

**"A method of protection from over-temperature and
corresponding arrangement"**

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5 Field of the Invention

This disclosure relates to techniques for protecting electrical/electronic devices from over-temperature.

10 This disclosure was developed with specific attention paid to its possible use in protecting from over-temperature a device associated with a DC power converter. An exemplary field of use of the disclosure is thermal protection of safety insulating transformers in off-line DC power converter designed e.g. to supply
15 modules including Light Emitting Diodes (LEDs) with a constant voltage output, such as a Safety Extra Low Voltage (SELV).

20 Reference to this possible field of application is not however to be construed in a limiting sense of the scope of the invention.

Description of the Related Art

LED modules used e.g. as lighting sources may be supplied by a constant voltage source via a linear
25 regulator, which regulates the current flow through the LED or LEDs and adapts the source voltage to actual LED voltage drop. This depends on the technology and operating conditions such as ambient temperature, direct current, and thermal dissipation conditions.
30 Using an electronic converter for supplying these modules with a constant voltage (in the place of a constant current) and the presence of a linear regulator "on board" the module itself may be useful for different reasons which are per se well known in
35 the prior art.

Object and Summary of the Invention

In order to allow a maximization of the output power, while guaranteeing always the safety of the device, such electronic power converters should be protected from over-temperature.

The object of the invention is thus to provide a cheap and integrated way of providing such a protection.

10 According to the present invention, that object is achieved by means of a method having the features set forth in the claims that follow. The invention also relates to a corresponding arrangement.

The claims are an integral part of the disclosure
15 of the invention provided herein.

In an embodiment, protection is provided by means of a thermal sensitive component, such as a Positive Temperature Coefficient (PTC) or Negative Temperature Coefficient (NTC) resistor arranged in proximity of the
20 main safety component of the power supply.

In an embodiment, the thermal component is mounted in proximity of the safety insulation transformer of the electronic converter.

In an embodiment, circuitry is provided to reduce
25 the output voltage of the electronic converter if the temperature of the transformer exceeds a first thermal threshold.

In various embodiments, the circuitry is provided in the feedback path of the electronic converter and
30 changes the set-point of the output voltage; in an embodiment, the circuitry guarantees that the rated output voltage remains unchanged if the temperature is below the first thermal threshold and to shut down the electronic converter if the temperature is above a
35 second thermal threshold.

In an embodiment, the thermal sensitive component is arranged in mechanical contact with (e.g. mounted on or integrated in) the protected device (e.g. a transformer). In an embodiment, a "concentric" (one
5 chamber) transformer with one or more windings at the primary side of the converter and one or more windings at the secondary side of the converter is used.

In an embodiment, a bobbin is used which provides enough pins to connect all windings and the terminals
10 of the thermal sensitive component to the PCB.

In an embodiment, a conventional PTC or NTC resistor is used with pin-through-hole (PTH) technology. Surface Mount Device (SMD) components with e.g. hand soldered pins may also be used. The pins of
15 the component are connected to the pins of the bobbin.

In an embodiment, the transformer is provided with one or more external layers, such as layers of tape, which fix the thermal component to the most external winding. Specifically, in an embodiment, two layers are
20 used and the thermal component is inserted between these outer layers, wherein the leads of the component are positioned in direction of the pins of the bobbin. In this case, the leads of the thermal component may be tied and soldered to the pins of the bobbin in order to
25 guarantee the electrical contact between the component and the conductive (e.g. metal) tracks on the PCB.

The thermal sensitive component may be positioned outside of the loop formed by the main switching net in order to avoid that the information provided by the
30 component is altered due to current induced in the component by the magnetic flux near the transformer. The leads of the thermal component may extend substantially perpendicular to the wires of the windings in order to minimize the magnetic coupling and
35 the energy transfer between them.

Brief description of the annexed drawings

The invention will now be described, by way of example only, with reference to the enclosed figures of drawing, wherein:

- figure 1 is a diagram showing a typical relationship between the input voltage to a LED module and the brightness produced thereby,
- figure 2 is a schematic representation of a circuit for connecting a thermal sensitive component in a feedback path of an electronic converter,
- figure 3 is a diagram representative of regulation of the output voltage in an electronic converter, and
- figures 4a and 4b show two possible scenarios of operation of the arrangement described herein.

Detailed description of preferred embodiments

In the following description, numerous specific details are given to provide a thorough understanding of embodiments. The embodiments can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the embodiments.

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or

characteristics may be combined in any suitable manner in one or more embodiments.

The headings provided herein are for convenience only and do not interpret the scope or meaning of the
5 embodiments.

Figure 1 shows the notional relationship between the supply voltage applied to a LED module and the brightness B of the LED or LEDs included therein. Specifically, if the supply voltage is below a minimum
10 forward voltage V_{Fmin} , the LED will be switched off. In the region between the minimum voltage V_{Fmin} and a voltage V_{rated} , variation of the brightness B of the LED may be noticeable in a range from B_{min} to B_{rated} . If the supply voltage is above a voltage V_{rated} , the brightness
15 of the LED will be almost constant, thanks to the "on board" regulator of the LED module.

An aspect of this disclosure is based on the recognition that the presence of an almost constant voltage at the input of a LED module is not a necessary
20 condition in order to guarantee the correct operation of the LED or LEDs therein. For example, a LED module may continue to operate even if the voltage supplied thereto is lower (or higher) than the specified forward voltage V_{rated} of the LED-modules. The inventors have
25 thus noted that the operating thermal range of a LED module can be maximized by decreasing the power delivered over a certain temperature range without affecting significantly the output light of the LED module.

To that effect, an embodiment of this disclosure relates to a thermal sensitive component, such as a PTC, mounted on a printed circuit board (PCB) in close
30 proximity of the insulating transformer. Preferably the component is glued to the transformer. In an embodiment, a PTC is mounted at the primary side of the
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transformer in compliance with the applicable safety requirements; the PTC is electrically insulated from the secondary winding of the transformer.

Generally a PTC has a low resistance value up to a certain threshold temperature, and above this temperature the resistance value increases exponentially with temperature. The specific electrical and thermal characteristics of the PTC used are chosen (in manner known per se) in accordance with the thermal class of the transformer.

Figure 2 shows a possible embodiment of circuitry for connecting a thermal sensitive component 20, such as a PTC, in the feedback path of an insulated electronic converter 10 having an input voltage V_{in} and an output voltage V_{out} to be fed to a LED module 30.

In an embodiment of this disclosure, the transformer Tr and the related circuitry in the feedback path as described in detail herein are included in the converter 10: nonetheless in Figure 2, these elements are shown externally of the converter 10 for ease of representation.

In the embodiment shown, the input voltage is derived from the mains (e.g. 240V - 50Hz) and the output voltage is applied to a LED module 30 comprised of a linear regulator LR that feeds one of more LEDs designated L as a whole.

A signal representative of the value of V_{out} is present on an output pin 11 of the converter 10 (or can be derived directly from the output of the converter 10).

The signal representative of the value of V_{out} may be scaled down by a resistive voltage divider 18 and fed to one of the inputs of an error amplifier 12 to be compared with a reference voltage signal V_{ref} . In the embodiment shown, the error amplifier 12 has an

associated (negative) feedback loop including regulation circuitry 14 to produce (in a manner known per se) an error signal V_{err} . The error signal V_{err} is then sent over a line 16 as a voltage error input to the switching modulator of the electronic converter 10.

The resistive voltage divider 18 includes a thermal sensitive component 20 such as a PTC. In the following it will be assumed that the thermal sensitive component 20 is arranged in close proximity or mechanical contact with the insulating transformer (schematically indicated Tr in the drawing) associated to the converter 10. In an embodiment, the PTC 20 is mounted at the primary side of the transformer Tr.

In an embodiment, the voltage divider 18 includes:

- an "upper" branch including a resistor R1, and
- a "lower" branch including the thermal sensitive component 20 and, preferably, a resistor R2 connected in series with the thermal sensitive component 20 (which for the time being will be considered to be a PTC, namely a resistor whose resistance value increases with temperature).

In such an embodiment, when and as long as the temperature T of the insulating transformer Tr is below the temperature threshold of the PTC, the scaling ratio of the voltage divider 18 is essentially constant, because small variations of the resistance of the PTC have only a small influence on the divided output signal.

When the temperature of the transformer exceeds a temperature threshold of the PTC, the resistance value of the PTC will increase exponentially and the output voltage of the voltage divider will increase.

In the embodiment illustrated in figure 2, the divided output voltage is connected to the inverting (negative) input of the error amplifier 12 and the

reference signal V_{ref} is connected to the non-inverting (positive) input.

Therefore, if the transformer temperature increases, the feedback regulator will find a new
5 working point which will in turn reduce the output voltage V_{out} of the electronic converter 10.

Figure 3 shows in that respect a typical relationship between the output voltage V_{out} and the transformer temperature $T(Tr)$, wherein the temperature
10 threshold of the PTC has been selected to be approximately 90°C .

A NTC resistor may be used as the thermal sensitive component 20 in the voltage divider, by possibly modifying the voltage divider and the
15 connection to the error amplifier 12 as required to ensure the desired operation.

In an embodiment, the protection effect may be improved by adding a second threshold to limit the minimum output voltage of the converter. For example,
20 the same voltage which is compared with the reference signal V_{ref} may be connected to a voltage comparator (not shown), which is able to shut down the converter.

In an embodiment, the error amplifier and the optional comparator form part of the integrated circuit
25 of the switching power supply.

Figure 4a and 4b show a further advantageous behaviour of the arrangements of this disclosure.

Specifically, figure 4a shows a diagram wherein the forward voltage of the LEDs remains essentially
30 constant, which is typically the case when the temperature of the LEDs remains constant. In this case, when the temperature T of the transformer Tr denoted $T(Tr)$ exceeds a temperature threshold $T1$ of the thermal sensitive component, the output voltage of the
35 electronic converter will decrease as explained in the

foregoing. As soon as the output voltage V_{out} falls below the forward voltage V_F of the LEDs, the LEDs will be switched off and consequently the current flow through the electronic converter will be reduced
5 drastically. This behaviour is particularly advantageous in protecting the electronic converter from an overload or short circuit at the output.

Figure 4b shows a diagram wherein the forward voltage of the LEDs decreases. This is typically the
10 case when the transformer temperature increases due to a rise of the ambient temperature $T(amb)$, which influences also the performance and the electrical characteristics of the LEDs. In fact, the voltage drop at the LEDs typically decreases when their temperature
15 increases. This behaviour may be advantageously used to increase the temperature range of the system, because the temperature at which the output voltage V_{out} falls below the forward voltage V_F of the LEDs is moved to a higher temperature.

20 In order to improve the mechanical contact and the heat transfer between the transformer and the thermal sensitive component 20, the component may be integrated in the transformer. Such an arrangement may be advantageous in terms of cost reduction, because no
25 complex and expansive manual operations, such as positioning and fixing (e.g. gluing) of the thermal component, are necessary.

In an embodiment, a "concentric" (one chamber) transformer with one or more windings at the primary
30 side of the converter and one or more windings at the secondary side of the converter may be used. For example the secondary winding may be realised with triple-insulation special wire (TEX-E), which guarantees a reinforced insulation between the primary

and secondary side according to well known safety application standards.

In an embodiment, a bobbin is used which provides enough pins to connect all windings and the terminals
5 of the thermal sensitive component to the PCB.

In an embodiment, the leads of the component may be connected to the pins of the bobbin. A conventional PTC or NTC resistor with pin-through-hole (PTH) technology may be used. Surface Mount Device (SMD)
10 components with e.g. hand soldered pins may also be used.

For example, the transformer may be provided with one or more external layers, such as layers of tape, which fix the thermal component to the most external
15 winding. Specifically, at least two outer layers may be used, wherein the thermal component is inserted between these outer layers and wherein the leads of the component are positioned in direction of the pins of the bobbin. In this case, the leads of the thermal
20 component may be tied and soldered to the pins of the bobbin in order to guarantee the electrical contact between the component and the conductive (e.g. metal) tracks on the PCB.

In an embodiment, the thermal sensitive component
25 is positioned outside of the loop formed by the main switching net in order to avoid that the information provided by the component is altered due to current induced in the component by the magnetic flux near the transformer.

30 In an embodiment, the leads of the thermal component are substantially perpendicular to the wires of the windings in order to minimize the magnetic coupling and the energy transfer between them.

In an embodiment, an EF16 horizontal bobbin
35 transformer is used. This arrangement includes by a

primary winding (CuL wire), an insulating tape layer, a secondary winding (TEX-E triple insulated wire) and an external or outer tape layer. Such a construction guarantees the insulating distance between the secondary terminals and the circuitry on the primary side. In this case, the thermal sensitive component is fixed in strict contact with the inner layers of wire and tape by means of a further external tape layer, wherein the leads of the component are kept as perpendicular as possible to the wires of the windings. Then the leads of the thermal component are soldered to two free pins of the bobbin to guarantee the electrical contact.

Without prejudice to the underlying principles of the invention, the details and the embodiments may vary, even appreciably, with reference to what has been described by way of example only, without departing from the scope of the invention as defined by the annexed claims.

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CLAIMS

1. A method of protecting from over-temperature a device (Tr) associated with an electronic converter (10) including a feedback path (11, 12 to 18) for regulating the output signal (V_{out}) of said electronic converter (10), the method including the steps of:
- providing a thermal sensitive component (20) sensitive to the temperature of said device (Tr),
 - including said thermal sensitive component (20) in said feedback path (11, 12 to 18) of said electronic converter (10), whereby said output signal (V_{out}) of said electronic converter (10) is reduced as a function of the temperature of said device (Tr) as sensed by said thermal sensitive component (20).
2. The method of claim 1, including the step of shutting down said electronic converter (10) if the temperature of said device reaches an upper temperature threshold.
3. The method of either of claims 1 or 2, wherein including said thermal sensitive component (20) in said feedback path (11, 12 to 18) of said electronic converter (10) includes the steps of:
- including in said feedback path (11, 12 to 18) of said electronic converter (10) a voltage divider (18, R1, R2, 20) to produce a feedback signal indicative of said output signal (V_{out}) of said electronic converter (10), and
 - including said thermal sensitive component (20) in said voltage divider (18, R1, R2, 20).
4. The method of any of the previous claims, including the step of arranging said thermal sensitive

component (20) in mechanical contact with said device (Tr) to be protected.

5 5. An arrangement for protecting from over-
temperature a device (Tr) associated with an electronic
converter (10) including a feedback path (11, 12 to 18)
for regulating the output signal (V_{out}) of said
electronic converter (10), the arrangement including a
thermal sensitive component (20) sensitive to the
10 temperature of said device (Tr), said thermal sensitive
component (20) being included in said feedback path
(11, 12 to 18) of said electronic converter (10) to
reduce said output signal (V_{out}) of said electronic
converter (10) as a function of the temperature of said
15 device (Tr) as sensed by said thermal sensitive
component (20).

6. The arrangement of claim 5, wherein said
thermal sensitive component (20) is a component
20 sensitive to temperature above a first temperature
threshold, whereby said output signal (V_{out}) remains
substantially constant if the temperature of said
device (Tr) is lower than said first temperature
threshold.

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7. The arrangement of either of claims 5 or 6,
wherein said feedback path (11, 12 to 18) of said
electronic converter (10) includes a voltage divider
(18, R1, R2, 20) to produce a feedback signal
30 indicative of said output signal (V_{out}) of said
electronic converter (10), and wherein said thermal
sensitive component (20) is included in said voltage
divider (18, R1, R2, 20).

8. The arrangement of claim 7, wherein said feedback path (11, 12 to 18) of said electronic converter (10) includes an error amplifier (12) for comparing the signal divided out of said voltage divider (18, R1, R2, 20) with a reference signal (V_{ref}); said error amplifier (12) generating an error signal (V_{err}) used to regulate said electronic converter (10), preferably by sending said error signal (V_{err}) to a switching modulator in said electronic converter.

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9. The arrangement of any of claims 5 to 8, wherein a resistor (R2) is connected in series with said thermal sensitive component (20).

10. The arrangement of any of claims 5 to 9, wherein said electronic converter (10) includes a thermal shutdown feature for shutting down said electronic converter (10) if temperature increases beyond a predetermined threshold.

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11. The arrangement of any of claims 5 to 10, wherein said thermal sensitive component (20) is arranged in mechanical contact with said device (Tr).

12. The arrangement of any of claims 5 to 11, wherein said device is a transformer (Tr).

13. The arrangement of claim 12, wherein said transformer (Tr) is a concentric transformer with one or more windings at the primary side of the converter and one or more windings at the secondary side of the converter, and wherein said thermal sensitive component is mounted in the vicinity of said transformer (Tr).

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14. The arrangement of either of claims 12 or 13, wherein said transformer (Tr) has a bobbin and wherein the leads of said thermal sensitive component (20) are connected to said bobbin.

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15. The arrangement of any of claims 12 to 14, wherein the leads of said thermal sensitive component (20) are substantially perpendicular to the wires of the windings of said transformer (Tr).

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16. The arrangement of any of claims 12 to 15, wherein said transformer (Tr) includes one or more outer layers, such as layers of tape, for fixing the thermal component (20) to the most external winding of said transformer (Tr).

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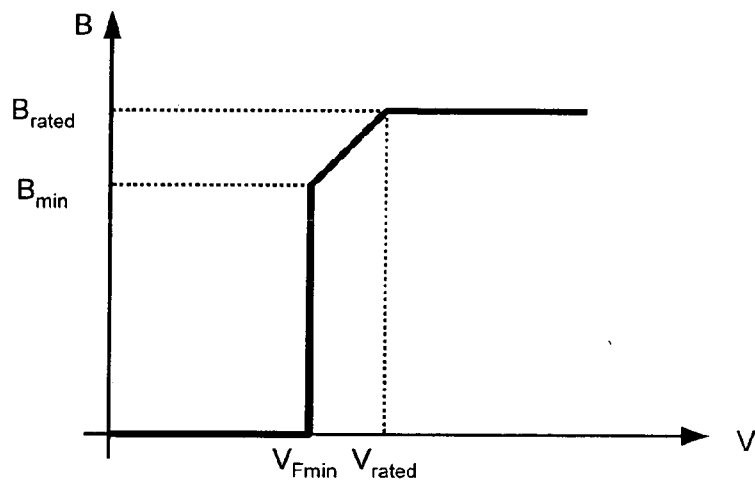


Fig. 1

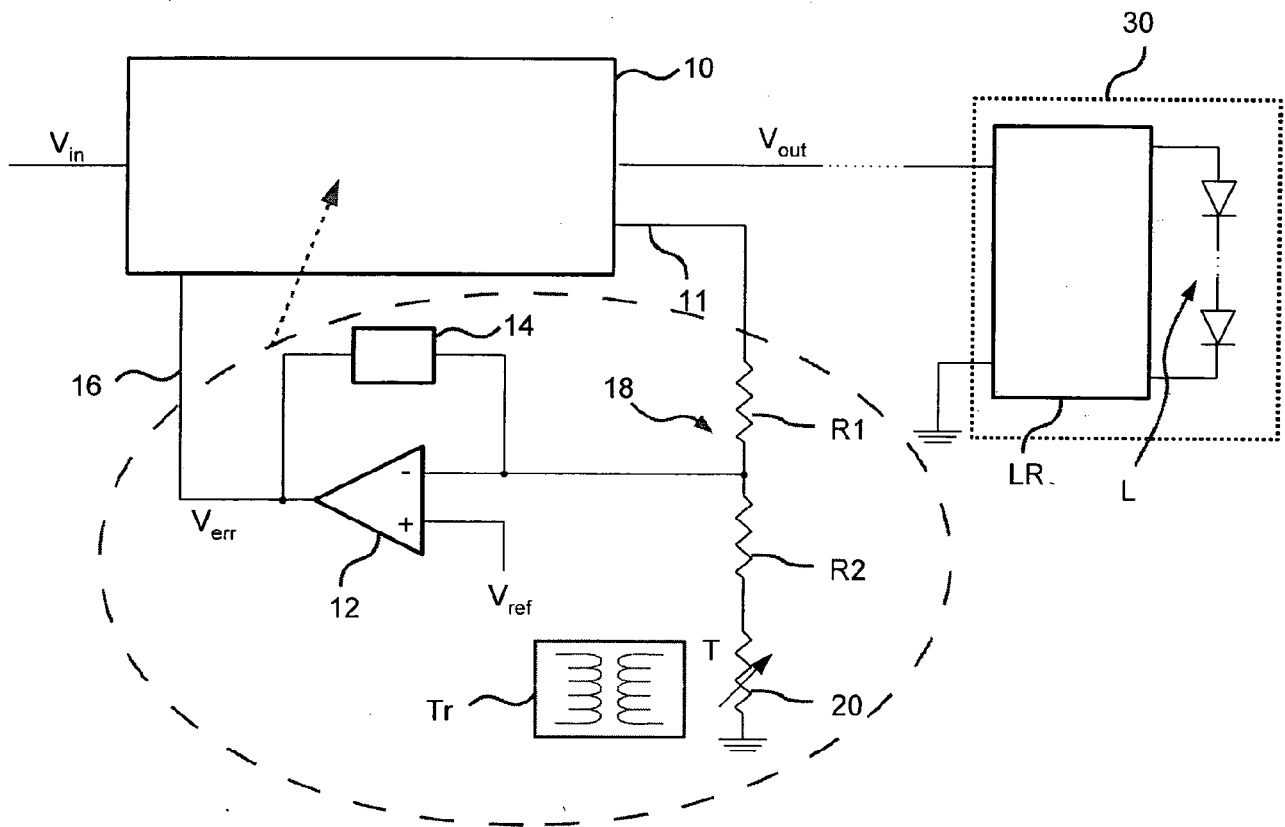


Fig. 2

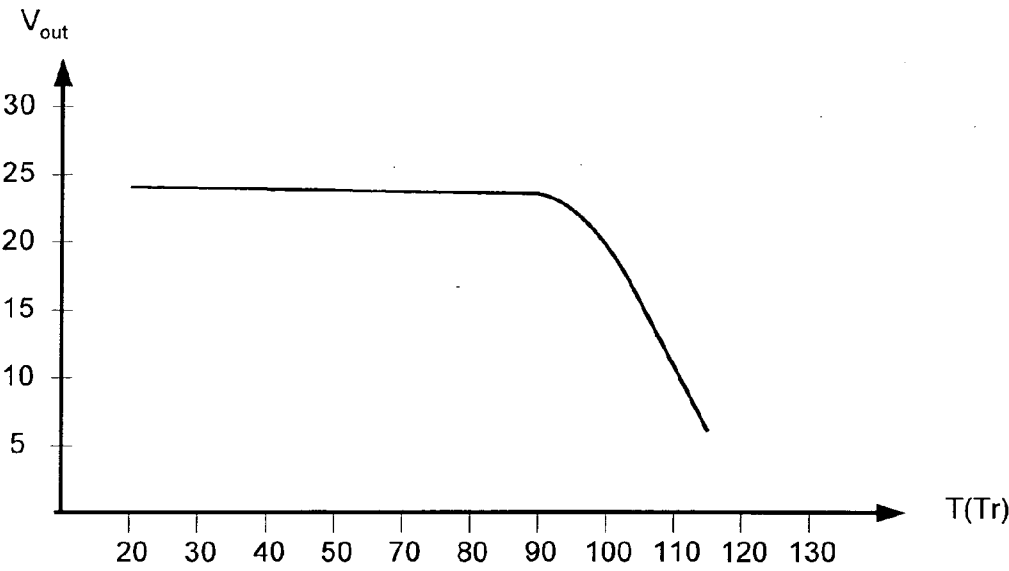


Fig. 3

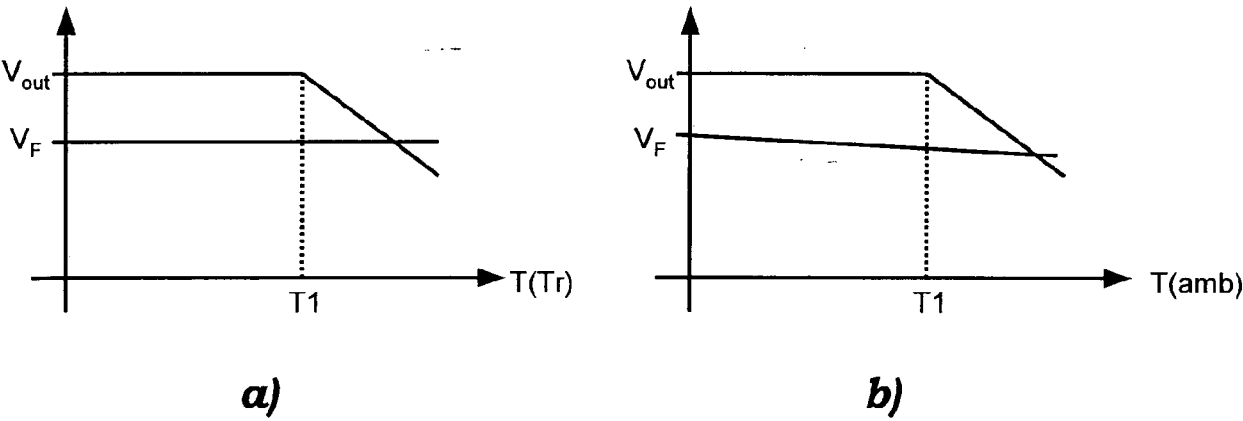


Fig. 4