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(54) **Device for PWM regulating the electric power supplied to one or more leds**

(57) A device is described for the PWM regulation of the electrical power supplied to one or more LEDs, wherein an interface circuit is provided which receives a

PWM input signal and outputs at least one processed signal based on the PWM input signal in order to enable/disable the converter circuit.

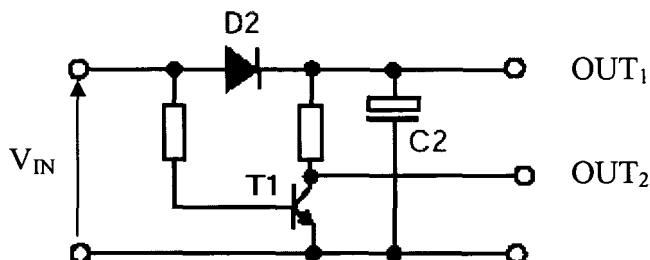


Fig. 2

Description

[0001] The present invention relates to a device which allows to carry out the regulation of the electrical power supplied to one or more LEDs in "Pulse Width Modulation" mode (PWM).

[0002] Among the lighting system currently known, those using Light Emitting Diodes (LEDs) with high emission power are increasingly widespread. The LEDs are grouped in modules, or spotlights, which are shaped such as to have two power terminals that can be connected to a standard-type socket.

[0003] To energize the spotlights, a DC/DC converter circuit is generally used, which receives a DC constant voltage and outputs a constant current.

[0004] An exemplary known converter circuit that can be used to this purpose is illustrated in Fig. 1, in which the integrated circuit IC is a regulator identified with the code L6902 and sold by ST Microelectronics. It is a constant voltage-constant current converter circuit for power LEDs, with $24V_{DC}$ input direct voltage and output constant current of 350mA or 700mA. A similar converter circuit is provided within each lighting module LD by means of a plurality of LEDs.

[0005] This type of system cannot, however, be PWM regulated, mainly because of the following:

- the circuit has electrolytic capacitors, which create turn-on and turn-off delays;
- by decreasing the value of the capacities, the delay problems during the turn-on or turn-off steps could be reduced, but the high dV/dt generates acoustic resonances within the capacitors, with an audible hum;
- the ripple current within small capacitors reaches destructive levels;
- the PWM frequency must be at least 100 Hz, in order to avoid a flickering perception of the light source at low levels.

[0006] A possible solution to these problems may be to be able of turning on/off the converter circuit very quickly, such as to carry out PWM regulation. Thereby, capacitors would not be subjected to excessive stress and would not cause problems.

[0007] By way of example, referring back to the converter circuit in Fig. 1, the integrated circuit IC provides a regulation pin PR, which allows carrying out the turn on/off function via a third control wire that may be connected thereto. However, a third wire creates serious problems to the connection of the LED modules in distributed systems. In fact, in the lighting systems currently installed, only two wires are normally provided, and this does not allow carrying out PWM regulation, unless the operator fits a new wire in existing systems.

[0008] Even though a third wire can be installed, it should be considered that, when three wires are connected, the possibility of errors will increase and the third

control wire is very likely to be subjected to interference, as it is a signal wire and not a power wire.

[0009] Furthermore, the LED modules equipped with standard connectors or lamp sockets are arranged for housing only two connecting wires, the third wire being impossible to connect to the module.

[0010] Having said that, the object of the present invention is to provide a device allowing PWM regulation to be carried out on the electrical power supplied to one or more LEDs without resorting to further wires other than those normally provided for supply.

[0011] Another object of the present invention is to propose a device of the above-mentioned type, which can be advantageously used both for regulating white light-emitting LED modules and coloured-light emitting LED modules.

[0012] Yet another object of the present invention is to propose a PWM regulation device having a very small size, such as to be easily incorporated in a standard-size LED lighting module.

[0013] A further object of the present invention is to propose a LED lighting module to be PWM regulated, which can be easily installed in replacement of one already installed, without the existing electrical system requiring to be changed.

[0014] These objects are achieved by the present invention, which relates to a device for PWM regulation of the electrical power supplied to one or more LEDs, comprising a DC/DC converter circuit which receives a DC constant voltage, and outputs a constant current to the one or more LEDs, characterized by comprising an interface circuit which receives a PWM input signal and outputs at least one processed signal based on the PWM input signal in order to enable/disable the converter circuit.

[0015] The device according to the invention solves all the mentioned problems of the prior art by means of a simple interface circuit which creates a control signal to turn on/off the converter in synchronism with the PWM input signal.

[0016] In a possible embodiment of the invention, the control signal outputted from the interface circuit is an inverted-phase PWM signal with respect to the PWM input signal. The control signal is connected to the input of the converter circuit, and particularly, to a regulation pin, which allows turning on/off the integrated circuit.

[0017] A device according to the present invention has multiple advantages. For example, the impulse current on the power line and the radio interferences emitted by the system are reduced; in the converter circuit, large-capacity electrolytic capacitors can be used without audible hum being generated and without the occurrence of delay times; furthermore, as a third signal transmission wire is not required to be introduced, light-regulation systems can be provided with cables of practically unlimited lengths.

[0018] According to another aspect of the present invention, a lighting module can be provided comprising

one or more LEDs housed in a same envelope, and in which at least one device is incorporated for the PWM regulation of the electrical power supplied to the one or more LEDs as that mentioned above.

[0019] The lighting modules that can be provided according to the present invention can include, for example, LEDs emitting light of a same colour, for example white light LEDs, in which only one regulation device according to the invention is required, and consequently only two power terminals which receive a PWM control signal.

[0020] Similarly, the modules can comprise LEDs emitting light of different colours, such as the three primary colours: red, blue and green (RGB), with a power terminal for each of the LEDs of a same colour to receive distinct PWM control signals, and with at least one power terminal in common with all LEDs. Each module will further comprise a regulation device for each of the LEDs of a same colour.

[0021] Further characteristics and advantages of the present invention will appear more clearly from the description below with reference to the annexed schematic drawings, in which:

- Fig. 1 is an electrical diagram of a converter circuit according to the prior art;
- Fig. 2 is an electrical diagram of the interface circuit to be connected to the circuit of Fig. 1;
- Fig. 3 is a time diagram that illustrates the signals produced by the interface circuit in Fig. 2 relative to the signal provided at the input thereof;
- Fig. 4 is an electrical diagram of a PWM regulation device according to the present invention, which includes a converter circuit such as that in Fig. 1;
- Fig. 5 is a block diagram of a lighting system for LED modules with white light emission;
- Fig. 6 is a block diagram of a lighting system for LED modules with coloured light emission;
- Fig. 7 is an electrical diagram of a PWM regulation device according to the present invention, which includes a converter circuit according to an alternative embodiment; and
- Fig. 8 is an electrical diagram of a PWM regulation device according to the present invention, which includes a converter circuit according to another possible alternative embodiment.

[0022] With reference to the circuit diagram in Fig. 2, which also includes the capacitor C2 of the converter circuit in Fig. 1 for clarity, the interface circuit provided according to the invention receives the signal V_{IN} and outputs the processed signal OUT_2 which allows enabling/disabling the converter circuit illustrated in Fig. 1.

[0023] Particularly, referring also to the time diagram in Fig. 3, the signal OUT_2 is an inversed-phase signal as compared with the PWM signal V_{IN} which allows turning on and off the converter in synchronism with the signal V_{IN} received by the interface circuit. In the embodiment represented herein, the signal OUT_2 is applied to the PR

pin of the integrated circuit IC provided in the converter circuit in Fig. 1.

[0024] The interface circuit in Fig. 2 further produces a signal OUT_1 , which is formed by the input signal V_{IN} being overlapped to the inverted-phase signal OUT_2 . Consequently, the signal OUT_1 is nothing else than a direct voltage equal to the high logic level, such as 24V DC, of the signal V_{IN} and/or signal OUT_2 .

[0025] The operation of the interface circuit represented in Fig. 2 can be explained as follows. When a fixed input direct voltage is provided, the transistor T1 has a low logic signal at the output OUT_2 thereof, which is suitable to allow the normal operation of the integrated circuit IC. The capacitor C2 is charged at the maximum input voltage, in this case of 24V DC.

[0026] When the PWM signal V_{IN} is provided at the input, the transistor T1 blocks the converter circuit in synchronism with the input signal, the capacitor C2 remains charged during the low logic level and ensures the prompt restarting of the converter circuit as soon as the voltage V_{IN} returns to the high logic level. In other words, the capacitor C2 is always charged: during the step of turning on the converter circuit as this is powered from the input; but also during the step of turning off (or disabling) the converter circuit, as the integrated circuit is blocked by the transistor T1 and the diode D2 prevents the discharge along the line.

[0027] In Fig. 4, the resulting whole circuit is represented of the regulation device according to the present invention, i.e. the circuit consisting of the converter circuit in Fig. 1 and interface circuit in Fig. 2. It may be seen that the few components added to the known converter circuit can be easily incorporated in a LED lighting module, without requiring modifications to be carried out to the module size.

[0028] Thereby, the PWM regulation can be carried out using only two wires. Traditional lighting systems can be thus replaced with LED systems to be PWM regulated, without modifying the existing system.

[0029] For example, referring to Fig. 5, a plurality of monochromatic LED lighting modules M1-Mn, for example white light LEDs, can be all connected by means of only two wires, in this case by arranging a power supply A10 capable of generating PWM signals V_{IN} with the desired high logic value. Each module M1-Mn thus incorporates a regulator device 10 according to the present invention, the whole circuit of which being represented in Fig. 4, and a certain number of LEDs LD.

[0030] As represented in Fig. 6, a device according to the present invention is further suitable for regulating colour lighting systems, thereby allowing to provide a regulation of the three primary colours - red, blue, and green (RGB), by means of a simplification of the system.

[0031] Each module MC1-MCn can, for example, comprise at least one LED for each colour, i.e. the LEDs designated with LDR, LDG and LDB, and a unit 30 comprising three independent regulation devices, one for each colour. The primary colours can be thus regulated such

that the modules MC1-MCn are connected in parallel, using only four wires for connection to the power supply A30. This function has never been possible so far, and the connection of the spotlights has always been carried out in series, due to the obvious requirement of using a centralized regulation system.

[0032] In Fig. 7, a diagram is shown of a regulation device according to the present invention, which includes an integrated circuit IC manufactured by ST Microelectronics and belonging, for example, to the family of regulators indicated with the prefix Lxx. In this circuit, a resistor RX can be provided to be connected to the control pin PR for setting the control voltage to be as low as 5V. In fact, several integrated circuits suitable to be used for this application have a control pin PR that only accepts signals consistent with the TTL standard.

[0033] The diagram in Fig. 8 relates to another possible embodiment of the present invention in which an integrated circuit IC manufactured by National Semiconductor is employed, and which belongs for example to the families of regulators indicated with the prefixes LM26xx or LM29xx. Using these types of integrated circuits, the control of the current is provided externally of the integrated circuit IC by means of a further transistor T2. Also in this case, a resistor RX may be provided which has the function already described above for the embodiment in Fig. 7.

Claims

1. A device for the PWM regulation of the electrical power supplied to one or more LEDs, comprising a DC/DC converter circuit which receives a DC constant voltage, and outputs a constant current to said one or more LEDs, **characterized by** comprising an interface circuit which receives a PWM input signal and outputs at least one processed signal based on the PWM input signal in order to enable/disable said converter circuit.
2. The device according to claim 1, wherein said signal outputted from said interface circuit is an inverse-phase PWM signal with respect to said PWM input signal.
3. The device according to claim 1, wherein the output of said interface circuit is connected to the input of said converter circuit.
4. The device according to claim 1, wherein said converter circuit is provided with at least one integrated circuit having at least one regulation pin, and wherein said inverse-phase PWM signal is applied to said regulation pin to turn on/off said integrated circuit.
5. The device according to claim 1, wherein said PWM signal applied at the input of said interface circuit has a high logic level with the same voltage value as the DC constant voltage value applied at the input of said converter circuit.
6. The device according to any of the preceding claims, wherein said interface circuit comprises two input terminals to which said PWM signal is applied.
7. A lighting module comprising one or more LEDs housed in a same envelope, **characterized by** incorporating at least one regulation device according to any of claims 1 to 6 in order to perform a PWM regulation of the electrical power supplied to said one or more LEDs.
8. The lighting module according to claim 7, wherein said one or more LEDs consist of LEDs emitting light of a same colour, and wherein said module includes a regulation device for said one or more LEDs.
9. The lighting module according to claim 8, wherein said one or more LEDs consist of white light LEDs.
10. The lighting module according to claim 7, wherein said LEDs consist of LEDs emitting light of a different colour, and wherein said module includes at least one power terminal for each of the LEDs of a same colour in order to receive distinct control PWM signals, as well as at least one power terminal in common with all said LEDs.
11. The lighting module according to claim 10, wherein at least one regulator device and at least one LED for each of the three colours red, blue and green are provided.

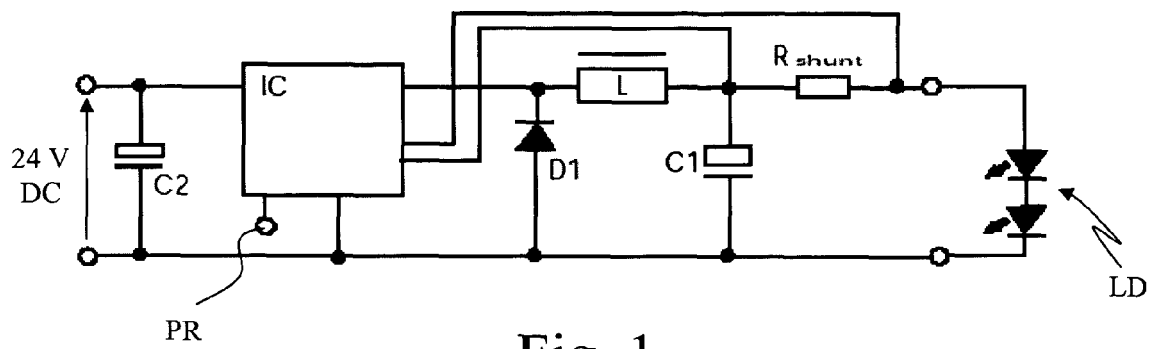


Fig. 1
(PRIOR ART)

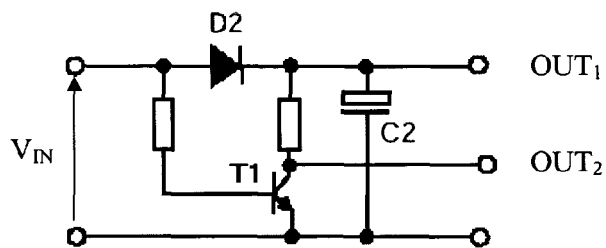


Fig. 2

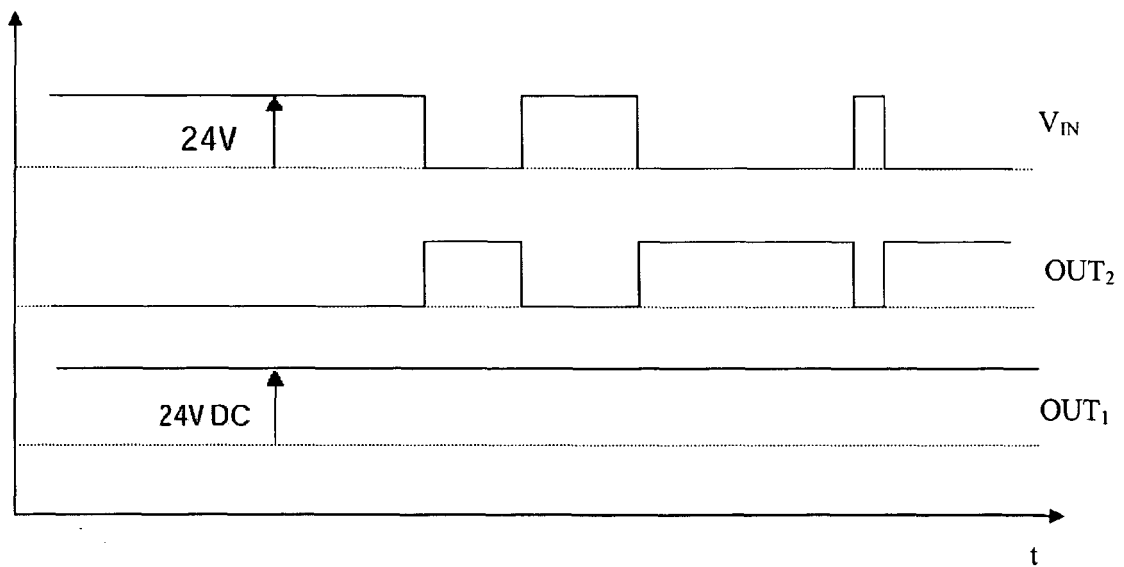


Fig. 3

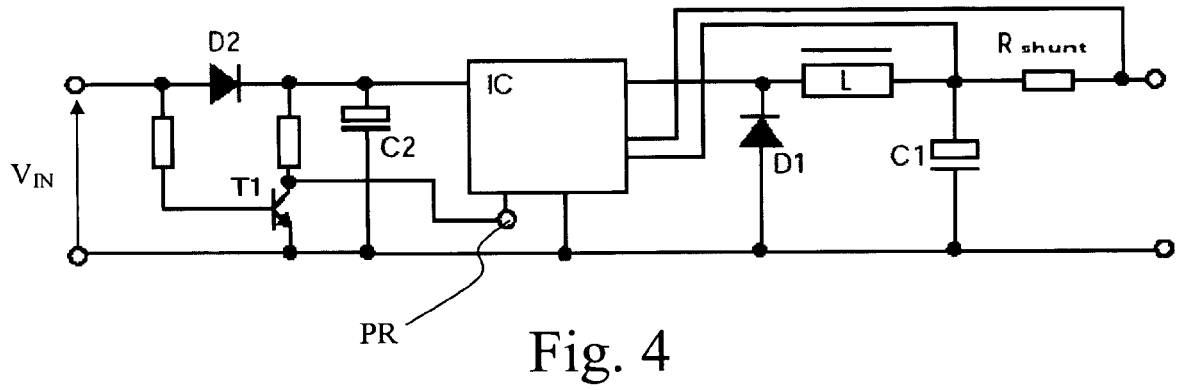


Fig. 5

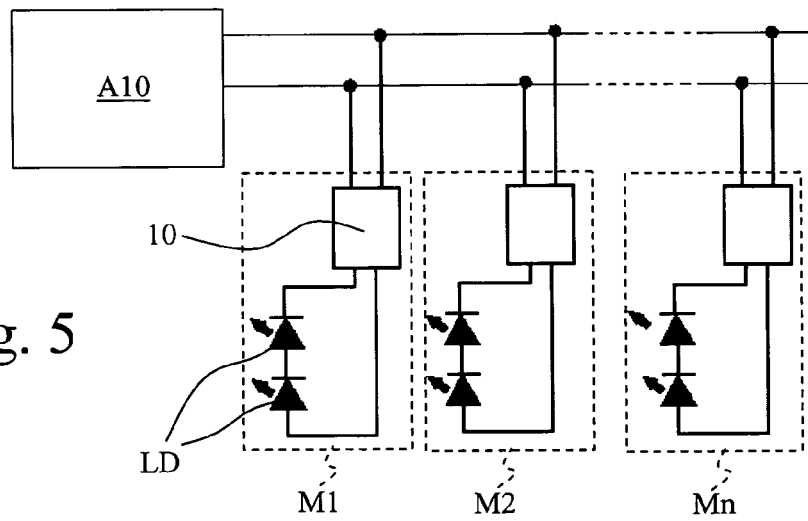
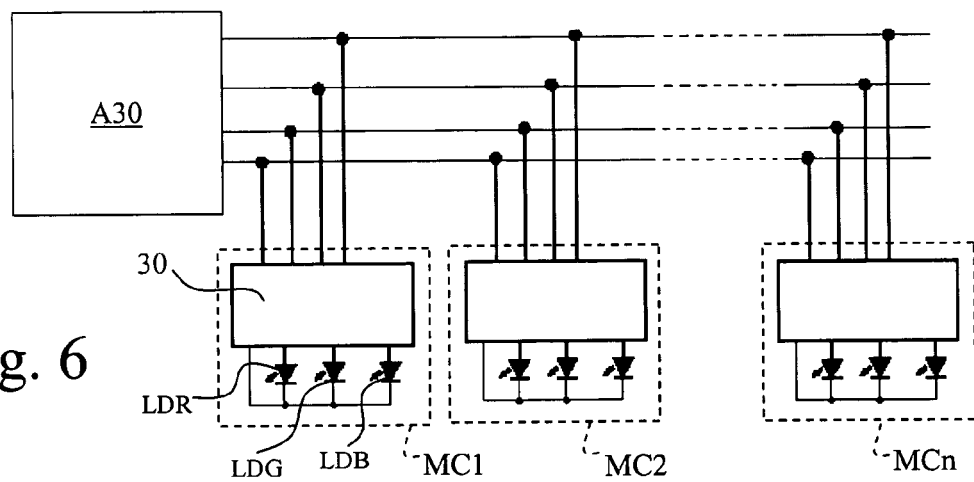


Fig. 6



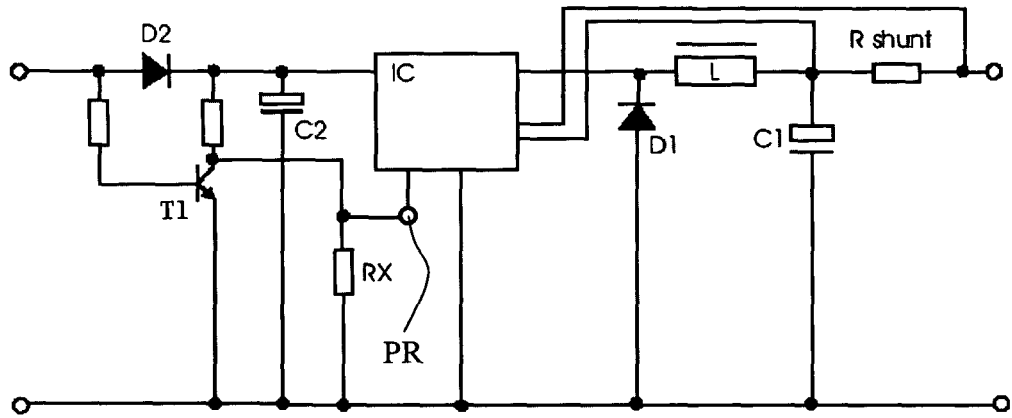


Fig. 7

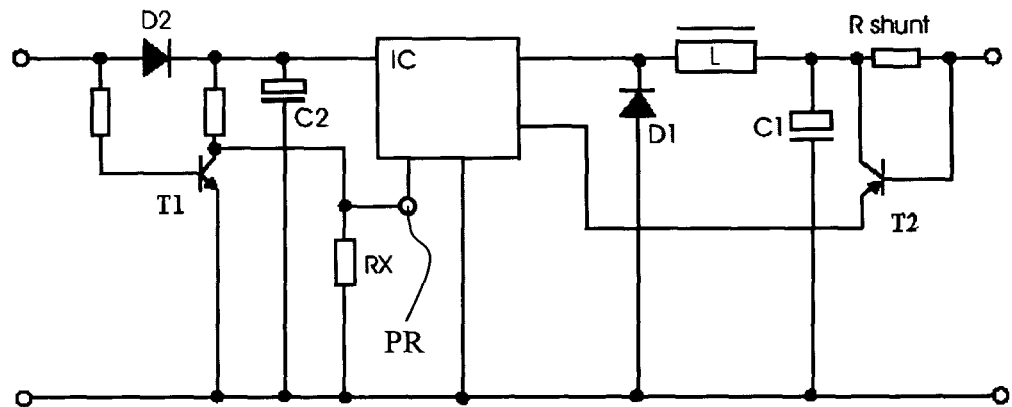


Fig. 8



European Patent
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EUROPEAN SEARCH REPORT

Application Number
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Place of search The Hague		Date of completion of the search 25 October 2006	Examiner Silva, João Carlos
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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