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(54) DRIVER DEVICE WITH PLURAL OUTPUT CHANNELS

(57) A driver device (1) for generating a load current for at least one load, the driver device (1) comprising an isolation barrier for isolating electrically a primary circuit (2) and a secondary circuit (4) of the driver device (1), the secondary circuit (4) comprises at least a first load terminal (LED1+) and a second load terminal (LED2+). The secondary circuit (4) comprises at least one filter circuit (1) connected with a load terminal (LED2+) of the first load terminal (LED1+) and the second load terminal (LED+), and the at least one filter circuit (11) is configured to provide a signal that is generated based on the load current output via the connected load terminal. The driver device (1) may form part of a system comprising the driver device (1) driving the load, and the load is connected between a common load terminal (LED-) and one of the first load terminal (LED1+) and the second load terminal (LED2+) of the driver device (1).

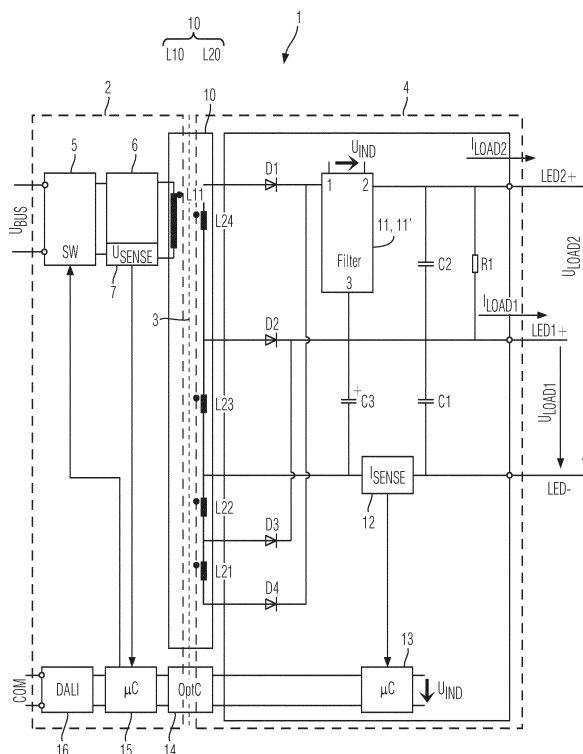


Fig. 1

Description

[0001] The invention concerns the field of driver devices for building automation applications, in particular applied in lighting systems. A driver device with plural output channels, e.g. with plural output channels for selectively operating loads at different voltage ranges and exhibiting an improved output channel monitoring is presented.

[0002] Converter devices, e.g. LED converters, implemented in a switch mode power supply (SMPS) circuit topology for generating a load current for driving lighting modules that include one or a plurality of light emitting diodes (LED) form an essential component of temporary lighting systems. The LLC resonant converter topology is a particular example for a converter device applied as a current source to drive LEDs. There exist practical limitations for an achievable load voltage range provided at the load output by the converter device due to considerations concerning device efficiency or switching frequency range, for example.

[0003] In order to overcome the limitations in providing a desired load voltage range, a practical approach is to use a transformer in the LLC resonant converter that provides multiple taps on a secondary winding of the transformer to achieve multiple output voltage ranges using different turn ratios of the transformer. Fig. 5 of the accompanying drawings displays a general design example for a secondary side circuitry for such an LLC resonant converter device using the transformer with multiple taps on the secondary winding, and alternative load output terminals LED1+ and LED2+ respectively connected with the corresponding taps of the transformer. The LLC resonant converter device has a common load terminal LED- connected with the common return path. The common return path may have a current measuring means for measuring the load current for implementing the current regulation control loop.

[0004] Measuring a current in each output channel of the converter device is not necessary for the current regulation and usually avoided for sake of low device complexity, compact design and competitive cost. Measuring the current in each output channel individually may require multiple current transformers portion with differential measurement and is not only expensive with regard to number of components and associated space on the printed circuit board (PCB), but it also results in a much more complex control loop design.

[0005] Nevertheless, for converter devices integrated within a lighting system via a communication network, it may be desirable to implement functions such as power output calculation and reporting the calculated output power via the lighting network, e.g. using a lighting protocol such as digital addressable lighting interface (DALI). This may require determining the load current for each load output individually.

[0006] Thus, it is desirable to provide in the driver device with multiple output channels a capability to determine the output power to a load for different output chan-

nels without significantly increasing circuit complexity and cost.

[0007] The driver device according to claim 1 and a corresponding building automation system including at least one such driver device provide an advantageous solution addressing the aforementioned issues.

[0008] A first aspect concerns the driver device for generating a load current for at least one load. The driver device comprises an isolation barrier for electrically isolating a primary circuit and a secondary circuit of the driver device. The secondary circuit comprises at least a first load terminal and a second load terminal, and the secondary circuit further comprises at least one filter circuit connected to one load terminal of the first load terminal and the second load terminal. The at least one filter circuit is configured to provide a signal that is generated based on the load current output via the load terminal.

[0009] The driver device according to independent claim 1 represents an economical and simple way of identifying which of the multiple load voltage ranges provided by the output terminals of the driver device actually is connected with the load and in use. The current load voltage output to the load is known by determining which output terminal and which corresponding load voltage range actually is in use. The driver device achieves this without requiring means for measuring the load current in each output channel individually. Therefore, for the purpose of load current regulation, it is still only necessary to measure the total load current, for example, in the common return path of the plural load output channels. Due to dispensing with the need for measuring the current of each output channel individually, the driver device has only modestly increased count of electric components arranged on the PCB, reduced space requirements on the PCB and limited complexity for designing the control loop for regulating the load current output by the driver device, although the load terminal and therefore the load voltage range currently in use is easily determinable. Thus, the driver device may implement further advantages functions such as determining load power output and even implement further reporting functions, which present particular advantages for application in advanced lighting systems.

[0010] A further advantageous application of the claimed driver device concerns implementing an individual switch-off of capability for plural load output channels of the driver device. Although a general switch-off capability of the driver device, for example, in case an over-voltage occurs at one of the output terminals without determining individually, at which output channel the over-voltage actually occurs, is generally possible, implementing an individual switch-off capability for the plural output channels becomes possible. This provides a switch-off capability with an increased accuracy and, more advantageous, individually for the plural load output channels. If it is known which of the load output channels is currently active, the switch-off capability may base on voltage thresholds individually predetermined for the plural out-

put channels and their corresponding load voltage ranges. Measuring the current load voltage may be performed by an electric circuitry (primary circuitry) arranged on the primary side of the transformer of the driver device commonly for all output channels. The driver device combines the knowledge on the currently used load output channel and therefore the current load output voltage range based on knowledge on the load voltage terminal currently in use and, thus, the known winding ratio of the transformer currently applicable in order to determine the current load voltage with the measured voltage on the primary side of the transformer. The driver device may select a currently applicable predetermined voltage threshold for overvoltage protection based on knowledge on the load terminal currently in use. Thus, an individual switch-off capability for plural output channels of the driver device becomes implementable with only reduced complexity increase in electronic circuitry.

[0011] The driver device according to an embodiment has the filter circuit including an inductor, and the inductor comprises a main winding, and an auxiliary winding configured to provide a signal induced by a current through a main winding of the inductor.

[0012] According to one embodiment of the driver device, the filter circuit includes a first capacitor and a second capacitor arranged with the inductor of the filter circuit in a π -circuit topology. In that case, the filter circuit may then be further configured to replace a filter capacitor in the secondary circuit of the driver device.

[0013] Further, the driver device, may comprises a transformer for providing the isolation barrier between the a primary circuit and a secondary circuit, and the driver device according to the above explained embodiment may have the secondary circuit comprising at least one diode, with the filter circuit is connected between a secondary winding of the transformer and the diode.

[0014] The driver device according to the above described embodiment may include the evaluation circuit configured to determine that the current is output via the load terminal in case of sensing the signal provided by the auxiliary winding.

[0015] The driver device according to another embodiment includes the inductor configured to go into saturation in case the load current flows through the main winding of the inductor.

[0016] According to this embodiment of the driver device, the driver device may further comprise an evaluation circuit configured to determine whether the current flows through the main winding based on the signal provided by the auxiliary winding, and, further, the evaluation circuit may be configured to determine that the current is output via the load terminal in case of sensing no signal provided by the auxiliary winding.

[0017] According to an embodiment of the driver device, the secondary circuit comprises a sensing means for sensing the load current, wherein the sensing means is connected to a common load terminal for connecting the load.

[0018] The driver device according to an embodiment has the sensing means configured to generate a signal proportional to the load current for controlling the load current in a control loop of the driver device.

[0019] In an embodiment, the driver device may be configured to output the load current in a first voltage range via the first load terminal to the load and to output the load current in a second voltage range via the second load terminal to the load, and the first voltage range and the second voltage range may be different voltage ranges.

[0020] According to an embodiment of the driver device, the driver device is configured to determine a load power output by the driver device based on the load current and the signal provided by the filter circuit, and the driver device is configured to output a communication signal encoding the determined load power.

[0021] The driver device according to an embodiment is configured output a communication signal encoding the determined load power.

[0022] According to an embodiment of the driver device, the driver device is configured to generate the communication signal based on a building automation interface protocol, in particular for a digital addressable lighting interface protocol, a DALI protocol, a DALI-2 protocol or a D4i protocol.

[0023] The driver device according to one embodiment is configured to switch off the driver device in case of determining that a load voltage provided by one of the first load terminal and the second terminal exceeds a preset threshold value based on the signal provided by the filter circuit and based on a voltage measured by the primary circuit.

[0024] The driver may be configured to set the preset threshold value individually for the first load terminal and the second load terminal.

[0025] According to an embodiment of the driver device, the primary circuit is configured to measure the voltage over the primary winding of the transformer, to determine the load terminal that outputs the load current to the load, to determine the load voltage based on the determined load terminal and a winding ratio of the transformer for the determined load terminal, and to compare the determined load voltage with the preset threshold value for the load terminal.

[0026] In an alternative embodiment, the evaluation circuit may be located on the primary side.

[0027] The driver device according to an embodiment is a switch mode power supply (SMPS), in particular a switch mode power supply in LLC resonant converter circuit topology.

[0028] The driver device may be a light driver device, in particular a LED driver device for driving the load that includes at least one LED lighting module.

[0029] A system comprising a driver device and a load, in particular at least one lighting module as the load, according to a second aspect includes at least one driver device according to the first aspect, and the load. The

system includes the load connected between a common load terminal and one of the first load terminal and the second load terminal of the driver device.

[0030] The following description of embodiments refers to the attached figures, in which

Fig. 1 shows a schematic circuit diagram that illustrates a driver device according to a first embodiment;

Fig. 2 shows a schematic circuit diagram that displays a first example of the secondary side circuit of the driver device according to the first embodiment;

Fig. 3 shows a schematic circuit diagram that displays a second example of the secondary side circuit of the driver device according to the first embodiment;

Fig. 4 shows a schematic circuit diagram that displays an example of the secondary side circuit of the driver device according to the second embodiment; and

Fig. 5 shows a schematic circuit diagram that displays an example of the secondary side circuit corresponding to a detail of a driver device according to prior art for comparison with the driver device according to the embodiments.

[0031] In the figures same reference signs denote same or corresponding elements. The discussion of the figures omits a repetitive discussion of same reference signs for different figures wherever deemed possible without adversely affecting comprehensibility.

[0032] Fig. 1 shows a schematic circuit diagram that illustrates a driver device 1 according to an embodiment.

[0033] The driver device 1 includes electric circuitry comprising a primary electric circuit 2 arranged on a primary side of an isolation barrier 3 and secondary electric circuit 4 arranged on a secondary side of the isolation barrier 3.

[0034] The isolation barrier 3 galvanically isolates the primary circuit 2 from the secondary circuit 4.

[0035] The driver device 1 implements the isolation barrier 3 of the driver device 1 using a transformer 10. The transformer 10 comprises primary windings 10, shown is a single primary winding L10, and secondary windings L20. The primary winding 10 is included in the primary circuit 2. The secondary winding L20 are included in the secondary circuit 4.

[0036] The secondary windings L20 of the driver device 1 include a first secondary winding L21, a second secondary winding L22, a third secondary winding L23, and a fourth secondary winding L24.

[0037] The driver device 1 is a driver device 1 that generates and outputs a load current I_{LOAD} as load current

I_{LOAD1} in a first load voltage range U_{LOAD1} or as a second load current I_{LOAD2} in a second load voltage range U_{LOAD2} .

[0038] The driver device 1 of fig. 1 is implemented based on a SMPS topology, and, more specifically, in a LLC converter circuit topology. However, the driver device 1 is not restricted to an implementation based on the LLC converter circuit topology for providing plural load output channels.

[0039] According to the known LLC converter circuit topology, the primary circuit 2 of the driver device 1 includes a switch circuit 5 and subsequent resonant tank circuit 6.

[0040] The switch circuit 5 obtains a DC bus voltage U_{BUS} and may include power switches in a full-bridge topology, in particular four power switches, or power switches, in particular two power switches in a half-bridge topology. The switch circuit 5 generates an output signal with a rectangular waveform. A difference between the full-bridge topology and the half-bridge topology is that the full-bridge topology generates a signal with a square waveform without DC offset, and an amplitude equal to the bus voltage U_{BUS} . The half-bridge topology emits a signal with the square waveform that is offset by $(U_{BUS} / 2)$. Therefore, the half-bridge topology generates and outputs the signal having half the amplitude of the signal generated by the full bridge topology.

[0041] The switch circuit 5 may include switches implemented by semiconductor switches controlled by a switch control signal with a fundamental switching frequency. A control circuit 15 of the primary circuit 2 may generate and output the switch control signal to the switch circuit 5.

[0042] The resonant tank circuit 6 obtains the signal output by the switch circuit 5. The resonant tank circuit 6 may include a resonant capacitor and two inductors: a resonant inductor in series with the resonant capacitor and the primary winding L10 of the transformer 10, and a magnetizing inductor in parallel with the resonant capacitor and the primary winding L10. The resonant tank circuit 6 performs filtering of the signal provided by the switch circuit 5 for filtering out the harmonics of the signal and thereby generating a signal having a sine waveform of the fundamental switching frequency of the switch circuit 5 to an input, in particular the input terminals of the primary winding L11, of the transformer 10.

[0043] The design considerations for the primary side circuit 2 correspond to the general and well-established design considerations for LLC converter circuits.

[0044] The driver device 1 includes a load interface to an electric load, wherein the load interface includes a common load terminal LED- and a first load terminal LED₁₊ and a second load terminal LED₂₊.

[0045] The load interface provides an output for the first voltage range U_{LOAD1} and the corresponding first load current I_{LOAD1} via the first load terminal LED₁₊ and the common load terminal LED-.

[0046] The load interface provides an output for the

second voltage range U_{LOAD2} and the corresponding first load current I_{LOAD2} via the first load terminal LED2+ and the common load terminal LED-.

[0047] The first voltage range U_{LOAD1} and the second voltage range U_{LOAD2} may be different voltage ranges. In particular, an upper voltage of the first voltage range U_{LOAD1} and the second voltage range U_{LOAD2} may have different voltage values.

[0048] The secondary circuit 4 of the driver device 1 may arrange, as depicted in fig. 1, a current sensing means 12 in a common return path of the secondary circuit 4. The common return path corresponds to the electric connection from the common load terminal LED- to the winding tap connected with one connection each of the elementary secondary windings 22 and 23 of the secondary winding 20 of the transformer 10.

[0049] The current sensing means 12 may generate a current measurement signal corresponding to, e.g. proportional to the load current I_{LOAD} to a control circuit 13 arranged as a part of the secondary circuit 4 of the driver device 1 on the secondary side of the transformer 10.

[0050] The control circuit 13 may include an integrated circuit (IC), in particular an application specific integrated circuit (ASIC), a microcontroller circuit (μC), a microprocessor or any combination of these circuit elements.

[0051] The current sensing means 12 may include a shunt (shunt resistor, measuring resistor) arranged in the common return path. The secondary circuit 4 may provide a measuring voltage across the shunt resistor directly or indirectly to an analogue input terminal of the control circuit 13 of the driver device 1.

[0052] The control circuit 13 may generate a return signal based on the measuring voltage that depends on a current value of the load current I_{LOAD} and output the return signal to a transfer means 14 that transmits the return signal over the isolation barrier.

[0053] The transfer means 14 may be implemented using an optocoupler or an electric transformer.

[0054] A control circuit 15 of the primary circuit 2 of the driver device 1 receives the return signal from the transfer means 14. The control circuit 15 may include an integrated circuit (IC), in particular an application specific integrated circuit (ASIC), a microcontroller circuit (μC), a microprocessor or any combination of these circuit elements.

[0055] The control circuit 15 generates a switch control signal for controlling the switches of the switch circuit 3 of the primary circuit 2 of the driver device 1 based on the return signal received from the secondary circuit 4.

[0056] In particular, the control circuit 15 may implement a controller of a control loop for regulating the load current I_{LOAD} to a preset load current value I_{LOAD_SET} .

[0057] The control circuit 15 may receive the preset load current value I_{LOAD_SET} via a communication signal from a communication interface 16 of the primary circuit 2 of the driver device 1.

[0058] The communication interface 16 may provide a bidirectional communication for the driver device 1 via

communication terminals COM of the driver device 1 over a communication network based on a predefined communication protocol, e.g. a lighting control protocol including, but not limited to the Digital Addressable Lighting Interface (DALI™) series of protocols. DALI provides a network-based protocol for controlling lighting.

[0059] The communication protocol may be a predecessor for DALI™, the 0-10 V lighting control system. Alternatively, an open standard alternative or one proprietary protocol for building automation may be used in addition or alternative to the DALI protocol.

[0060] The DALI™ protocol may include the DALI™ protocol, a DALI-2™ and a D4i™ protocol.

[0061] DALI™ is specified by a series of technical standards in IEC 62386. The DALI™ refers to devices that comply with a DiIA released testing and certification requirements, and are listed as either registered (DALI version-1) or certified (DALI-2) on a DiIA website.

[0062] The control circuit 16 may generate output signals for transmission via the communication module 16 and the communication network.

[0063] The communication network may be a wired or a wireless network, e.g. a radio communication network.

[0064] The secondary circuit 4 shown in fig. 1 comprises the secondary windings L20 of the transformer 10, a first load path including the first load terminal LED1+, a second load path including the output terminal LED2+ and a common return path including the common terminal LED-.

[0065] The first load path comprises the secondary winding L22 and L23, and the rectifying diodes D2 and D3, a filter capacitor C3 and an output capacitor C1. The capacitor C3 is an electrolytic capacitor.

[0066] The second load path comprises the secondary windings L21 and L22, L23 and L24, and the rectifying diodes D1 and D4, output capacitors C1 and C2.

[0067] In the embodiment of fig. 1, a filter circuit 11 replaces the filter capacitor C4 included in the second load path in the secondary circuit 4 of the known driver device 50 as illustrated in fig. 5.

[0068] In the specific example of the first embodiment of the invention illustrated in fig. 1, a first terminal of the filter circuit 11 is connected with the cathode of the diode D1 and the cathode of the diode D4. A second terminal of the filter circuit 11 is connected with the second load terminal LED2+, a first terminal of the output capacitor C2 of the second load path and a first terminal of a resistor R1 (output resistor R1) that is connected between the second load terminal LED2+ and the first load terminal LED1+.

[0069] A third terminal of the filter circuit 11 of fig. 1 is connected with the first load terminal LED1+, a first terminal of the output capacitor C1, a first terminal of the filter capacitor C3 of the first load path, a cathode of the rectifier diode D2 and a rectifier diode D3 of the first load path.

[0070] The filter circuit 11 generates an indicator signal U_{IND} based on an electric current through filter circuit 11

and provides the indicator signal U_{IND} to the control circuit 13. The control circuit 13 obtains the indicator signal U_{IND} and evaluates the obtained indicator signal U_{IND} in order to determine whether a first load current I_{LOAD1} is output via the first load terminal LED₁+ or a second load current I_{LOAD2} is output via the second load terminal LED2+.

[0071] The control circuit 13 includes an evaluation circuit, which determines based on the indicator signal U_{IND} and the current measurement signal provided by the current measurement means 12 arranged in the common return path, whether the first load current I_{LOAD1} is output via the first load terminal LED₁+ or the second load current I_{LOAD2} is output via the second load terminal LED2+.

[0072] A specific circuit example of the filter circuit 11 will be discussed with reference to fig. 2. The filter circuit 11 is arranged in the current path between Diodes D1 and D4 and the second load terminal LED2+.

[0073] In an alternative variant, the secondary circuit 4 may replace the filter capacitor C3 of the first load path with a further filter circuit 11' in the first load path in an entirely corresponding manner to the filter circuit 11 in the second load path. In this embodiment, the further filter circuit 11' generates a further indicator signal U_{IND}' based on the an electric current through the further filter circuit 11' and provides the further indicator signal U_{IND}' to the control circuit 13. The control circuit 13 obtains the indicator signal U_{IND}' and the indicator signal U_{IND} , and evaluates the obtained indicator signals U_{IND}' and U_{IND} in order to determine whether a first load current I_{LOAD1} is output via the first load terminal LED₁+ or a second load current I_{LOAD2} is output via the second load terminal LED2+.

[0074] The control circuit 13 generates a load indication signal based on the evaluation including information whether the first load current I_{LOAD1} is output via the first load terminal LED₁+ or a second load current I_{LOAD2} is output via the second load terminal LED2+ and outputs the load indication signal to the transfer means 14. The transfer means 14 transmits the load indication signal over the isolation barrier 3 to the control circuit 15 of the primary circuit 2 for further processing.

[0075] Fig. 2 shows a more detailed schematic circuit diagram that displays a first example of the secondary circuit 4 of the driver device 1 according to the first embodiment.

[0076] The driver device 1 includes the secondary circuit 4 with the filter circuit 11 arranged in the second load path in a corresponding manner to fig. 1. Fig. 2 provides a particular circuit layout for the filter circuit 11, which will be discussed in more detail.

[0077] The filter circuit 11 of fig. 11 comprises a first capacitor C5, a second capacitor C6, and an inductor. The components C5, C6, and L1 are arranged in a π -filter circuit topology replacing capacitor C4 shown in fig. 5.

[0078] In particular, the main winding L1 of the inductor has first terminal that is connected with the first terminal of the filter circuit 11 and a second terminal that is con-

nected with the second terminal of the filter circuit. The main winding L1 is therefore connected in series with a load connected between the second load terminal LED2+ and the common load terminal LED- when a load is connected to the second current path. The first capacitor C5 has a first terminal connected with the first terminal of the filter circuit 11, and a second terminal of the first capacitor C5 is connected with the third terminal of the filter circuit 11. The second capacitor C6 has a first terminal connected with the second terminal of the filter circuit 11, and a second terminal of the second capacitor C6 is connected with the third terminal of the filter circuit 11. The capacitors C5 and C6 are connected in parallel.

[0079] The inductor of the filter circuit 11 includes the main winding L1 and an auxiliary winding L2_{AUX}. A first terminal of the auxiliary winding L2_{AUX} is connected with a first terminal of the resistor R2 and a second terminal of the auxiliary winding L2 is connected with a second terminal of the resistor R2. An electric current through the main winding L2 will induce a voltage in the auxiliary winding L2_{AUX}. The voltage U_{IND} over the resistor R2 may indicate a current flow through the main winding L2 and therefore indicates the load current I_{LOAD2} output by the second load path via the second load terminal LED2+ to a load connected to the second load terminal LED2+ and the common load terminal LED-.

[0080] The evaluation of the indicator signal U_{IND} by the control circuit 13 may correspond to the embodiment discussed with reference to fig. 1.

[0081] The control circuit 13 determines that the load is connected via the second load terminal LED2+ and the common load terminal LED-, in case the load current I_{LOAD} is output and the indicator voltage U_{IND} is present at the respective inputs of the control circuit 13 that obtain the indicator voltage U_{IND} . Determining that the indicator voltage U_{IND} is present may correspond to measuring the indicator voltage U_{IND} exceeding a first threshold voltage. In particular, determining that the indicator voltage U_{IND} is present may correspond to determining that the indicator voltage U_{IND} has a voltage value different to 0 V.

[0082] Fig. 3 depicts a schematic circuit diagram that illustrates a second example of the secondary circuit 4 of the driver device 1 according to the first embodiment.

[0083] The secondary circuit 4 of the driver device 1 includes a filter circuit 11' that differs in its circuit structure and arrangement from the filter circuit 11 displayed in fig. 2 and discussed with reference to fig. 2.

[0084] The filter circuit 11' comprises an inductor with a main winding L3 and an auxiliary winding L3_{AUX}. A first terminal of the main winding L3 is connected with a first terminal of the filter circuit 11'. A second terminal of the main winding L3 is connected with a second terminal of the filter circuit 11'. Contrary to the first example, the second example maintains the filter capacitor C4 of the second load path that is connected with the filter capacitor C4 connected to the cathode of the rectifier diode D1 and the cathode of the rectifier diode D4. A second terminal of the filter capacitor C4 is connected with the cathode

of the rectifier diode D2, the cathode of the rectifier diode D3 and the first load terminal LED1+. The filter capacitor C4 may be an electrolytic capacitor.

[0085] A resistor R3 is connected in parallel with the auxiliary winding L3_{AUX}, and a voltage over the resistor R3 is provided as the indicator voltage U_{IND} to inputs of the control circuit 13 of the secondary circuit 4.

[0086] Fig. 4 illustrates a schematic circuit diagram of a second embodiment of the secondary side circuit 4 of the driver device 1.

[0087] The secondary circuit 4 of the driver device includes a filter circuit 11" that differs in its circuit structure and arrangement from the filter circuit 11 displayed in fig. 2 and corresponds in its general circuit structure to the filter circuit 11' of fig. 3.

[0088] Contrary to figs. 2 and 3, the embodiment of fig. 4 arranges the filter circuit 11" connected with a first terminal of the filter circuit 11" to a terminal (tap) of the secondary winding L24 of the secondary windings L20 of the transformer 10. The second terminal of the filter circuit 11" is connected with the anode of the diode D1 of the second load path.

[0089] The filter circuit 11" comprises an inductor with a main winding L3 an auxiliary winding L3_{AUX}. A first terminal of the induct main winding or L3 is connected with a first terminal of the filter circuit 11". A second terminal of the main winding L3 is connected with a second terminal of the filter circuit 11". Thus, the filter circuit 11" is connected between the transformer 10, in particular between the secondary windings L20 of the transformer 10 and the diode D1.

[0090] Contrary to the first example of the first embodiment, the second embodiment maintains the filter capacitor C4 of the second load path that is connected with a first terminal of the filter capacitor C4 to the cathode of the rectifier diode D1 and the cathode of the rectifier diode D4. A second terminal of the filter capacitor C4 is connected with the cathode of the rectifier diode D2, the cathode of the rectifier diode D3 and the first load terminal LED1+. The filter capacitor C4 may be an electrolytic capacitor.

[0091] A resistor R4 is connected in parallel with the auxiliary winding L3_{AUX}, and a voltage over the resistor R4 is provided as the indicator voltage U_{IND} to inputs of the control circuit 13 of the secondary circuit 4.

[0092] The main winding L3 may be configured to go into saturation in case a load current I_{LOAD2} is output via the second load terminal LED2+. In case the main winding L3 goes into saturation, no magnetic flux occurs through the main winding L3 and equally no voltage is induced in the auxiliary winding L3_{AUX}. Thus, the auxiliary winding L3_{AUX} provides no measurable voltage to the resistor R4. The control circuit 13 of the second embodiment of the filter circuit 11 determines based on the indicator signal, in particular the indicator voltage U_{IND} provided by the auxiliary winding L3_{AUX} whether the main winding L3 is in saturation.

[0093] Contrary to the first embodiment of the filter circuit

circuit 11 or 11', the control circuit 13 determines that the load is connected via the second load terminal LED2+ and the common load terminal LED-, in case the load current I_{LOAD} is output, and simultaneously the indicator voltage U_{IND} is not present at the respective inputs of the control circuit 13 that obtains the indicator voltage U_{IND}.

[0094] Determining that the indicator voltage U_{IND} is not present may correspond to measuring the indicator voltage U_{IND} being smaller than a second threshold voltage. The second threshold voltage is smaller than the first threshold voltage. In particular, determining that the indicator voltage U_{IND} is not present may correspond to measuring the indicator voltage U_{IND} is not measurable by the control circuit 13.

[0095] In an alternative embodiment valid for all examples explained above, the evaluation circuit 13 may be integrated into control circuit 15 on the primary side (as part of primary circuit 2).

[0096] Fig. 5 shows a schematic circuit diagram that displays an example of a conventional secondary circuit 54 of a known driver device 50 for a comparison with the driver device 1 according to the discussed embodiments.

[0097] The secondary circuit 54 of the known driver device 50 that is implemented in a LLC converter circuit topology of fig. 5 differs from the embodiments shown in figs. 2, 3, and 4 by having no filter circuit capable of providing an indicator signal. The simple circuit layout of the secondary circuit 54 of fig. 5 does neither acquire nor provide any information, which load terminal of the first and second load terminals LED₁+ and LED2+ of the driver device 50 is connected with an electric load, e.g. a lighting module.

[0098] In consequence of the simple layout, the lighting module 50 may only provide the capability to implement an emergency shutdown functionality by comparing the primary side voltage over the primary winding L11 of the transformer with a threshold voltage that ensures that neither of the load voltages U_{LOAD1} and U_{LOAD2} exceeds an admissible voltage value. Exceeding the admissible voltage value corresponds to determining that an inadmissible overvoltage is present at one of the first load terminal LED1+ and LED2+.

[0099] Furthermore, the simple layout of the driver device 50 of fig. 5, the lighting module 50 does not provide the capability to calculate the actual output power provided to the connected electric load individually for each of the output channels of the driver device 50.

[0100] The driver device 50 of fig. 5 illustrates at least two key advantages, the driver device 1 provides and which are achieved by any of the particular examples of the filter circuit 11, 11', 11" and its corresponding arrangement in the secondary circuit 4 shown in figs. 2, 3, and 4.

[0101] It is noted that, although the driver device 1 according to the first aspect discusses embodiments using a LLC converter circuit topology with two load output channels and a single filter circuit arranged in one of the two load output channels, the driver device 1 is not limited

to this particular structure.

[0102] Alternatively, the driver device 1 may arrange the filter circuit 11, 11', 11" as a first filter circuit 11, 11', 11" in the first load output channel, and a second filter circuit 11, 11', 11" in the second load output channel.

[0103] The circuit topology of the second load output channel that includes the second filter circuit 11, 11', 11" may correspond to the circuit topology of the first load output channel. In particular, the circuit topology of the second load output channel that includes the second filter circuit 11, 11', 11" and the circuit topology of the second filter circuit 11, 11', 11" may correspond to the circuit topology of any of the embodiments discussed with reference to figs. 2, 3, and 4.

[0104] Alternatively, the driver device 1 may include the secondary circuit 4 comprising multiple (a plurality of) load output channels, e.g. a first load output channel and n second load output channels, wherein n is an integer number of 2 or more. In this particular embodiment, the first load output channel and (n-1) second load output channels include each a respective filter circuit 11, 11', 11", e.g. a filter circuit 11, 11', 11" the circuit topology of any of the embodiments discussed with reference to figs. 2, 3, and 4. In a further alternative embodiment, the first load output channel and all n second load output channels include each a respective filter circuit 11, 11', 11", e.g. a filter circuit 11, 11', 11" the circuit topology of any of the embodiments discussed with reference to figs. 2, 3, and 4.

[0105] The embodiments of the driver device 1, as well as the building automation system including at least one and more often a large number of such driver devices 1, are susceptible to an advantageous industrial application by implementing an economical and simple way of identifying, which of the multiple load output terminals LED₁+ and LED2+ of the driver device 1 are connected to the load and provide the load current I_{LOAD}, I_{LOAD1}, I_{LOAD2} to the load.

Claims

1. Driver device for generating a load current (I_{LOAD1}, I_{LOAD2}) for at least one load, the driver device comprising

an isolation barrier (3) for electrically isolating a primary circuit (2) and a secondary circuit (4) of the driver device,

the secondary circuit (4) comprises at least a first load terminal (LED1+) and a second load terminal (LED2+), and

the secondary circuit (4) comprising a filter circuit (11, 11', 11") connected with one load terminal (LED2+) of the first load terminal (LED1+) and the second load terminal (LED2+),

the filter circuit (11, 11', 11") is configured to provide a signal (U_{IND}) that is generated based on

the load current (I_{LOAD1}, I_{LOAD2}) output via the connected load terminal (LED2+).

2. The driver device according to claim 1, wherein

the filter circuit (11, 11', 11") includes an inductor, and

the inductor comprises a main winding (L1, L2, L3) and an auxiliary winding (L1_{AUX}, L2_{AUX}, L3_{AUX}) configured to provide a signal induced by a current through the main winding (L1, L2, L3) of the inductor.

3. The driver device according to claim 2, wherein the filter circuit (11) includes a first capacitor (C5) and a second capacitor (C6) arranged with the inductor of the filter circuit (11) in a π -circuit topology.

4. The driver device according to claim 2 or 3, wherein the evaluation circuit (13) is configured to determine that the current (I_{LOAD1}, I_{LOAD2}) is output via the load terminal (LED2+) connected to the filter circuit (11, 11') in case of sensing the signal (U_{IND}) provided by the auxiliary winding (L1_{AUX}, L2_{AUX}).

5. The driver device according to any one of the preceding claims, wherein the secondary circuit (4) comprises at least one diode (D1), and the filter circuit (11, 11') is connected between the diode (D1) and the load terminal (LED2+).

6. The driver device according to claims 2, wherein the main winding (L3) is configured to go into saturation in case the load current (I_{LOAD}) flows through the main winding (L3) of the inductor.

7. The driver device according to claim 6, wherein the evaluation circuit (13) is configured to determine that the current (I_{LOAD1}, I_{LOAD2}) is output via the connected load terminal (LED2+) in case of sensing no signal provided by the auxiliary winding (L3_{AUX}).

8. The driver device according to any one of claims 2 to 7, wherein the driver device (1) comprises an evaluation circuit (13) configured to determine whether the current (I_{LOAD1}, I_{LOAD2}) flows through the main winding (L1, L2, L3) based on the signal (U_{IND}) provided by the auxiliary winding (L1_{AUX}, L2_{AUX}, L3_{AUX}).

9. The driver device according to any of the claims 6 to 8, wherein the driver (1) comprises a transformer (10) for providing the isolation barrier (3) between the primary circuit (2) and the secondary circuit (4) and at least one diode (D1), and the filter circuit (11") is connected between a secondary winding (L20) of the trans-

former (10) and the diode (D1).

10. The driver device according to any one of the preceding claims, wherein
the secondary circuit (4) comprises a sensing means (12) for sensing the load current (I_{LOAD1} , I_{LOAD2}), wherein the sensing means (12) is connected with a common load terminal (LED-) for connecting the load. 5
11. The driver device according to claim 10, wherein the sensing means (12) is configured to generate a signal proportional to the load current (I_{LOAD}) for controlling the load current (I_{LOAD1} , I_{LOAD2}) in a control loop of the driver device. 10 15
12. The driver device according to any one of the preceding claims, wherein
the driver device is configured to output the load current (I_{LOAD1}) in a first voltage range via the first load terminal (LED1+) to the load and to output the load current (I_{LOAD2}) in a second voltage range via the second load terminal (LED2+) to the load. 20
13. The driver device according to claim 12, wherein the first voltage range and the second voltage range differ. 25
14. The driver device according to any one of the preceding claims, wherein
the driver device is configured to determine a load power output by the driver device based on the load current (I_{LOAD1} , I_{LOAD2}) and the signal (U_{IND}) provided by the filter circuit (11, 11', 11"). 30 35
15. The driver device according to any one of the preceding claims, wherein
the driver device (1) is configured to switch off the driver device (1) in case of determining that a load voltage (U_{LOAD1} , U_{LOAD2}) provided by one of the first load terminal (LED1+) and the second terminal (LED2+) exceeds a preset threshold value based on the signal (U_{IND}) provided by the filter circuit (11) and based on a voltage (U_{SENSE}) measured by the primary circuit (2), 40 45
wherein the driver device (1) is configured to set the preset threshold value individually for the first load terminal (LED1+) and the second load terminal (LED2+). 50
16. The driver device according to any one of the preceding claims, wherein 55
the primary circuit (2) is configured to measure the voltage over the primary winding (L10) of the transformer (10),

to determine the load terminal (LED1+, LED2+) that outputs the load current (I_{LOAD1} , I_{LOAD2}) to the load,
to determine the load voltage (U_{LOAD}) based on the determined load terminal (LED1+, LED2+) and a winding ratio of the transformer (10) for the determined load terminal (LED1+, LED2+), and
to compare the determined load voltage (I_{LOAD1} , I_{LOAD2}) with the preset threshold value for the determined load terminal (LED1+, LED2+).

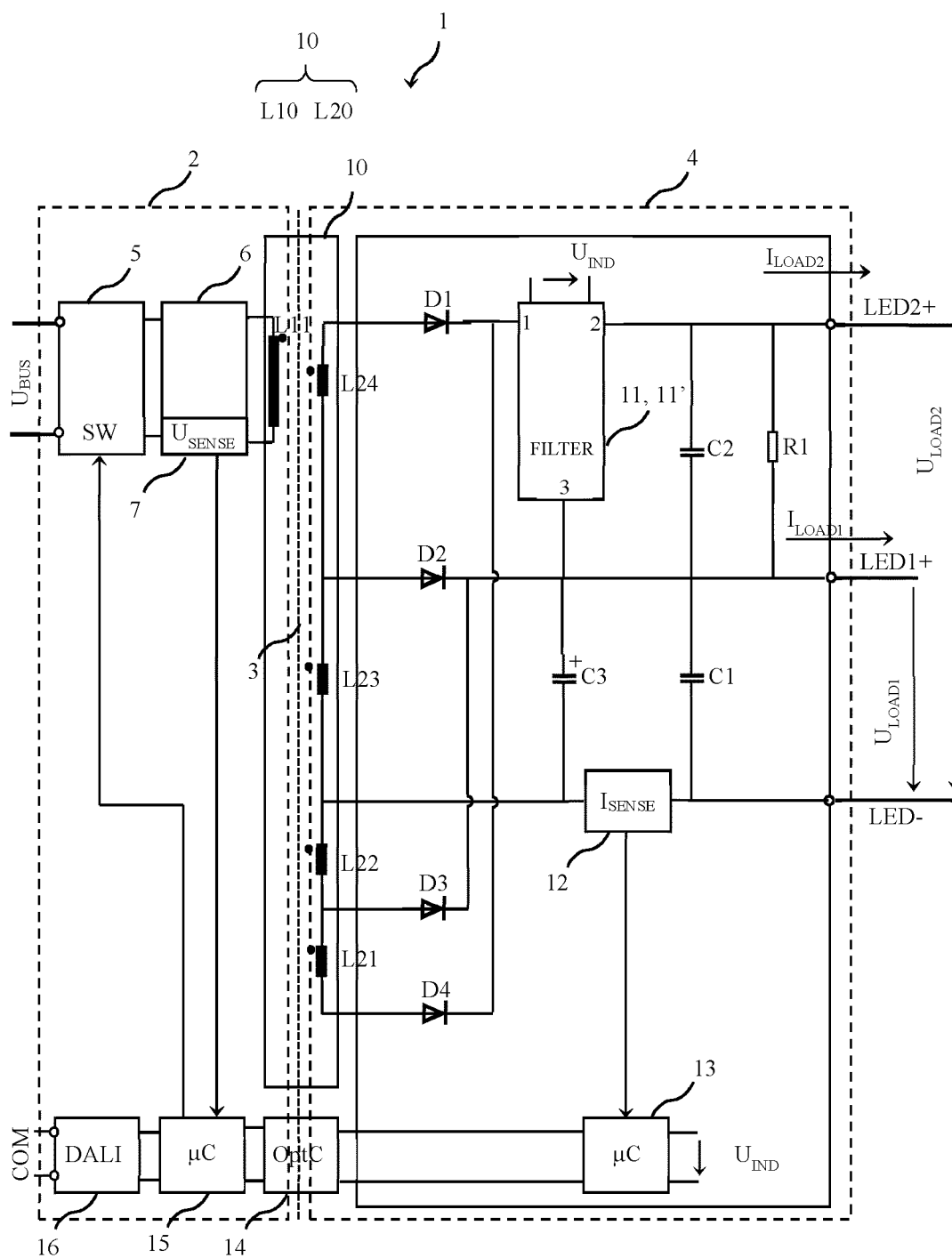


FIG. 1

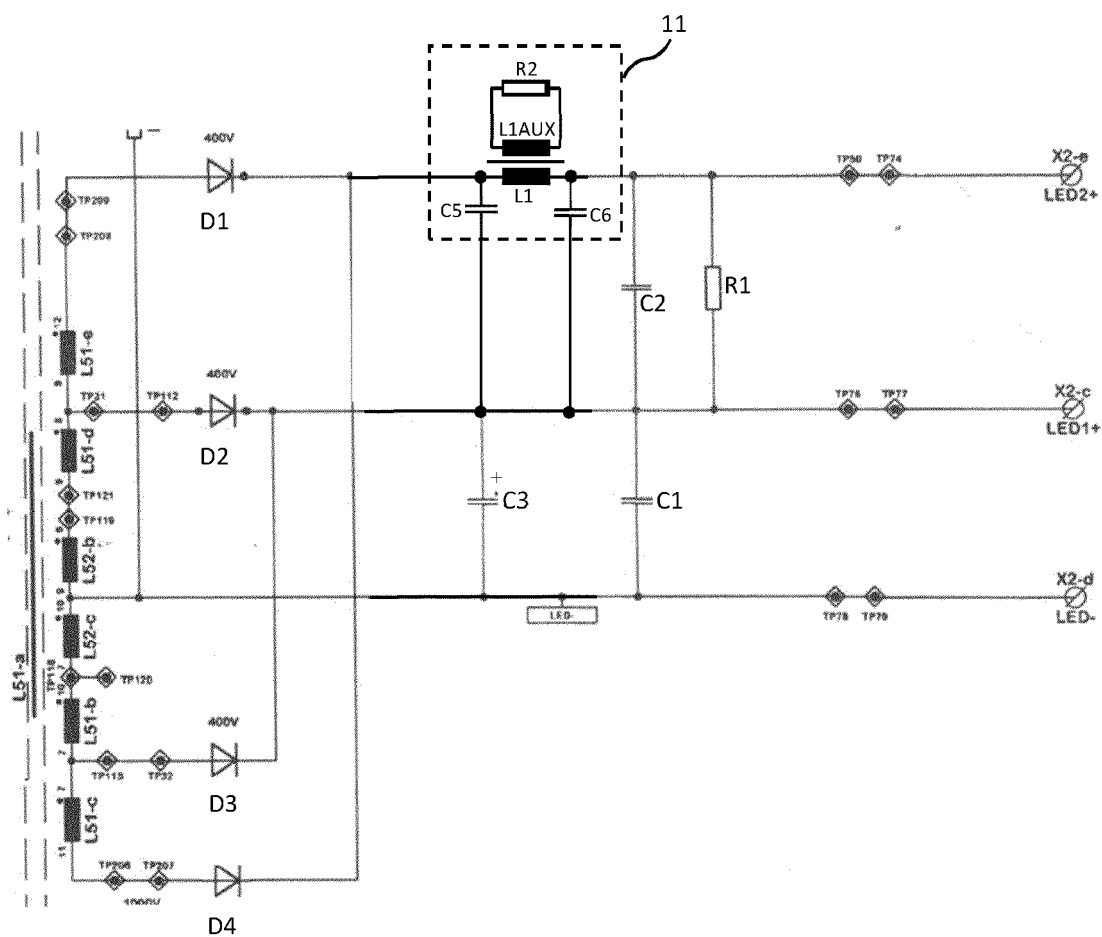


FIG. 2

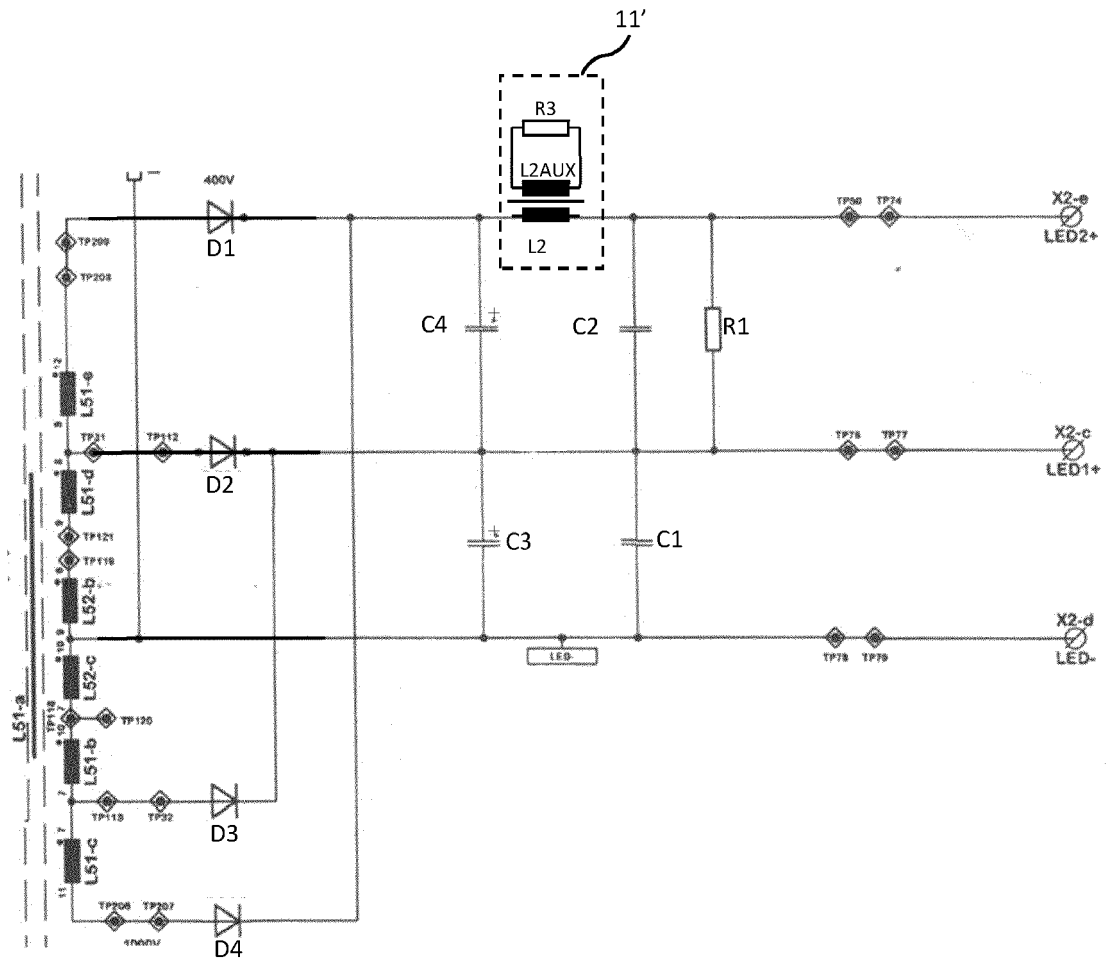


FIG. 3

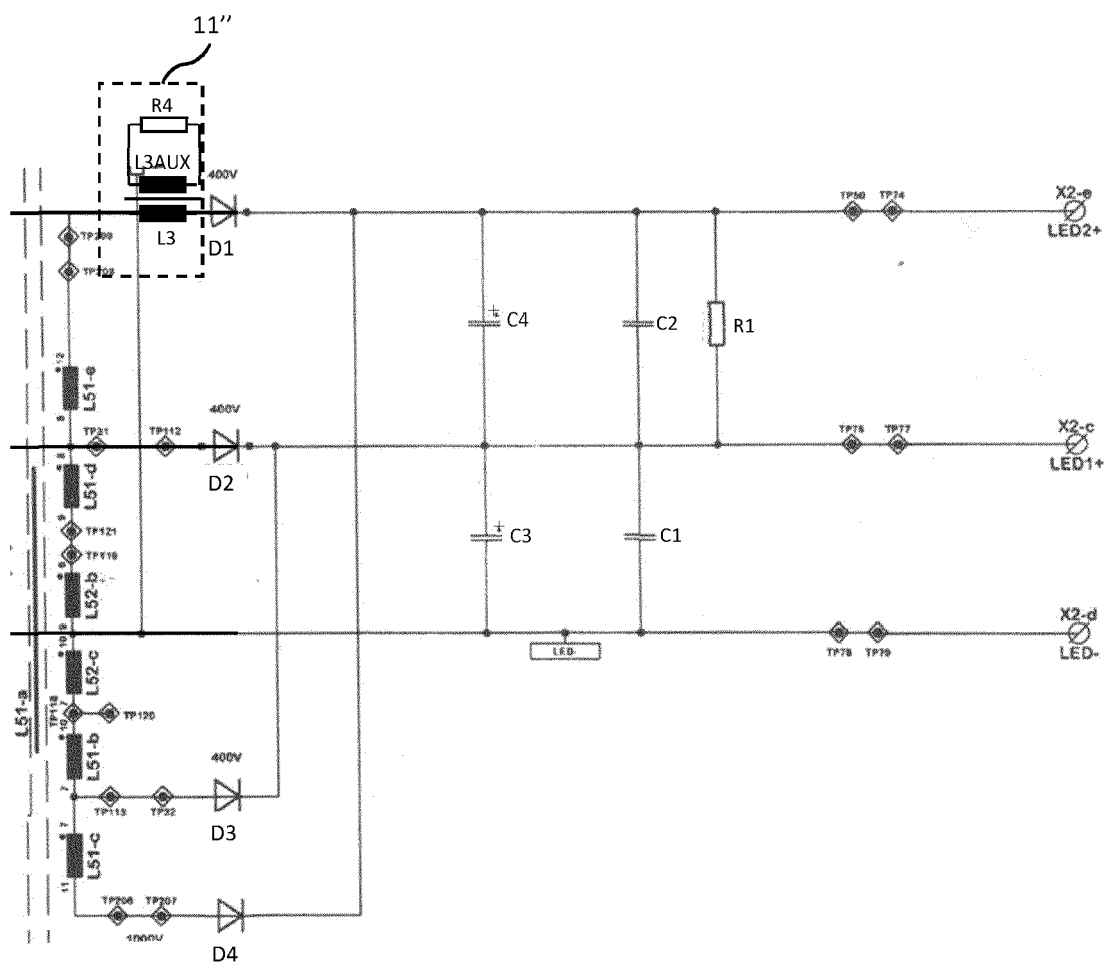


FIG. 4

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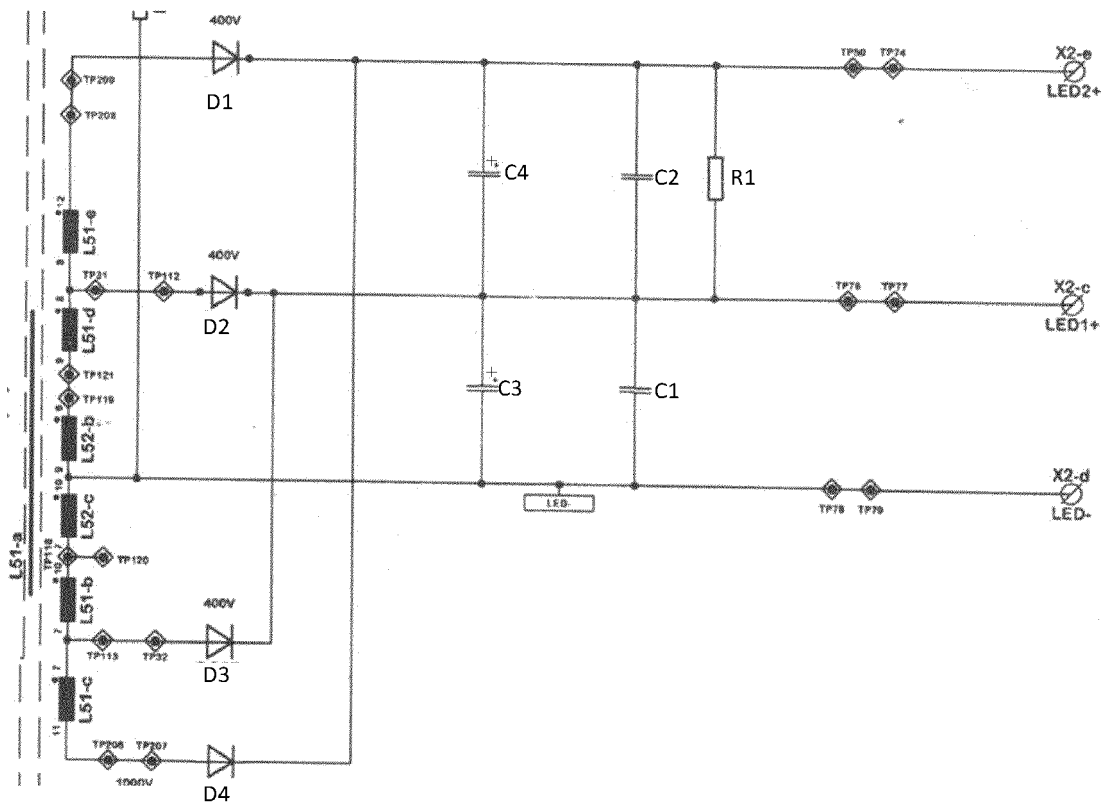


FIG. 5
(PRIOR ART)



EUROPEAN SEARCH REPORT

Application Number

EP 23 15 6221

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2022/086978 A1 (ARCHER MICHAEL [US] ET AL) 17 March 2022 (2022-03-17)	1, 5, 10, 11	INV. H05B45/382
Y	* figure 4 *	2, 4, 8, 12, 13	H05B45/50 H05B45/46
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			H05B
Place of search			Examiner
Munich			Boudet, Joachim
Date of completion of the search			
19 July 2023			
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 23 15 6221

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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19-07-2023

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