allowing to efficiently detect short current and over voltage conditions, all by reducing the complexity and especially the pin number requirements.

SUMMARY OF THE INVENTION

[0010] According to a first aspect of the invention, an isolated LED driver with open circuit and short-circuit at one pin is provided. The isolated LED driver comprises a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver, means for detecting the voltage on the secondary side of the isolation stage and producing a voltage-representing signal, means for detecting the current flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver, and producing a current-representing signal, and means combining for a current-representing signal, optionally the decoupled AC component of the current representing signal, with the voltage representing signal and feeding it to an input pin of the control unit.

[0011] Advantageously, while only utilizing one controller pin, this aspect of the invention allows fast detections of both over voltage and over current conditions. In fact, in this approach, two different signals (one representative for the output voltage and one representative for the output current) are fed to a single controller pin.

[0012] In a preferred embodiment, the current representing signal is supplied to a further input of the control unit for a feedback control of the LED load current.

[0013] In a further preferred embodiment, the control unit is a microcontroller or an application-specific integrated circuit, ASIC.

[0014] In a further preferred embodiment, the means for detecting the voltage on the secondary side of the isolation stage comprise an analog to digital converter, ADC.

[0015] In a further preferred embodiment, the LED driver comprises a LLC converter.

[0016] In a further preferred embodiment, the control unit is further configured to compare the current representing signal with a threshold value in order to derive regulation values for the LLC current transformer, for example, a frequency, a duty cycle value or an actuating variable.

[0017] In a further preferred embodiment, the means for combining the current representing signal further comprises a diode for combining the current representing signal with the voltage representing signal to obtain a total signal.

[0018] In a further preferred embodiment, the control unit further comprises a comparator configured to compare the total signal to a threshold value and, if the total signal is higher than the threshold value, to detect a short-circuit condition or an over voltage condition.

[0019] This has the advantage that, LED over-voltage detection and over-current detection are performed, while using a single micro-controller pin by using its on-board high-speed comparator.

[0020] In a further preferred embodiment, the comparator is a comparator with variable reference and polarity.

[0021] In a further preferred embodiment, the comparator is a comparator with single reference.

[0022] In a further preferred embodiment, the control unit is configured to switch off the means for combing the current representing signal in the short-circuit condition or over voltage condition.

[0023] According to a second aspect of the invention, a method for an isolated LED driver is provided. The method comprises the steps of: controlling at least one switch on the primary side of an isolation stage of the LED driver, detecting the voltage on the secondary side of the isolation stage and producing a voltage-representing signal, detecting the current flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver; producing a current-representing signal; combining for a current-representing signal, optionally a decoupled AC component of the current representing signal, with the voltage representing signal; and feeding it to an input pin of the control unit.

[0024] According to a third aspect of the invention, an isolated LED driver with open circuit and short-circuit at one pin is provided. The isolated LED driver comprises a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver, means for detecting the voltage on the secondary side of the isolation stage and producing a voltage-representing signal, a comparator supplied with the voltage representing signal at its non-inverted input, wherein the reference level of the comparator and, in synchronization therewith, the polarity of the comparator output signal are switched in order to produce a signal indicating, in time multiplex a LED load open circuit and short-circuit indicating signal.

[0025] According to a fourth aspect, a method for an isolated LED driver is provided. The method comprises the steps of controlling at least one switch on the primary side of an isolation stage of the LED driver; detecting the voltage on the secondary side of the isolation stage and producing a -voltage-representing signal; and switching the reference level of a comparator and, in synchronization therewith, the polarity of the comparator output signal in order to produce a signal indicating, in time multiplex, a LED load open circuit and short-circuit indicating signal, wherein the comparator is supplied with the voltage representing signal at its non-inverted input.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Fig. 1 shows an exemplary circuit of an LED driver according to prior art;

Fig. 2 shows an exemplary embodiment of a circuit of an isolated LED driver according to the invention;

Fig. 3 shows exemplary behaviors of current I_{LED} and voltage V_{LED} in an isolated LED driver according to the invention;

Fig. 4 shows an exemplary embodiment of a comparator according to the invention;

Fig. 5 shows an exemplary embodiment of an LED driver according to the invention;

Fig. 6 shows exemplary embodiments of behaviors of a voltage V in an isolated LED driver as a function of time according to the invention;

Fig. 7 shows a method for an isolated LED driver according to an embodiment; and

Fig. 8 shows a further method for an isolated LED driver according to an embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] Aspects of the present invention are described herein in the context of an isolated LED driver.

[0028] The present invention is described more fully hereinafter with reference to the accompanying drawings, in which various aspects of the present invention are shown. This invention however may be embodied in many different forms and should not be construed as limited to the various aspects of the present invention presented through this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. The various aspects

of the present invention illustrated in the drawings may not be drawn to scale. Rather, the dimensions of the various features may be expanded or reduced for clarity. In addition, some of the drawings may be simplified for clarity. Thus, the drawings may not depict all of the components of a given apparatus.

[0029] Various aspects of an isolated LED driver will be presented. However, as those skilled in the art will readily appreciate, these aspects may be extended to aspects of LED drivers without departing from the invention.

[0030] It is further understood that the aspect of the present invention might contain integrated circuits that can be readily manufactured using conventional semiconductor technologies, such as complementary metal-oxide semiconductor technology, short "CMOS". In addition, the aspects of the present invention may be implemented with other manufacturing processes for making optical as well as electrical devices. Reference will now be made in detail to implementations of the exemplary aspects as illustrated in the accompanying drawings. The same references signs will be used throughout the drawings and the following detailed descriptions to refer to the same or like parts.

[0031] Now referring to Fig. 2, an exemplary embodiment of a circuit of an isolated LED driver 200 with open circuit and short-circuit at one input terminal ("pin") of a preferably integrated control circuitry in according to the invention is shown.

[0032] The isolated LED driver 200 comprises a control unit (not shown in Fig. 2) controlling at least one switch on the primary side of an isolation stage of the LED driver 200. The switching of the switch determines the power supplied to a LED load and especially the LED current. Thus, the LED current may be feedback-controlled back to the control circuitry by a current signal representing the LED current. The control circuitry compares LED current signal with a nominal value (which may be varied for a dimming control) and controls the switching of the switch.

[0033] The LLC comprises a half-bridge DC/AC converter with two serially connected switches (FETs), M40, M41. The half-bridge arrangement M40, M41 is fed with a DC voltage. The mid-point of the switches M40, M41 is connected to a resonance capacitor C51 and the primary side winding L51a of the transformer of the LLC. The primary side winding L51a of the transformer of the LLC is coupled with a secondary side winding L51b connected to a rectifier, which in the example is a diode arrangement D52a, D52b, D52c and D52d. The diodes may be Schottky diodes. The shown example represents a full-bridge rectifier. However, alternatively a middle-tapped rectifier may be used.

[0034] The output of the rectifier (diode arrangement) is fed to a capacitor C52, the DC voltage of which is applied to output terminals LED+ and LED- for supplying a LED load.

[0035] Furthermore, on the secondary side two primary side windings L52b, L52c of a sensing transformer for the secondary side current to the secondary side voltage are provided.

[0036] The primary side windings of the sensing transformers L52b, L52c are coupled with a secondary side of the sensing transformer L52a.

[0037] On the basis of the voltage across the secondary side winding L52a of the sensing transformer, a signal ISNS PK indicating the peak current of the LED current is generated as well as a further signal ISNS_AVG indicating the average value of the LED current. Both signals ISNS_PK and ISNS_AVG can be used by the control circuitry 2 as feedback signals in order to set the clocking of the half-bridge switches M40, M41.

[0038] According to the invention the AC component of the LED current is decoupled via a transformer L53a, L53b in order to generate a signal which may be sent to a sensing terminal OVP_SCP_PIN of the control circuitry.

[0039] As furthermore, shown in Fig. 2, this signal representing the decoupled AC component of this sensed LED current is thus combined with a signal produced by the circuitry 202 sensing, using a further transformer L51c, L51b, the voltage on the secondary side of the power transformer of the transformer L51a, L51b of the LLC.

[0040] Moreover, the LED driver 200 comprises means for detecting the voltage on the secondary side of the isolation stage 202 and producing a voltage-representing signal. Furthermore, the LED driver 200 comprises means for detecting the current flowing on the secondary side 204, and especially the current through an LED load when connected at supply terminals of the LED driver, and producing a current-representing signal, means combining for a current-representing signal, optionally the decoupled AC component of the current representing signal, with the voltage representing signal and feeding it to an input pin of the control unit OVP_SCP_PIN in Fig. 2.

[0041] This provides the advantage that the pins of the control unit, e.g. a microcontroller, can be used more efficiently and, thus, saving costs.

[0042] The control unit can further be configured to compare the current representing signal with a threshold value in order to derive regulation values for the LLC current transformer, for example, a frequency, a duty cycle value or an actuating variable.

[0043] The control unit can be a microcontroller or an application-specific integrated circuit (ASIC). Within the controller, e.g., an analog-to-digital converter, ADC, can be used to determine the LED voltage. Additionally, a comparator 206 can be used to detect over voltage conditions (when the voltage at that pin rises above a certain threshold). In this embodiment, the voltage signal is generated by the LED voltage source.

[0044] If a short-circuit of the LED takes place, then a current pulse is generated in the signal I_{SNS_PK}. This current pulse can be transformed via current transformer to a voltage signal which can then be coupled to the voltage

signal at a diode. In short circuit conditions, a peak occurs in this signal, which can be fed to a comparator within the controller. The comparator will detect the peak so that the controller can react to the short-circuit condition.

[0045] Advantageously, the current signal does not affect the voltage signal during normal operation (where I_{LED} is a constant DC), but it increases the voltage signal during transients of I_{LED} such as in the case of a short circuit of the output.

[0046] Moreover, in the short-circuit condition or over voltage condition the control unit can be configured to switch off the means for combining the current representing signal.

[0047] Fig. 3 shows exemplary behaviors of the current I_{LED} and voltage V_{LED} in the isolated LED driver 200 according to the invention.

[0048] After being detected, V_{LED} and I_{LED} are combined into a single total signal and then fed to the comparator 206, as shown in figure 4.

[0049] The comparator 206 can be a comparator configured to compare the total signal to a threshold value and, if the total signal is higher than the threshold value, to detect a short-circuit condition or an over voltage condition. The comparator 206 can be a comparator with variable reference and polarity or a comparator with single reference.

[0050] The circuit shown in Fig. 4, further comprises two diodes D1 and D2, one resistance R1 and one capacitance C1. The signals V_{LED} and I_{LED} pass through the diodes D1 and D2, respectively. Afterwards, they are combined into a single signal PA3 which is fed to the comparator 206 and then compared to the reference voltage $V_{ref,int}$ in order to detect an over voltage or short current condition.

[0051] Fig. 5 shows an exemplary embodiment of an isolated LED driver 800 comprising a comparator 806 according to the invention.

[0052] In this embodiment an isolated LED driver 800 with open circuit and short-circuit at one pin, comprises a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver, means for detecting the voltage on the secondary side of the isolation stage and producing a voltage-representing signal, a comparator 806 supplied with the voltage representing signal at its non-inverted input, wherein the reference level of the comparator and, in synchronization therewith, the polarity of the comparator output signal are switched in order to produce a signal indicating, in time multiplex a LED load open circuit and short-circuit indicating signal.

[0053] The LED driver 800 shown in Fig. 5 comprises an LED load, whose voltage V_{LED} is compared to a reference voltage V_{ref} by the comparator 806. Moreover, the LED driver 800 comprises three resistors R1, R2, and R3 and two capacitors C1 and C2.

[0054] The comparator 806 can comprise an operational amplifier, wherein the polarity of the operational amplifier output circuit depends on the polarity of the difference between the two input voltages V_{LED} and V_{ref}.

[0055] Fig. 6 shows exemplary behaviors of the voltage V_{LED} in an isolated LED driver as a function of time according to the invention.

[0056] In this embodiment, V_{ref} represents the variable reference, namely voltage varying between V_{REFINT} and $½V_{REFINT}$, wherein V_{REFINT}=1,2V The frequency of variation is 1kHz.

[0057] As it can be taken from Fig. 9, in case of an over voltage event or short circuit event, a peak is produced in the output signal of the comparator 806 on a microcontroller.

[0058] Fig. 7 shows a method 1000 for an isolated LED driver 200 according to an embodiment.

[0059] The method 1000 comprises the following steps:

controlling 1002 at least one switch on the primary side of an isolation stage of the LED driver 200;

detecting 1004 the voltage 202 on the secondary side of the isolation stage and producing a voltage-representing signal;

detecting 1006 the current flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver 200;

producing 1008 a current-representing signal;

combining 1010 for a current-representing signal, optionally a decoupled AC component of the current representing signal, with the voltage representing signal; and

feeding 1012 it to an input pin of the control unit.

[0060] Fig. 8 shows a further method 1100 for an isolated LED driver 800 according to an embodiment.

[0061] The method 1100 comprises the following steps:

controlling 1102 at least one switch on the primary side of an isolation stage of the LED driver;

detecting 1104 the voltage on the secondary side of the isolation stage and producing a - voltage-representing signal; and

switching 1106 the reference level of a comparator and, in synchronization therewith, the polarity of the comparator output signal in order to produce a signal indicating, in time multiplex, a LED load open circuit and short-circuit indicating signal, wherein the comparator is supplied with the voltage representing signal at its non-inverted input.

[0062] All features of all embodiments described,

shown and/or claimed herein can be combined with each other.

[0063] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only and not limitation. Numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the spirit of scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described embodiments. Rather, the scope of the invention should be defined in accordance with the following claims and their equivalence.

[0064] Although the invention has been illustrated and described with respect to one or more implementations, equivalent alternations and modifications will occur to those skilled in the art upon the reading of the understanding of the specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only of the several implementations, such features may be combined with one or more other features of the other implementations as may be desired and advantage for any given or particular application.

Reference Signs

[0065]

200	driver
202	means
204	means
206	comparator
800	driver
802	means
806	comparator
1000	method
1002	step
1004	step
1006	step
1008	step
1010	step
1012	step
1100	method
1102	step
1104	step
1106	step

Claims

1. Isolated LED driver (200) with open circuit and short-circuit at one pin, comprising:

- a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver (200),
- means for detecting the voltage on the secondary side of the isolation stage and producing a voltage-representing signal,
- means for detecting the current flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver (200), and producing a current-representing signal,
- means for combining a current-representing signal, optionally a decoupled AC component of the current representing signal, with the voltage representing signal and feeding it to an input pin of the control unit.

2. Isolated LED driver (200) according to claim 1, wherein
the current representing signal is supplied to a further input of the control unit for a feedback control of the LED load current.

3. Isolated LED driver (200) according to any one of the preceding claims, wherein
the control unit is a microcontroller or an application-specific integrated circuit, ASIC.

4. Isolated LED driver (200) according to any one of the preceding claims, wherein
the means for detecting the voltage (202) on the secondary side of the isolation stage comprise an analog to digital converter, ADC.

5. Isolated LED driver (200) according to any one of the preceding claims, comprising a LLC converter.

6. Isolated LED driver (200) according to claims 5 and 2, wherein the control unit is further configured to compare the current representing signal with a threshold value in order to derive regulation values for the LLC current transformer, for example, a frequency, a duty cycle value or an actuating variable.

7. Isolated LED driver (200) according to any one of the preceding claims, wherein the means for combining the current representing signal further comprises a diode for combining the current representing signal with the voltage representing signal to obtain a total signal.

8. Isolated LED driver (200) according to claim 8, wherein
the control unit further comprises a comparator configured to compare the total signal to a threshold value and, if the total signal is higher than the threshold value, to detect a short-circuit condition or an over voltage condition.

9. Isolated LED driver (200) according to claim 9, wherein
the comparator is a comparator with variable refer-

ence and polarity.

10. Isolated LED driver (200) according to claim 9, wherein
the comparator is a comparator with single reference.

11. Isolated LED driver (200) according to claim 8, wherein
the control unit is configured to switch off the means for combining the current representing signal in the short-circuit condition or over voltage condition.

12. A method (1000) for an isolated LED driver (200), comprising:

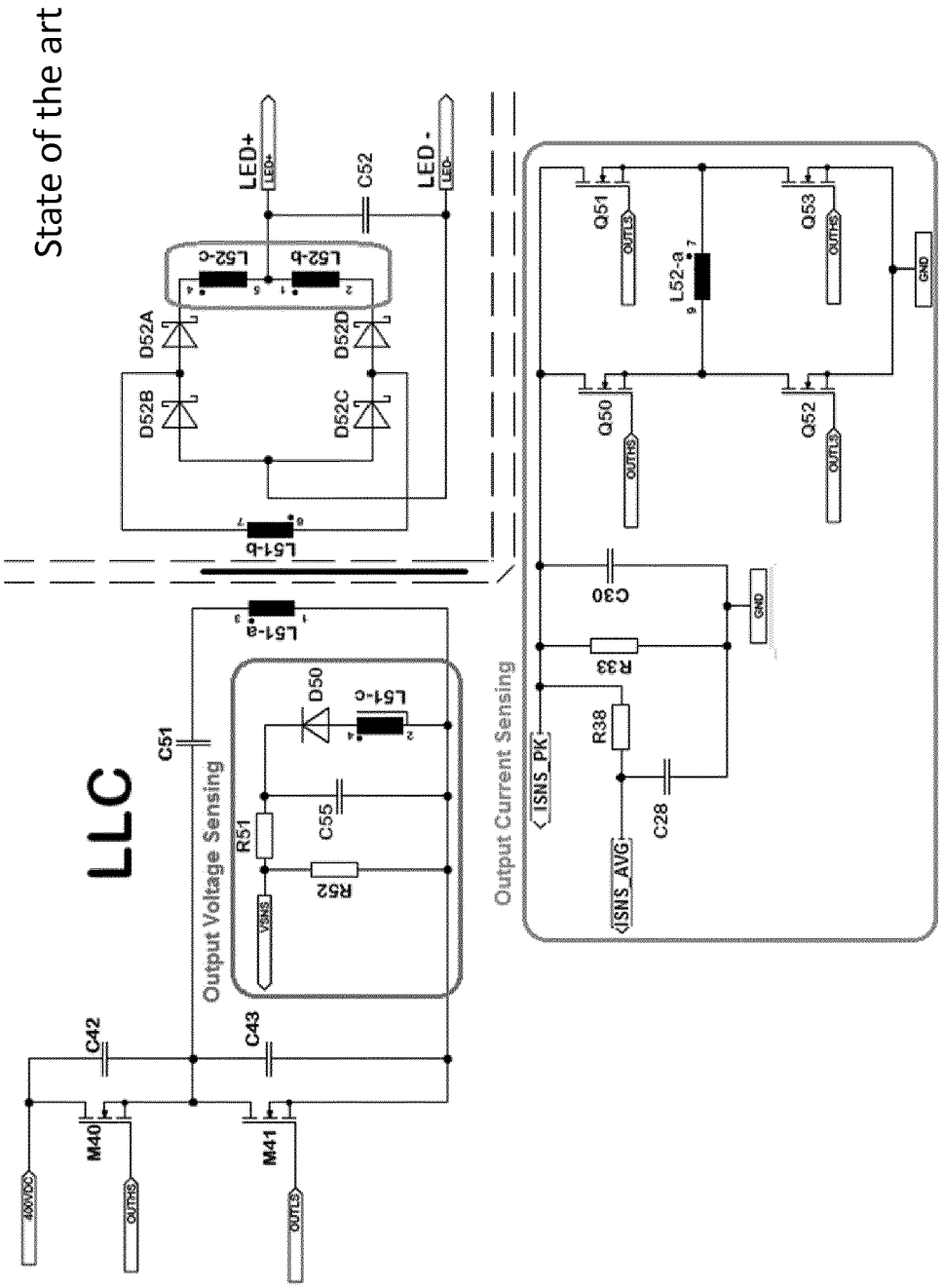
- controlling (1002) at least one switch on the primary side of an isolation stage of the LED driver (200),
- detecting (1004) the voltage on the secondary side of the isolation stage and producing a voltage-representing signal,
- detecting (1006) the current flowing on the secondary side, and especially the current through an LED load when connected at supply terminals of the LED driver (200);
- producing (1008) a current-representing signal;
- combining (1010) for a current-representing signal, optionally a decoupled AC component of the current representing signal, with the voltage representing signal; and
- feeding (1012) it to an input pin of the control unit.

13. Isolated LED driver (800) with open circuit and short-circuit at one pin, comprising:

- a control unit controlling at least one switch on the primary side of an isolation stage of the LED driver (800);
- means for detecting the voltage (802) on the secondary side of the isolation stage and producing a voltage-representing signal;
- a comparator (806) supplied with the voltage representing signal at its non-inverted input, wherein the reference level of the comparator (806) and, in synchronization therewith, the polarity of the comparator output signal are switched in order to produce a signal indicating, in time multiplex a LED load open circuit and short-circuit indicating signal.

14. A method (1100) for an isolated LED driver (800), comprising:

- controlling (1102) at least one switch on the primary side of an isolation stage of the LED driver (800);
- detecting (1104) the voltage on the secondary side of the isolation stage and producing a -voltage-representing signal; and
- switching (1106) the reference level of a comparator (806) and, in synchronization therewith, the polarity of the comparator output signal in order to produce a signal indicating, in time multiplex, a LED load open circuit and short-circuit indicating signal, wherein the comparator (806) is supplied with the voltage representing signal at its non-inverted input.


State of the art
LLC
LED+
LED-
C52
L52-c
L52-b
D52A
D52B
D52C
D52D
L51-b
L51-a
L51-c
D50
C51
Output Voltage Sensing
R51
C55
R52
VSNS
C42
C43
M40
M41
400VDC
OUTHS
OUTLS
Output Current Sensing
Q51
Q53
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Q50
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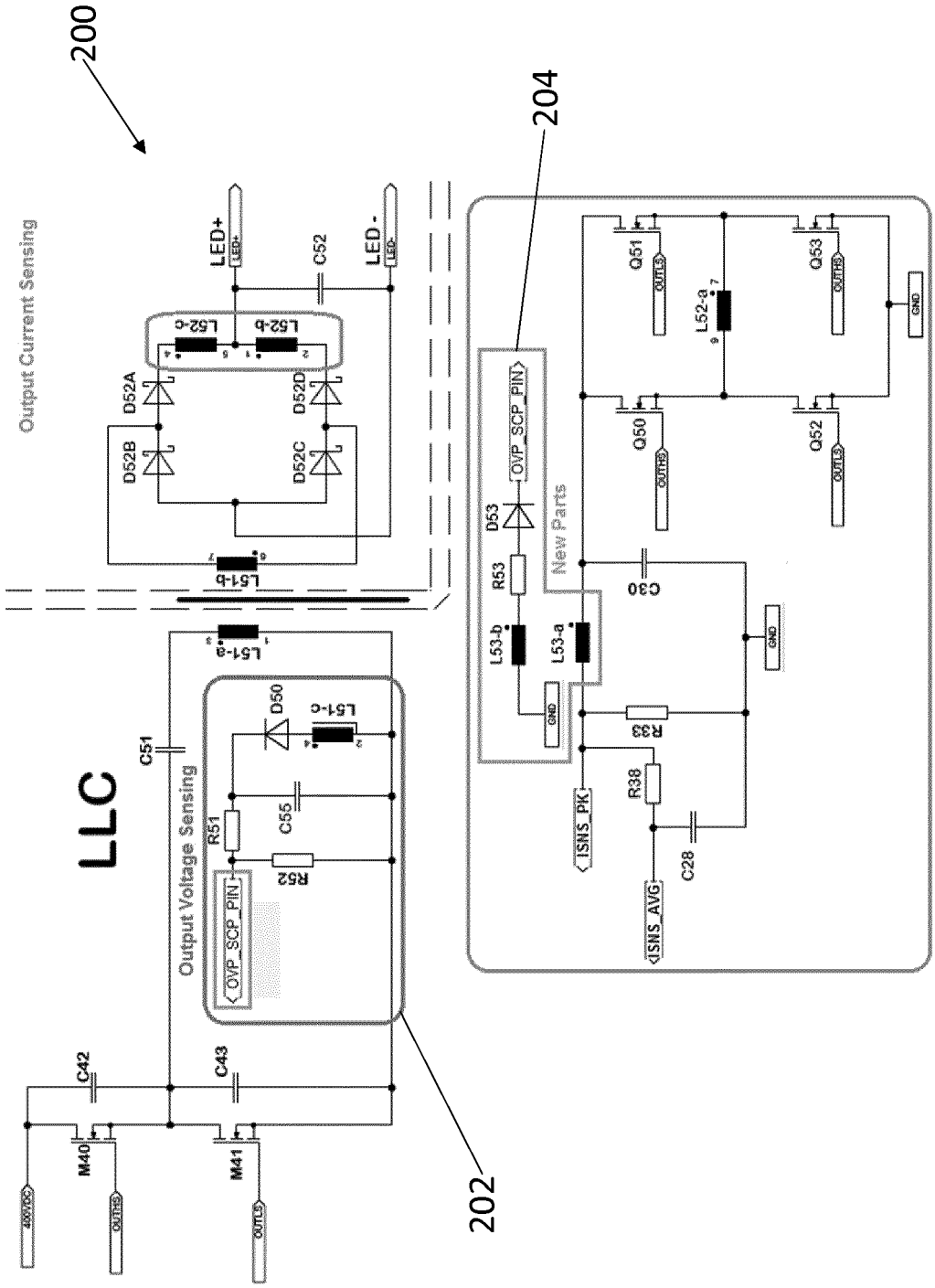
C30
R33
R38
C28
ISNS_PK
ISNS_AVG

Fig. 1


200
204
202
LLC
Output Current Sensing
Output Voltage Sensing
New Parts
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LED-
C52
D52A
D52B
D52C
D52D
L52-b
L52-c
L51-b
L51-a
L51-c
D50
C51
R51
C55
R52
OVP_SCP_PIN
C42
C43
M40
M41
400VDC
OUTHS
OUTLS
D53
R53
L53-b
L53-a
GND
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C28
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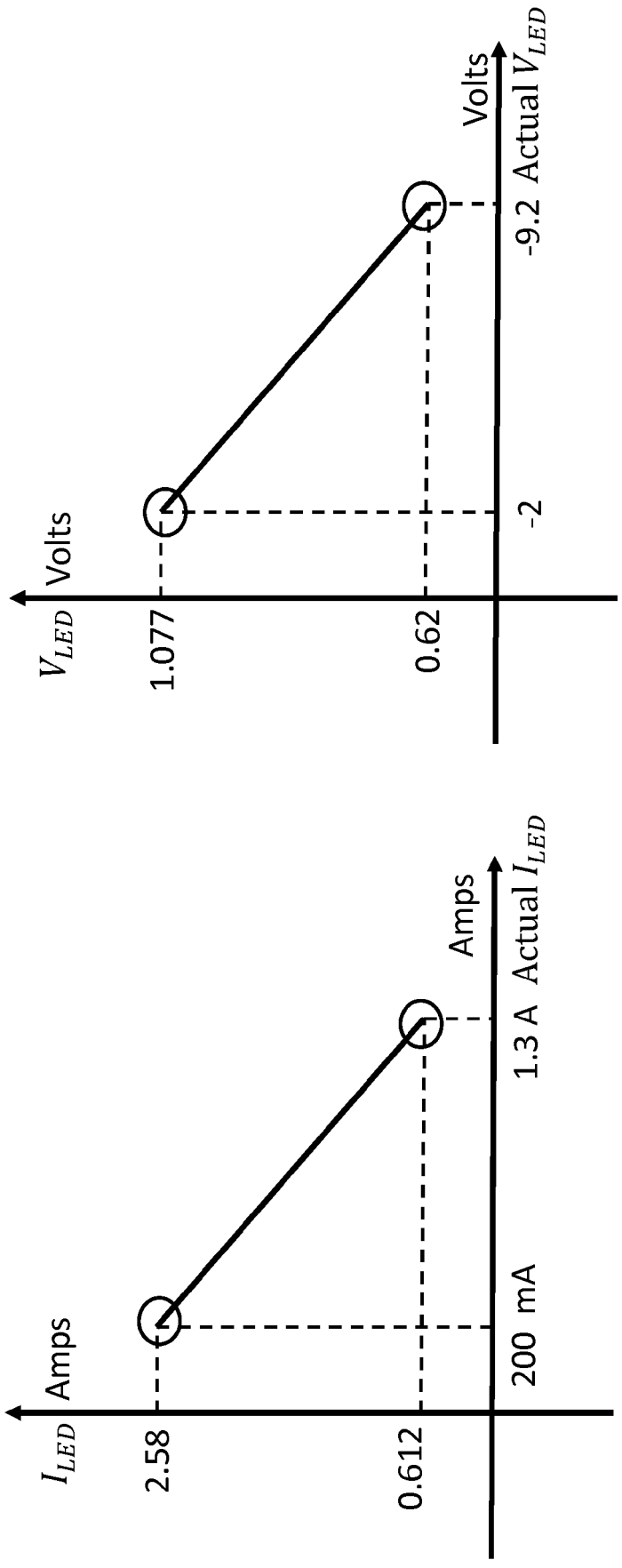
ISNS_AVG
Q51
Q53
Q50
Q52
L52-a

Fig. 2


Volts
Actual V_{LED}
-9.2
-2
V_{LED}
1.077
0.62
Amps
Actual I_{LED}
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I_{LED}
2.58
0.612

Fig. 3

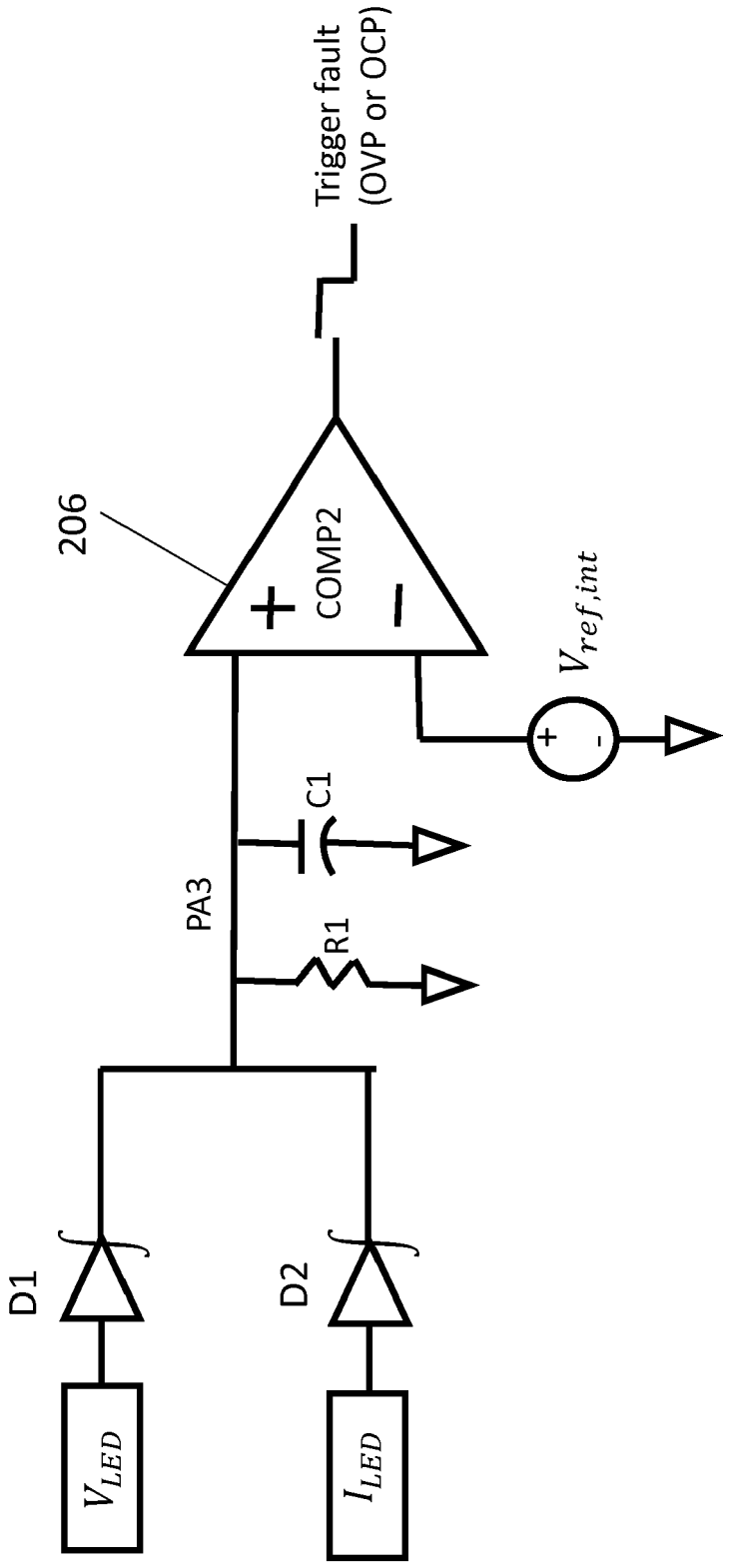
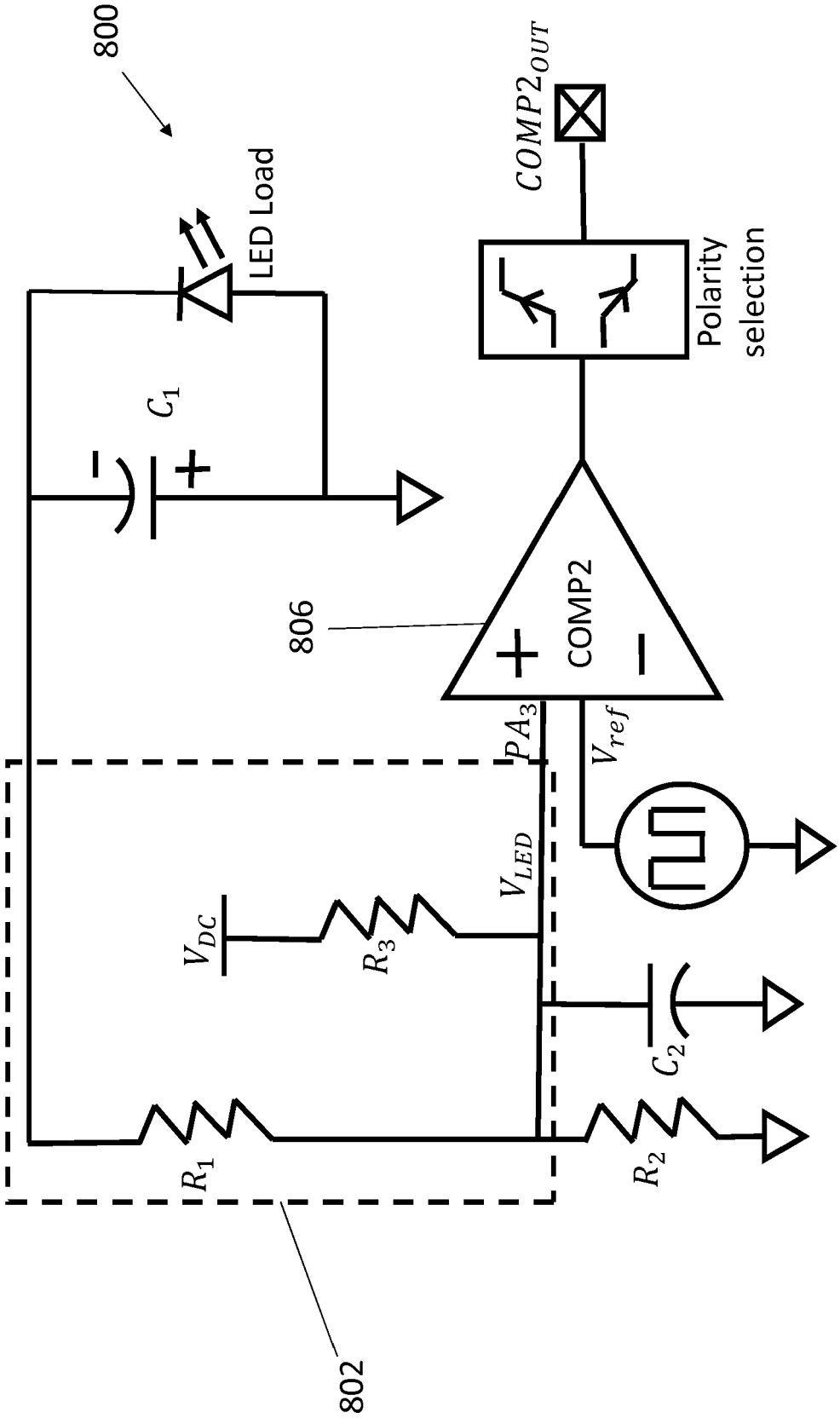

Trigger fault
(OVP or OCP)
206
COMP2
+
-
$V_{ref,int}$
+
-
C1
PA3
R1
D1
D2
V_{LED}
I_{LED}

Fig. 4


800
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$COMP2_{OUT}$
Polarity selection
C_1
806
COMP2
PA_3
V_{ref}
V_{LED}
V_{DC}
R_3
C_2
R_1
R_2
802

Fig. 5

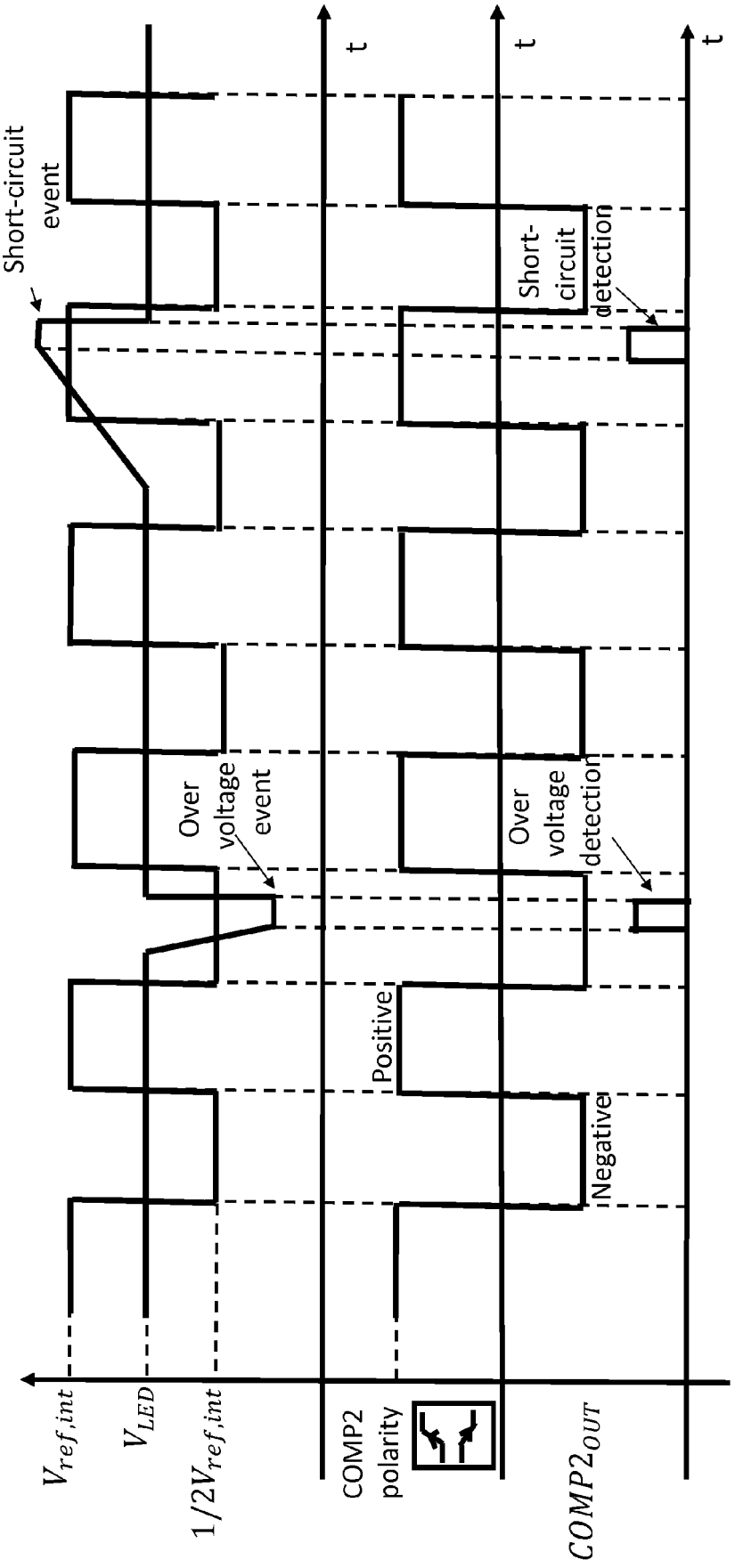
Short-circuit event
Over voltage event
Positive
Negative
Short-circuit detection
Over voltage detection
t
t
t
$V_{ref,int}$
V_{LED}
$1/2V_{ref,int}$
COMP2 polarity
$COMP2_{OUT}$

Fig. 6


1000
1002
controlling
1004
detecting
1006
producing
1008
producing
1010
combining
1012
feeding

Fig. 7

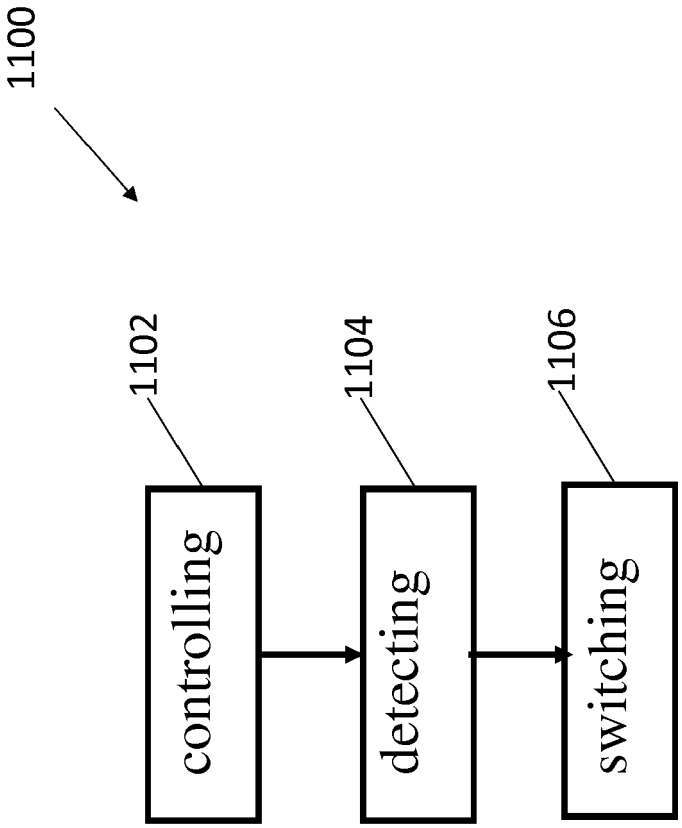

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 3603

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H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 April 2019	Heiner, Christoph

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