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

(11) EP 2 109 348 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.10.2009 Bulletin 2009/42

(51) Int Cl.:
H05B 37/02 *(2006.01)*

(21) Application number: **09157501.9**

(22) Date of filing: **07.04.2009**

(84) Designated Contracting States:
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 SE SI SK TR

(30) Priority: **08.04.2008 IT TO20080268**

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(54) Lighting device and system, and corresponding control method

(57) Described herein is a lighting device (3'), provided with: a lighting assembly (5') having at least a first light source (6') with a plurality of lighting elements (28) that can be controlled individually; and a first processing circuit (7'), which generates a first control signal that carries first control information for controlling the lighting elements (28). The first light source (6') includes a second microprocessor processing circuit (22), designed to process the first control signal to obtain the first control information. Moreover disclosed is a lighting system (10), having: a controller (2), designed to transmit a second control signal for managing the lighting system (10); and the aforesaid lighting device (3'), which is operatively coupled to the controller (2) and generates the first control signal as a function of the second control signal.

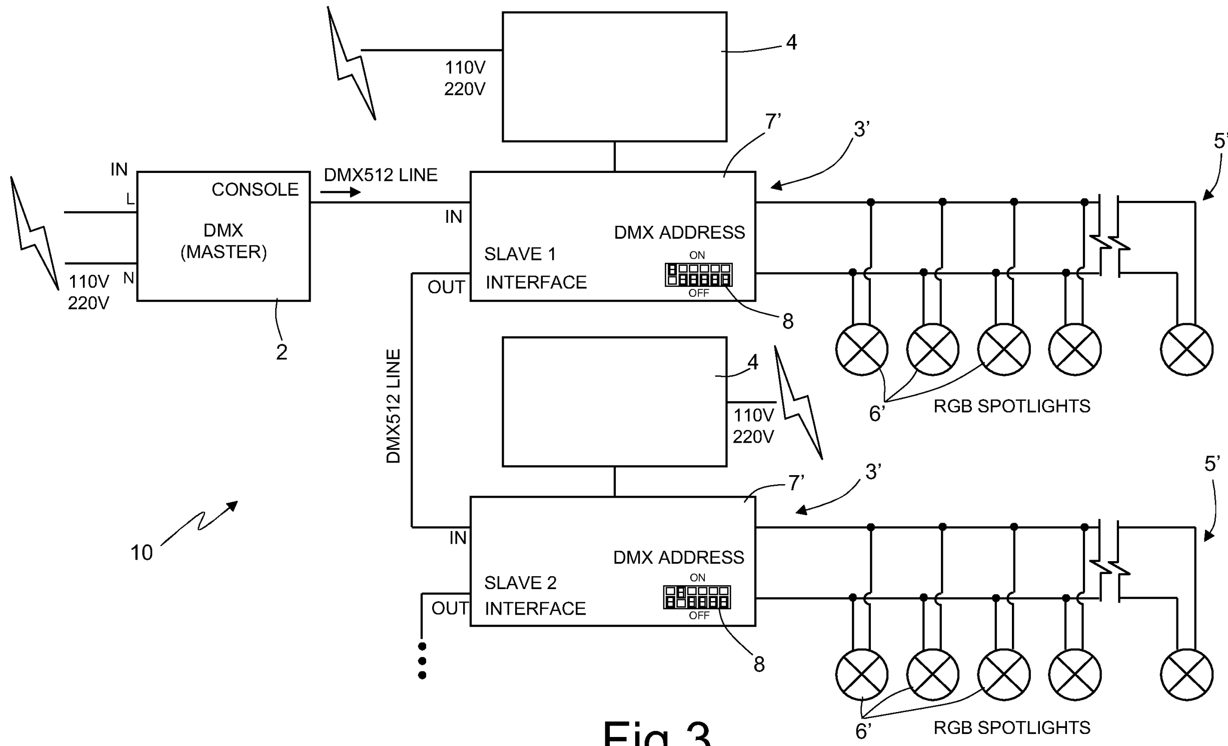

Fig.3

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Description

[0001] The present invention relates to a lighting device and system and to a corresponding control method, for example designed for household applications; in particular, the following description will make explicit reference, without this implying any loss of generality, to a lighting system using LED (Light Emitting Diode) light sources and a communication protocol of a DMX512 type.

[0002] The increasing use of LED light sources is known in a wide range of fields of application, for example in the automotive field, in indoor and outdoor lighting, and in industrial or consumer electronics; LEDs enable in fact a high lighting efficiency combined with low consumption levels.

[0003] Also known is the use of the DMX512 communication protocol (also known as E1.11, USITT DMX-512-A standard) for control of complex lighting systems that are provided with a number of lighting devices or units.

[0004] Figure 1 illustrates by way of example a lighting system, designated as a whole by the reference number 1, which uses the DMX512 protocol.

[0005] In particular, the lighting system 1 comprises: a controller 2 (commonly defined as DMX512 console), operating as "master"; a plurality of controlled devices 3, having "slave" functions; and a plurality of power supplies 4, which are each connected to the electric mains supply (and consequently receive a mains voltage of 220 V or 110 V) and which supply a respective controlled device 3.

[0006] The controller 2 is connected at output to a first one of the controlled devices 3 and transmits a DMX512 control signal, for controlling the lighting system 1, through a DMX512 communication line. In a known way, the DMX512 control signal is a digital signal transmitted in an asynchronous serial mode at the rate of 250 Kbit/s, and generally contains a start byte, followed by up to a maximum of 512 information bytes, each byte representing a different DMX512 channel. The controlled devices 3 are cascaded according to the so-called "daisy-chain" mode, and comprise each a DMX512 input, connected to the preceding controlled device 3 in the chain, and a DMX512 output, connected to the next controlled device 3 in the chain by means of a respective DMX512 communication line. The first controlled device 3 of the chain is connected to the output of the controller 2 and receives the DMX512 control signal, which is then retransmitted in the chain from one controlled device 3 to the next.

[0007] Each controlled device 3 comprises a respective lighting assembly 5, formed by a plurality of light sources 6, connected in series to one another (as will be described in detail hereinafter). For example, each light source 6 is of the RGB-LED type (so-called "RGB spotlights"), and is constituted by a set of three LEDs, which generate one a red light, one a green light, and one a blue light. Each controlled device 3 is associated to one or more channels of the DMX512 control signal, and comprises a communication interface 7, designed to extract from the DMX512 control signal one or more information bytes (or channels) associated thereto, and to process these information for driving the respective lighting assembly 5. The DMX512 address of each controlled device 3 (which indicates the information bytes associated thereto) can be set via a switching unit of the DIP-switch type 8, with which each controlled device 3 is equipped.

[0008] According to the contents of the information bytes received, each controlled device 3 drives, by means of a respective driving stage (not illustrated herein), supplied by the respective power supply 4, the lighting assembly 5 associated thereto; for example, each controlled device 3 can receive a first channel, carrying colour information, and a second channel, carrying brightness information for driving the corresponding light sources 6. In particular, the driving stage generates, and transmits at output to the lighting assembly 5, PWM (Pulse-Width Modulation) driving signals and is designed to adjust the brightness and colour of the light emitted by the respective lighting assembly 5 by means of a variation of the duty cycle and amplitude values of the generated PWM driving signals. The variation of the duty cycle involves a variation of the rate of turning-on and turning-off of the light sources 6, and consequently a variation of the emitted brightness.

[0009] In greater detail, and with reference to Figure 2, the communication interface 7 has: a pair of supply inputs 7a, which receives a supply signal Val from the respective power supply 4 (not illustrated herein), for example a 24-V voltage signal, with a power of between 60 W and 100 W; a first pair of outputs 7b, designed to drive the blue LEDs (B) of the light sources 6 with a first PWM driving signal; a second pair of outputs 7c, designed to drive the green LEDs (G) of the light sources 6 with a second PWM driving signal; and a third pair of outputs 7d, designed to drive the red LEDs (R) of the light sources 6 with a third PWM driving signal. As illustrated in Figure 2, the LEDs of the light sources 6 which have one and the same colour are cascaded together (the first LED of the cascade being connected to a first output of the respective pair of outputs 7b-7d, and the last LED of the cascade being connected to the second output of the respective pair of outputs 7b-7d). In particular, each LED has a first terminal connected to the LED that precedes it in the cascade, and a second terminal connected to the next LED in the cascade.

[0010] According to the signal received by the controller 2, each controlled device 3 is hence able to adjust the light emitted by the respective lighting assembly 5, driving simultaneously with one and the same PWM driving signal, the LEDs of the same type (in this case of the same colour) of the various light sources 6 connected in series. In particular, it is possible to control the colour of the emitted light, and adjust its brightness (operation known as "dimming").

[0011] The wiring of each light source 6 of each controlled device 3 consequently requires six electrical wires. In addition, it is necessary, during installation, to make the cascaded connection of the LEDs of the various light sources 6. Generally, for simplicity of execution (the light sources 6 can be located in places that are not readily accessible), this cascaded connection is not made at the various light sources 6, but within a junction box, conveyed into which are all the electrical wires (for example, in a number equal to sixty, in the case where ten light sources 6 are present) associated to the various light sources 6 of the controlled device 3.

[0012] It is clear that the wiring required by a lighting system 1 of the above sort has a considerable complexity, normally requiring long times and high costs for installation. In addition, there is a high risk of malfunctioning due to a wrong execution of the wiring, and identification of failures is rendered problematical by the high number of connections required. On account of the connection in series of the various light sources 6, an outage on one of them has moreover repercussions on the others, rendering them simultaneously unusable.

[0013] The aim of the present invention is consequently to solve the aforementioned problems and disadvantages by providing a lighting system that will have a lower complexity and consequently reduced costs and times for installation.

[0014] According to the present invention, a lighting device and system are provided as defined in claims 1 and 12, respectively; further provided is a corresponding control method, as defined in claim 19.

[0015] For a better understanding of the invention, embodiments thereof are now described, purely by way of non-limiting example and with reference to the attached drawings, wherein:

- Figure 1 shows a simplified block diagram of a lighting system of a known type;
- Figure 2 shows a simplified diagram of the electrical connections in a controlled device of the lighting system of Figure 1;
- Figure 3 shows a simplified block diagram of a lighting system according to one embodiment of the present invention; and
- Figure 4 shows a circuit block diagram of a portion of the lighting system of Figure 3.

[0016] As illustrated in Figure 3, a lighting system 10, according to one embodiment of the present invention, has a structure substantially similar to the one described with reference to Figure 1, so that parts that are similar will be designated by the same reference numbers and will not be described in detail again.

[0017] A controller (or console) 2 is operatively coupled to a plurality of controlled devices, here designated by 3', via the DMX512 protocol, and the controlled devices 3' are cascaded together according to a "daisy-chain" connection. Each controlled device 3' is supplied by a respective power supply 4 (which may be provided inside or outside the same controlled device), and comprises a respective lighting assembly, here designated by 5', provided with light sources, here designated by 6', for example of the RGB-LED type.

[0018] According to one aspect of the present invention, and as will be described in detail hereinafter, the communication interface of each controlled device 3', here designated by 7', is designed to decode the DMX512 control signal received by the controller 2 to extract the information bytes associated to the same controlled device (in a way substantially similar to what has been described previously), and is further configured so as to re-encode in numeric form the control information thus extracted so as to generate a serial control signal, designed to control lighting parameters of the light sources 6' of the respective lighting assembly 5'. The serial control signal is retransmitted at output in the form of an asynchronous serial data flow having a given format and a given transmission rate. The data format may envisage transmission of a control byte for each type of LED of the light sources 6' (for example, for a total of three control byte, one for control of the blue LEDs, one for control of the green LEDs, and one for control of the red LEDs), and of one or more verify bits, for example, implementing a check-sum sequence; the transmission rate used for retransmission of the control information is, for example, lower than the transmission rate envisaged by the DMX512 protocol, for example, equal to 96% of this rate (for example, lower than 10 Kbit/s).

[0019] The DMX512 control signal carries general control information for a lighting assembly 5' (for example, corresponding to the colour and to the intensity of the light that is to be emitted), whilst the serial control signal carries specific information (processed by the communication interface 7' as a function of the aforesaid general information) regarding the operating parameters required of the individual LEDs of the light sources 6'. To implement the operations described, the communication interface 7' is provided with a purposely designed processing logic circuit (not illustrated herein), comprising, for example, a microprocessor.

[0020] The control information thus encoded are transmitted to the corresponding lighting assembly 5' through a transmission line comprising just two electrical wires, common to all the light sources 6' of the lighting assembly 5'. Each light source 6' is in fact provided with a decoding circuit (described hereinafter), designed to receive the serial data flow that encodes the control information from the communication interface 7', and to obtain therefrom the information necessary for driving the various types of LEDs. For this purpose, the decoding circuit is provided with a respective processing logic circuit, comprising, for example, a microprocessor (the light sources 6' can consequently be defined as "smart light sources").

[0021] According to one aspect of the present invention, the communication interface 7' is further configured so as to combine or mix the control information (contained in the serial control signal) to the supply signal Val (for example, once again equal to 24 V and with a power of between 60 W and 100 W) so as to transmit with just the two electrical wires both the same control information and the supply signal necessary for driving the light sources 6'. The decoding circuit on board each light source 6' is consequently able to decode the control information separating it from the supply signal, whilst a driving circuit (described hereinafter), which is also on board the light source 6', is able to implement the driving operations on the basis of the decoded control information, using the supply signal.

[0022] The light sources 6' of each lighting assembly 5' are in this case connected in parallel to one another, having each a first input and a second input connected to a respective electrical wire of the transmission line.

[0023] In greater detail, and with reference to Figure 4, the communication interface 7' comprises: a first logic circuit 12, for example provided with a microprocessor, designed to receive and process the DMX512 control signal so as to generate the serial control signal, having the desired data format; a data buffer 14, connected to the first logic circuit 12, and used by the same first logic circuit 12 for storing temporarily the DMX512 control signal (given the different rate of retransmission of the serial control signal); and an encoding circuit 16, connected to the output of the first logic circuit 12 and to the power supply 4 and designed to receive the serial control signal and to generate an encoded signal Sc, which mixes the control information to the supply signal Val. The encoded signal Sc is sent to the output of the interface circuit 7', and transmitted, by means of the transmission line with two electrical wires, to the lighting assembly 5'.

[0024] In one embodiment, the encoding circuit 16 comprises a circuit formed by an H bridge of MOSFET transistors, and implements the encoding of the control information in the form of a reversal of polarity of the supply signal Val. In particular, the encoded signal Sc is a voltage signal having two possible values (+24 V or -24 V), corresponding to the serial control signal generated by the interface circuit 7' (for example, corresponding to a binary value "1" of the serial control signal is a value of +24 V of the encoded signal, and corresponding to a binary value "0" of the serial control signal is a value -24 V of the encoded signal). The H-bridge circuit has a first input, which receives the supply signal Val, a second input connected to a reference potential (the ground of the circuit), and a first output and a second output, present between which is the encoded signal Sc, and comprises four MOSFETs 18a-18d, operatively coupled in pairs. In particular, a first MOSFET 18a is connected between the first input and the first output and has its control terminal that is connected to the output of the interface circuit 7' and receives the serial control signal; a second MOSFET 18b, which is operatively coupled to the first MOSFET 18a, is connected between the second input and the second output and has its control terminal connected to the output of the interface circuit 7'; a third MOSFET 18c is connected between the first input and the second output and has its control terminal connected to the output of the interface circuit 7' with the interposition of an inverter stage 19 (consequently, it receives the negated serial control signal); and a fourth MOSFET 18d, which is operatively coupled to the third MOSFET 18c, is connected between the second input and the first output and has its control terminal connected to the output of the interface circuit 7' with the interposition of the inverter stage 19. During operation, when the serial control signal has a logic value "1", the first and second MOSFETs 18a, 18b are on, whilst the third and fourth MOSFETs 18c, 18d are off, so that the encoded signal Sc between the first output and the second output has a voltage value of +24 V; instead, when the serial control signal has a logic value "0", the third and fourth MOSFETs 18c, 18d are on, whilst the first and second MOSFETs 18a, 18b are off, so that the encoded signal Sc between the first and second outputs has a value of -24 V.

[0025] The decoding circuit, designated by 20, of each light source 6' comprises: a level-translator stage 21, which is connected to the transmission line with two electrical wires, receives at input the encoded signal Sc, and supplies at output a translated encoded signal (which has, for example, a dynamics of +/-5 V); and a second logic circuit 22, for example, provided with a respective microprocessor circuit, which is connected to the output of the level-translator stage 21 and receives the translated encoded signal, and is designed to decode the control information transmitted by the interface circuit 7' (in particular, separating the serial data flow from the supply signal Val). The second logic circuit 22 also processes the decoded information so as to generate driving control signals.

[0026] The driving circuit, designated by 24, of each light source 6' comprises: a rectifier stage 25, which receives at input, and is designed to rectify, the encoded signal Sc (so as to reconstruct the supply signal Val); and a plurality of driving stages 26, which receive the d.c. supply signal Val rectified by the rectifier stage 25, and respective driving control signals generated by the second logic circuit 22. The driving stages 26 generate at output PWM driving signals (for example, current signals), designed to drive in an appropriate way respective lighting elements 28 of the light source 6'. For example, each light source 6', of the RGB-LED type, comprises three lighting elements 28 (three LEDs, a red one, a green one, and a blue one), and the driving circuit 24 comprises three driving stages 26, each designed to drive a respective lighting element 28.

[0027] Basically, the light sources 6' of each lighting assembly 5' receive the encoded signal Sc, decode it internally via the respective decoding circuits 20, and drive accordingly the respective lighting elements 28 by means of the respective driving circuits 24. Consequently, the lighting elements 28 of a same type (or colour) are turned on in a substantially simultaneous way, according to the same operating modes (for example, with a same brightness).

[0028] A variant of the lighting system 10 may, however, envisage that the light sources 6' of each lighting assembly 5' can be addressed separately. For the purpose, the first logic circuit 12 of the interface circuit 7' is configured so as to generate a serial control signal that associates address information to the control information corresponding to the lighting parameters; for example, the protocol can envisage serial transmission of an address byte followed by one or more bytes containing the control information. In this case, the decoding circuit 20 of each light source 6' is configured so as to read the address information and to extract and decode only the control information associated to the address assigned to the same light source 6'. A control system of this type enables a greater flexibility and variety of lighting configurations, without leading to an increase of the complexity of the lighting system.

[0029] The advantages that can be obtained with the lighting system described emerge clearly from the above description.

[0030] In particular, the use of "smart" light sources 6' (i.e., provided with an internal processing logic circuit) enables use of a single transmission line with just two electrical wires for connection between each communication interface 7' and the respective lighting assembly 5'. A serial control signal, common to all the light sources 6', is transmitted on the transmission line and appropriately interpreted by the decoding circuit 20 of each light source 6' so as to suitably drive the corresponding lighting elements 28. In this way, the complexity of the electrical connections in the lighting system 10 is extremely reduced, as likewise the times and costs required for installation. For example, it is not necessary to make electrical connections between the various light sources 6' of the same lighting assembly 5' (unlike the cascaded connection described with reference to the known art).

[0031] The light sources 6' can moreover be individually addressed by the controller 2, enabling a considerable increase in the versatility of the system and of the lighting effects that can be obtained.

[0032] The parallel connection of the various light sources 6' makes it possible to prevent a failure on one of them from having repercussions on the others. In addition, the presence of a processing logic circuit on board each light source 6' enables rapid diagnosis of the possible failures.

[0033] Furthermore, the system described has reduced electromagnetic disturbance, in so far as it does not envisage transmission of PWM driving signals to the various light sources 6' (which, as is known, can be a source of radio-frequency emissions).

[0034] Finally, it is evident that modifications and variations may be made to what has been described and illustrated herein, without thereby departing from the scope of the present invention, as defined in the annexed claims.

[0035] In particular, it is evident that in the lighting system 10 different types of light sources 6' could be used, for example of the luminescent or fluorescent type. In addition, monochromatic LEDs could be used, for example white-light ones, instead of, or in addition to, the RGB LEDs. Alternatively, quadrichromatic RGBA LEDs could be used, i.e., four LEDs of red, green, blue, and amber colour (and four respective driving channels). The number of controlled devices 3' and light sources 6' can moreover vary. At output, instead of the spotlights, different apparatuses that use high-power or low-power LEDs could be present.

[0036] A communication protocol can be used between the controller 2 and the various controlled devices 3' that is different from the DMX512 protocol; for example, it is possible to use the RDM (Remote Device Management) protocol, the TCP-IP protocol, or the DALI protocol.

[0037] In addition, a wireless transmission could be implemented between the controller 2 and the controlled devices 3', and between the controlled devices 3' themselves, which could be provided for this purpose with an appropriate radio transceiver. The signals could be transmitted at distances of up to 250 metres (the assemblies of independent LEDs could, for example, be isolated and installed at even considerable distances from one another), further favouring the use of the technology described in residential, industrial, and urban domotics.

[0038] It is evident that the data format generated by the first logic circuit 12 in the communication interface 7' may be different, as may also be different the protocol for transmission of these data; the decoding circuit 20 of the light sources 6' may be modified accordingly.

[0039] In addition, the encoding circuit 16 could be configured so as to implement a different encoding of the control information, and/or a different "mixing" with the supply signal Val. For example, the supply signal Val could be appropriately modulated as a function of the information to be transmitted.

[0040] Finally, a variant of the supply system 10 envisages transmission of the serial control signal to the light sources 6', separately from the supply signal Val (the encoding circuit 16 is consequently not present in the communication interface 7'). In this case, two further electrical wires are used for transmitting the supply signal Val to the various light sources 6', in addition to the two electrical wires carrying the control information. Even though it requires a greater wiring complexity (which would be in any case simplified as compared to the traditional solutions), this solution enables a simplification of the operations required for the decoding circuit 20 in the various light sources 6', it being consequently possible to simplify the same circuit and so reduce its costs.

Claims

1. A lighting device (3'), comprising: a lighting assembly (5') provided with at least a first light source (6') having a plurality of lighting elements (28) that can be controlled individually; and a first processing circuit (7') configured to generate a first control signal that carries first control information for controlling said

lighting elements (28), **characterized in that** said first light source (6') includes a second processing circuit (22) designed to process said first control signal to obtain said first control information.

2. The device according to claim 1, wherein said second processing circuit comprises a microprocessor circuit (22).

3. The device according to claim 1 or 2, wherein said first processing circuit (7') comprises an encoding circuit (16) designed to encode said first control signal on the basis of a supply signal (Val) so as to generate an encoded signal (Sc) carrying said first control information mixed to said supply signal (Val); said second processing circuit (22) being designed to decode said encoded signal (Sc) for retrieving said first control information from said first control signal, and said light source (6') further comprising a driving circuit (24) designed to retrieve said supply signal (Val) from said encoded signal (Sc) and to drive said lighting elements (28) using said supply signal (Val), as a function of said first control information.

4. The device according to claim 3, wherein said first processing circuit (7') is electrically connected to said light source (6') via a transmission line having just two electrical wires, designed to carry said encoded signal (Sc).

5. The device according to claim 3 or 4, wherein said first control signal is a digital signal having a first value and a second value, and said encoding circuit (16) is configured so as to encode said encoded signal (Sc) as inversions of polarity of said supply signal (Val); said encoded signal (Sc) having the value of said supply signal (Val) when said numeric signal has said first value, and the inverted value of said supply signal (Val) when said numeric signal has said second value.

6. The device according to claim 5, wherein said encoding circuit comprises a circuit formed by an H bridge (16) of transistors, which receives at input said first control signal and supplies at output said encoded signal (Sc).

7. The device according to any one of claims 3 to 6, wherein said driving circuit (24) comprises a rectifier stage (25) designed to receive said encoded signal (Sc) and to reconstruct said supply signal (Val), and a plurality of driving stages (26) connected to said rectifier stage (25); each of said driving stages (26) being designed to receive said supply signal (Val) and to drive a respective one of said lighting elements (28), on the basis of respective control information received by said second processing circuit (22).

8. The device according to any one of the preceding claims, wherein said light sources (6') are of the RGB or RGBA LED type, and said lighting elements (28) comprise a first LED, of a red colour, a second LED, of a green colour, and a third LED, of a blue colour.

9. The device according to any one of the preceding claims, further comprising at least one further light source (6') connected to said first processing circuit (7') and provided with a respective second processing circuit (22); said first and further light sources (6') being connected together in parallel to one and the same transmission line carrying said first control signal.

10. The device according to claim 9, wherein an address is associated to each of said first and further light sources (6'); said first control signal being configured to associate a given source address to first control information corresponding to a given one of said first and further light sources (6') having said given source address, and said second processing circuit (22) of said given light source (6') being configured to process said first control signal to obtain said first control information associated to said given source address.

11. The device according to any one of the preceding claims, wherein said first control signal is a serial signal, organized according to a protocol that envisages subsequent transmission of first control information, each of said first control information being associated individually to one of said lighting elements (28).

12. A lighting system (10) comprising a controller (2) designed to transmit a second control signal for managing said lighting system (10), and at least a first lighting device (3') according to any one of the preceding claims, operatively coupled to said controller (2); said first lighting device (3') being configured to generate said first control signal as a function of said second control signal.

13. The system according to claim 12, further comprising at least a further lighting device (3'), independent of said first lighting device (3'), which is operatively coupled to said controller (2) and receives said second control signal; a device address being associated to said first and further control devices (3'), and said second control signal being configured to associate to a given device address second control information corresponding to a given one of said first and further lighting device (3') having said given device address, and said first processing circuit (7') of said given lighting device (3') being configured to process said second control signal to obtain said second control information associated to said given device address.

14. The system according to Claim 13, wherein said controller (2) and said first lighting device (3'), and said first and further lighting devices (3'), are operatively coupled by means of a DMX512 communication protocol.

15. The system according to Claim 14, wherein said controller and said first lighting device (3'), and said first and further lighting devices (3') are operatively coupled by means of a wireless communication protocol.

16. The system according to any one of claims 12 to 15, wherein said first control signal is an asynchronous serial signal having a transmission rate lower than a transmission rate of said second control signal.

17. The system according to claim 16, wherein said first lighting device (3') further comprises a storage buffer (14) designed to store said second control signal temporarily.

18. A light source (6') of a lighting device (3'), according to any one of claims 1 to 11.

19. A method for controlling a lighting system (10), **characterized by** comprising:

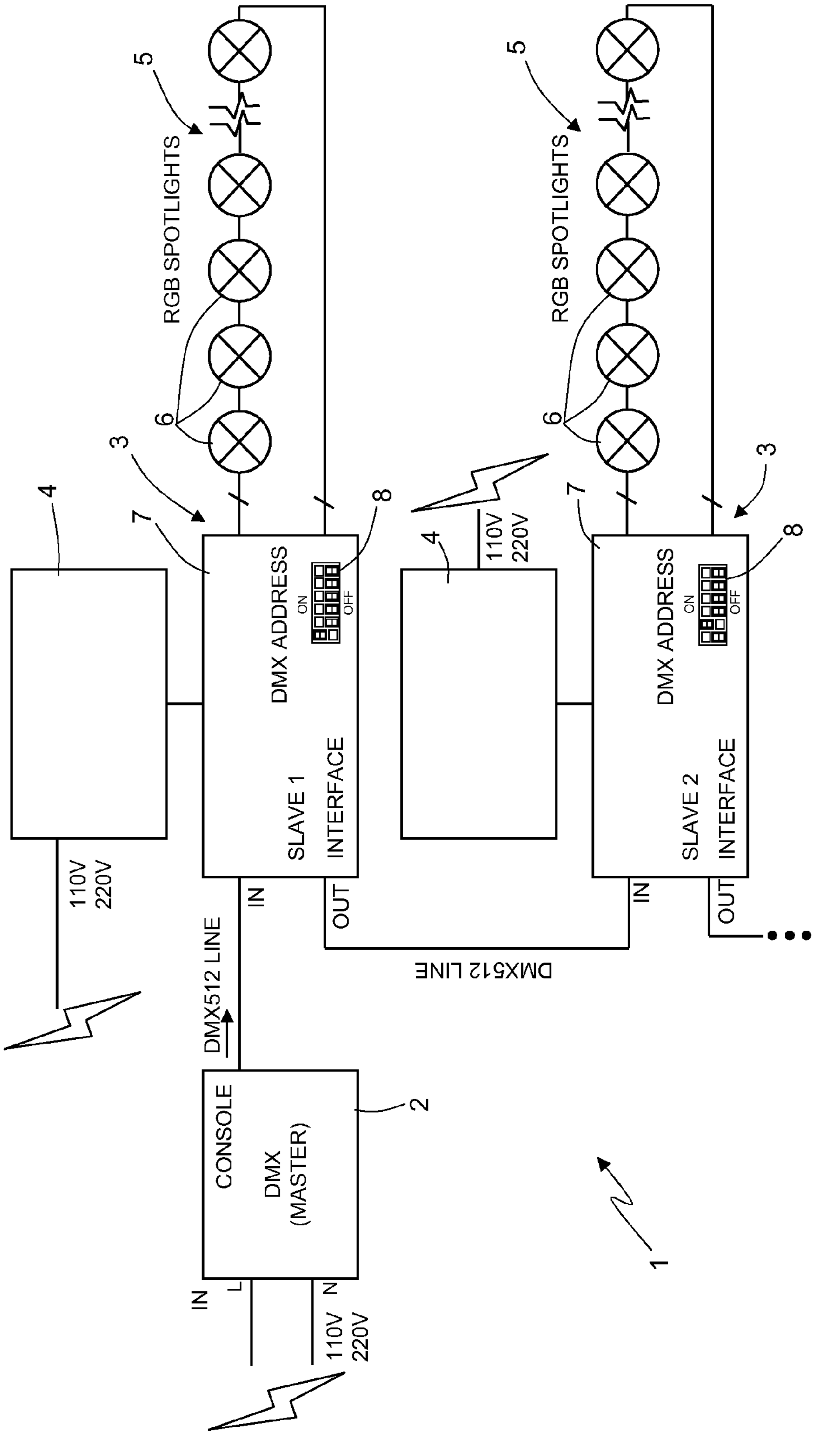
- generating, by a first processing circuit (7') of a lighting device (3') of said lighting system (10), a first control signal carrying first information for control of individually controllable lighting elements (28) of a corresponding light source (6'), starting from a second control signal received by a controller (2) of said lighting system (10); and
- processing, by a second processing circuit (22) of said light source (6'), said first control signal to obtain said first control information.

20. The method according to claim 19, comprising encoding, by said first processing circuit (7'), said first control signal on the basis of a supply signal (Val) so as to generate an encoded signal (Sc) carrying said first control information mixed to said supply signal (Val); said step of processing comprising the step of decoding said encoded signal (Sc) to retrieve said first control information from said first control signal.

21. The method according to claim 20, further comprising, by a driving circuit (24) of said light source (6'), retrieving said supply signal (Val) from said encoded signal (Sc), and driving said lighting elements (28) using said supply signal (Val), as a function of said first control information.

22. The method according to any one of claims 19 to 21, wherein said lighting device (3') comprises at least one further light source (6'), and wherein a source address is associated to each of said first and further light sources (6'); said step of generating comprising associating a given source address to first control information corresponding to a given one of said first and further light sources (6') having said given source address; and said step of processing, by said second processing circuit (22) of said given light source (6'), comprising processing said first control signal to obtain said first control information associated to said given source address.

23. The method according to any one of claims 19 to 22, further comprising transmitting, by said controller (2), said second control signal according to a DMX512 communication protocol or a wireless communication protocol.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DMX512 LINE
RGB SPOTLIGHTS
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DMX ADDRESS
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SLAVE 2
INTERFACE
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Fig.1

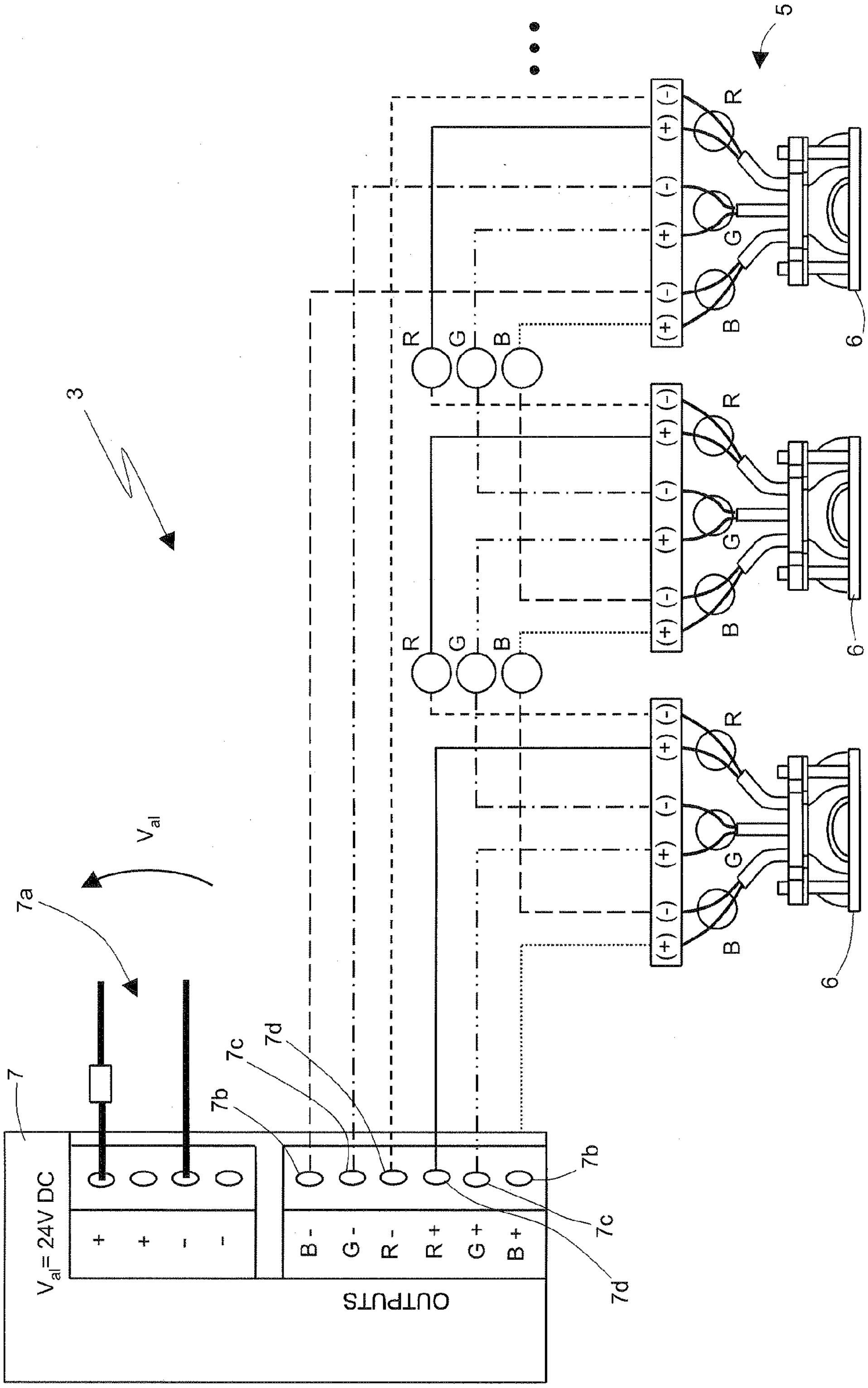

Fig.2

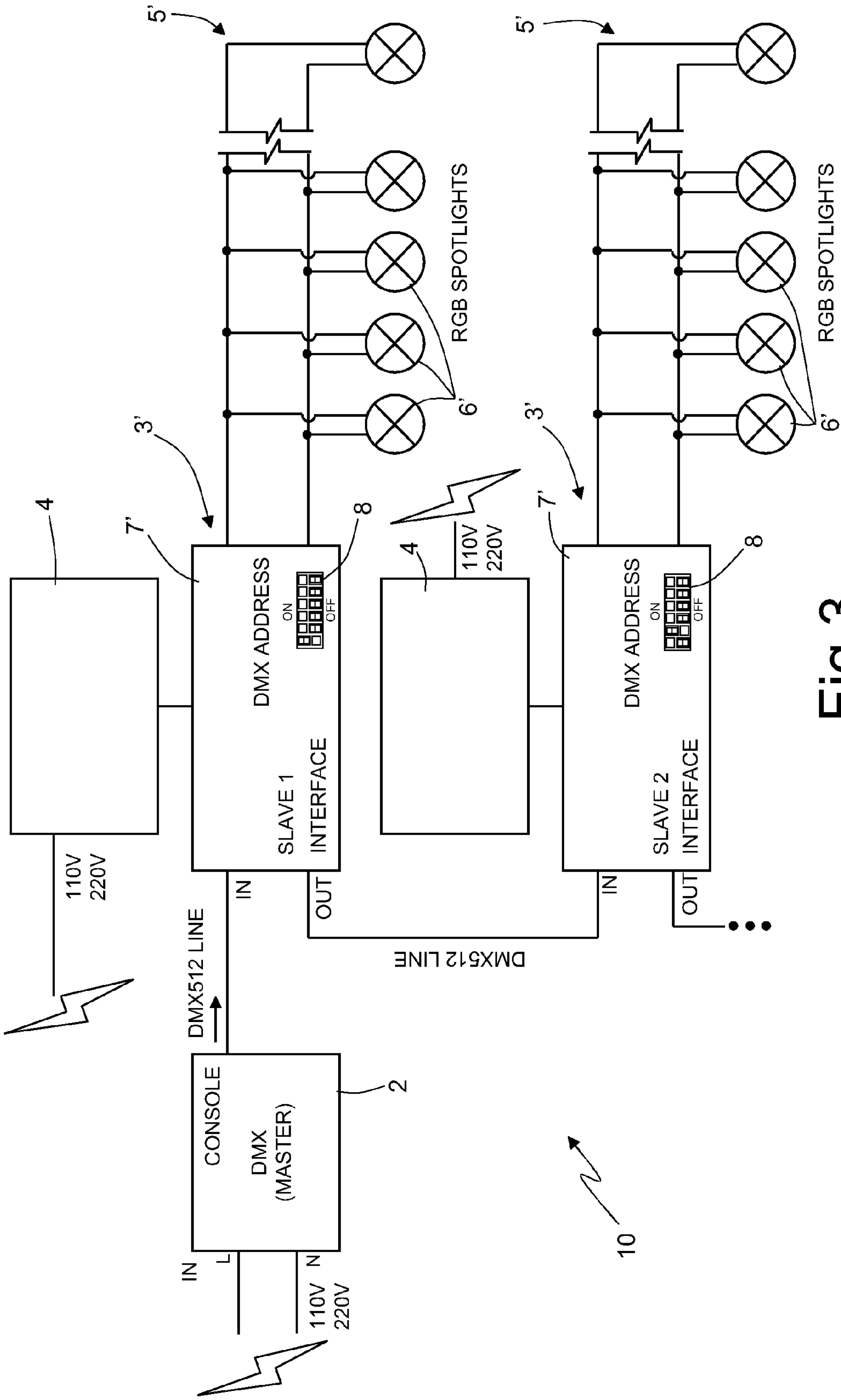
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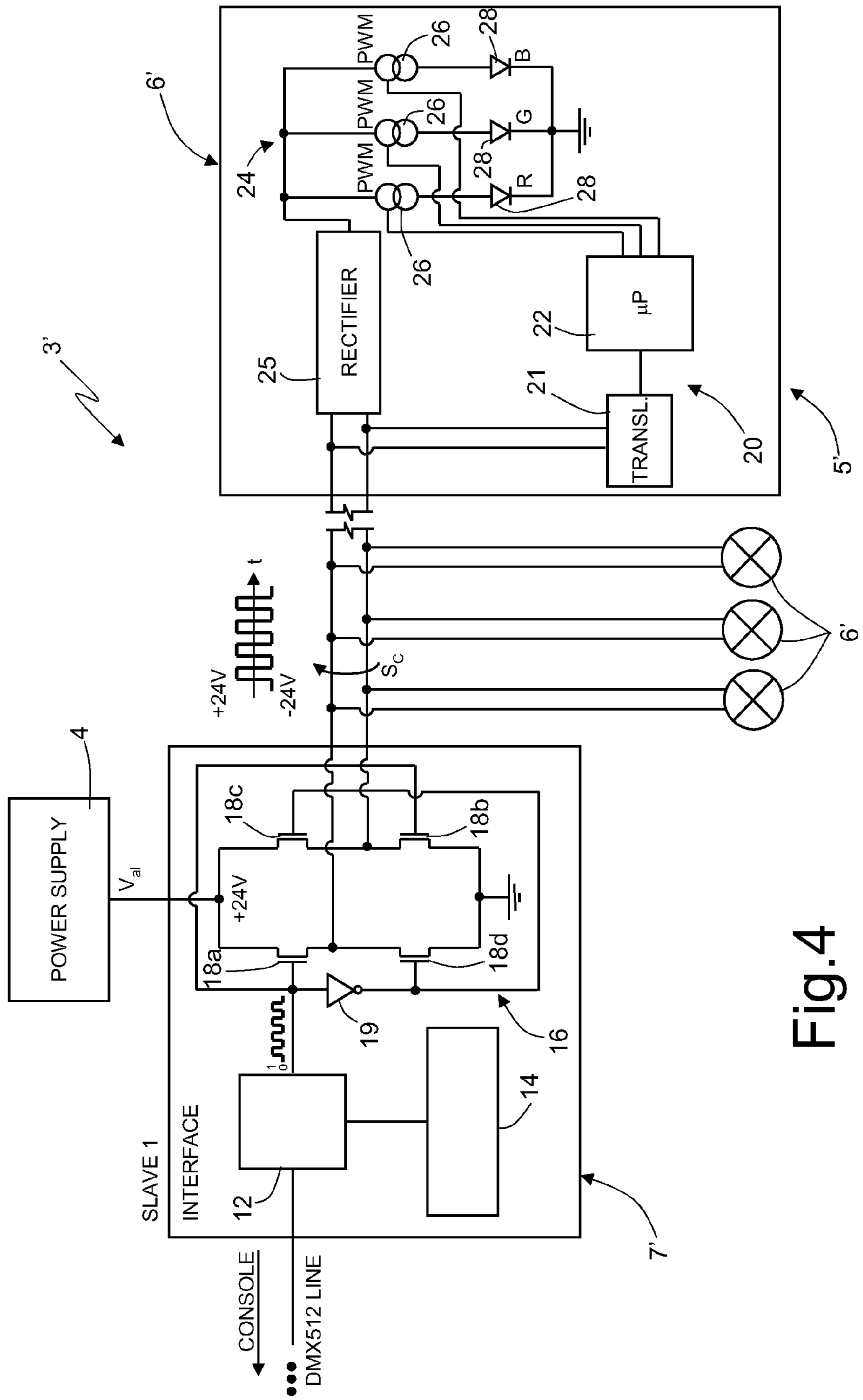
Fig.3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t
6'
RECTIFIER
25
TRANSL.
21
μP
22
20
5'
24
PWM
PWM
PWM
26
26
26
28
28
28
R
G
B

Fig.4