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

(11) EP 3 503 686 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.06.2019 Bulletin 2019/26

(51) Int Cl.:
H05B 33/08 *(2006.01)*

(21) Application number: **17306883.4**

(22) Date of filing: **21.12.2017**

(84) Designated Contracting States:
AL 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 RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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(54) CIRCUIT FOR DIRECT CONVERSION POWER SUPPLY

(57) A multiplexed direct conversion circuit for providing power supply to a display by using a temporal multiplexing of charging/supplying phases for the backlighting elements that are grouped in a plurality of groups corresponding to different areas of the screen of the display. The power supply is time-multiplexed for each of the different groups according a brightness level of a display area for a current image, the display area corresponding to a group of backlight elements. The principles apply both to flyback and forward converters.

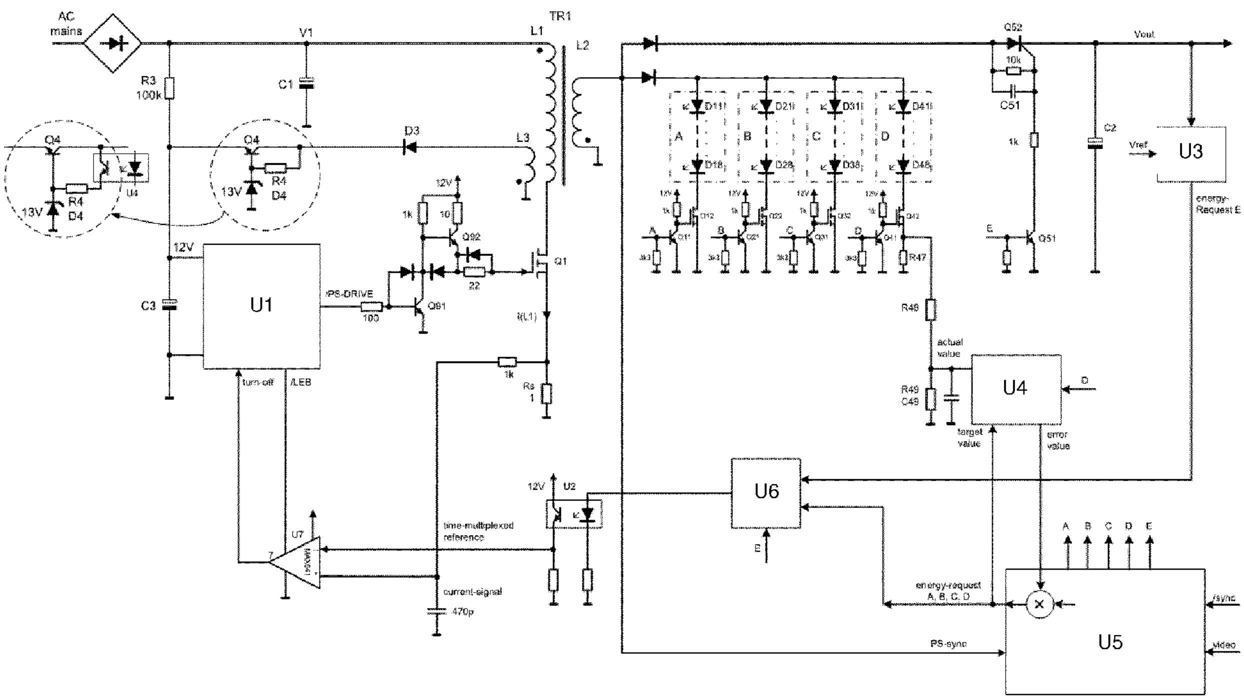


Figure 4

EP 3 503 686 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to the domain of power supplies and more particularly to power supplies for screens with backlight illumination such as LCD screens.

BACKGROUND

[0002] This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present disclosure that are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art unless explicitly indicated.

[0003] Display technologies such as Liquid Crystal Display (LCD) produce a colored image by selectively filtering light (typically white but sometimes colored) produced by a so-called backlight, originally provided by a series of cold cathode fluorescent lamps (CCFLs) but now typically provided by a set of Light Emitting Diodes (LED) and in near future probably by Organic Light Emitting Diodes (OLED) too. The backlight is placed behind millions of individual LCD shutters, arranged in a grid, that open and close to allow a metered amount of the light through.

[0004] Conventionally, the backlight is supplied from the AC mains via two power converters in series. The first stage brings the AC down to a mains-separated continuous voltage of lower voltage than the mains, that is upconverted in a second step to the desired backlight driving voltage or current. This cascading of two power supplies has a multiplied inefficiency. Improving the efficiency of the backlight could improve the overall power consumption of the display since nearly 95% of its consumption is due to the backlight.

[0005] Switching power supplies conventionally use either forward converters or flyback converter.

[0006] It can therefore be appreciated that there is a need for a solution for a more efficient power supply that addresses at least some of the problems of the prior art. The present disclosure provides such a solution.

SUMMARY

[0007] The present disclosure describes a multiplexed direct conversion circuit for providing power supply to a display by using a temporal multiplexing of charging/supplying phases for the backlighting elements that are grouped in a plurality of groups corresponding to different areas of the screen of the display. The power supply is time-multiplexed for each of the different groups according a brightness level of a display area for a current image, the display area corresponding to a group of backlight elements. The principles apply both to flyback and forward converters.
This direct conversion avoids using an intermediary power conversion followed by an up- or down conversion to supply the backlight element and therefore improves the efficiency and reduces the power consumption of the device.

[0008] In a first aspect, the disclosure is directed to an electronic circuitry for supplying power to a plurality of loads comprising: a transformer comprising at least a first winding and a secondary winding, wherein the first winding is connected at one side to a source of AC mains through a rectifier and to a capacitor to the ground; a first switch connected between the first winding and the ground through a series resistor; a plurality of second switches for the plurality of loads connected to the secondary winding through a diode and to the plurality of loads; a controller configured to control a time-multiplexed cycle of, for each of the plurality of loads, a charging phase and a supplying phase, by controlling the activation of the first switch and of the plurality of second switches, and cycling over the plurality of loads, wherein for at least one load, the charging phase is started by activating the first switch and inactivating the plurality of second switches until a needed current value for the load has been accumulated, the charge phase is then stopped by inactivating the first switch and the supplying phase is started by activating one of the second switches to discharge the accumulated current into the load connected to the active second switch.

[0009] In a second aspect, the disclosure is directed to a display device comprising the electronic circuitry according to first aspect wherein the plurality of loads comprises a plurality of light emitting components providing backlighting to a plurality of corresponding areas of the display. In a first variant of second aspect, a first comparator is configured to compare a value representing the needed current for a load and a value representing the current accumulated into the first winding. In a second variant of second aspect, the controller is further configured to analyse brightness of the plurality of areas of an image to be displayed and determine a corresponding amount of needed current for the corresponding light emitting components. In a third variant of second aspect, a second comparator is configured to compare a value representing the needed current for a load and a value representing the current provided to one load, and generating an error value to be added to a further value of needed current for the load in order to perform a correction. In a fifth variant of second aspect, a mains separator provides a signal representative of the value of the needed current for a load and ensure separation from mains. In a sixth variant of second aspect, one of the load is a plurality of electronic circuits requiring a continuous power supply. In a seventh variant of second aspect, the controller is further configured to cycle between the loads successively for the plurality of loads. In an eighth variant of second aspect, the controller is further configured to cycle between the loads according to the amount of needed current for each load attributing multiple successive charging phase and supplying phase to a load needing more current than at least another load needing less current. Unless explicitly stated, variants can be combined together.

[0010] In a third aspect, the disclosure is directed to a method for controlling a time-multiplexed cycle of, for each of the plurality of loads, a charging phase and a supplying phase, comprising controlling the activation of the first switch and of the plurality of second switches, and cycling over the plurality of loads, wherein for at least one load, the charging phase is started by activating a first switch and inactivating a plurality of second switches until a needed current value for the load has been accumulated, the charge phase is then stopped by inactivating the first switch and the supplying phase is started by activating one of the second switches to discharge the accumulated current into the load connected to the active second switch. A first variant of third aspect further comprises determining when a needed current value for the load has been accumulated by comparing a value representing the needed current for a load and a value representing the current accumulated into a first winding. A second variant of third aspect further comprises analysing brightness of the plurality of areas of an image to be displayed and determining a corresponding amount of needed current for the corresponding light emitting components.

BRIEF DESCRIPTION OF DRAWINGS

[0011] Preferred features of the present disclosure will now be described, by way of nonlimiting example, with reference to the accompanying drawings, in which:

Figure 1 illustrates an exemplary circuit diagram for a direct flyback conversion power supply for a display backlight according to a preferred embodiment of the disclosure;
Figure 2a illustrates an exemplary temporal diagram for a direct flyback conversion power supply according to the preferred embodiment of the disclosure;
Figure 2b illustrates another exemplary temporal diagram for a direct flyback conversion power supply according to an alternate embodiment of the disclosure;
Figure 3a illustrates an exemplary splitting of an image to be displayed into four rectangular areas with corresponding four backlight groups.
Figure 3b illustrates an exemplary level of expected brightness corresponding to the image of figure 3a;
Figure 4 illustrates a detailed exemplary circuit diagram for a direct flyback conversion power supply according to an embodiment of the disclosure;
Figure 5 illustrates an exemplary circuit diagram for a generic direct flyback conversion power supply for a plurality of loads according to an embodiment of the disclosure;
Figure 6 illustrates an exemplary circuit diagram for a direct forward conversion power supply for a display backlight according to an embodiment of the disclosure.

DESCRIPTION OF EMBODIMENTS

[0012] **Figure 1** illustrates an exemplary circuit diagram for a direct flyback conversion power supply for a display backlight according to a preferred embodiment of the disclosure. Such circuit is adapted for driving the backlight elements as well as other electronic modules of a device such as LCD television (or LCD monitor or other display device using backlight). In the exemplary embodiment illustrated in figure 1, the circuit drives a backlight split in four groups of lighting elements (such as LEDs, OLEDs, etc), the groups having conventionally a rectangular shape and identical size to cover the four regions depicted in figure 2: upper left (group A), bottom left (group B), bottom right (group C) and upper right (group D). The person skilled in the art will appreciate that the illustration of figure 1 does not limit the disclosure to any number of regions or any shape. Other embodiments use a greater number of regions (e.g. 8, 16 or 32 regions), other type of shapes (e.g.: triangular shape, circular), a mix of different shapes of different sizes and even simply horizontal or vertical line of lighting elements. In another embodiment several shapes could be connected temporarily or permanent not necessarily being adjacent to each other.

[0013] Each of the group of LEDs is controlled by a corresponding switch (A, B, C, D in figure 1) and is supplied from a secondary winding L2 of transformer TR1. The transformer TR1 is coupled directly to the rectified and filtered AC mains. The circuit constitutes a flyback converter configurated to operate in a time-multiplexed mode under control of a switch SW1, using a two-phase process where the first phase is a charging phase and the second phase is a supplying phase. Transformer TR1 stores in the first winding L1 an amount of energy during the first phase (SW1 closed) and transfers this energy to the secondary winding L2 during the second phase (SW1 open). The stored energy is proportional to the second power of the current:

$$E(L_1) = I_{L1}^2 \times L_1 / 2$$

the current being proportional to the time:

$$I_{L1} = T_{on} \times V_1 / L_1$$

[0014] Thus, the stored energy is controllable by circuit U1 (a Pulse Width Modulation (PWM) controller), L1 and

V1. By controlling the current in L1 (via measuring in the series resistor Rs) the amount of energy becomes independent of V1. When the switch SW1 opens, this stored energy is transferred to the secondary side of the winding and to the load depending on switches A, B, C, D and E. The circuit U1 collaborates with controller U5. U1 obtains, though the controller U5, the desired amount of energy for each group of backlight LEDs, stores this energy in L1 and transfers it to the appropriate group of backlight LEDs by means of a having the appropriate switch A, B, C, D or E selected by controller U5. Thus, the power supply is time-multiplexed for different independent loads and draws its energy directly from a single transformer, without requiring an intermediary supply. With such a principle, the efficiency of the power supply can be maximized since there is no intermediate loss.

[0015] A video picture analyser U6 is configured to analyse the image to be displayed and determines, for each area of the display, a required brightness level for the corresponding group of backlight LEDs. In the preferred embodiment, the brightness level is equal to the maximal brightness level of the area. In an alternate embodiment, this brightness level is equal to the sum of brightness of the pixels in an area of the picture and the required corresponding current is the square-root of that value.

[0016] This level of brightness is combined with lighting characteristics of the backlight LEDs to determine the needed current (or energy) for each group of LEDs to achieve the target level of brightness. In an improved embodiment a feedback loop for increasing the accuracy of the provided energy is possible by measuring the secondary side currents or the light output. The value of needed current is provided to the Time Multiplexer through the mains separator U2. In order to dispatch appropriately the energy, a set of time slots are attributed to each group of LEDs as well as to a further group for supplying power to the other electronic modules (E in figure 1). Each time slot comprises the two phases (charging and supplying) for one corresponding circuit (A, B, C, D, E), based on a T_{on} signal (not shown) generated by the PWM controller U1, synchronized with the signals for switches A, B, C, D, E.

[0017] There are successive charging phases and supplying phases for each of the groups, together constituting one cycle and cycles are iterated continuously while the devices are powered on. In a charging phase for one group, the switch SW1 is closed (ON) until the required charging current is accumulated in the first winding L1 and the switches A to E are opened (OFF). In a supplying phase for the group, the switch SW1 is opened and one of the switches corresponding to one of the groups (A to E) is closed (ON) while the other ones stay open (OFF). When SW1 opens, a flyback voltage appears at the secondary winding L2 and the stored energy is transferred to the secondary side of transformer TR1 into the respective load selected by the control signals A to D. This process goes from groups A to D and the requests of light are time multiplexed by controller U5.

[0018] The supply of V_{out} is slightly different since it is the supply voltage for the electronic circuitry of the LCD television. V_{out} at C2 is compared with a reference voltage in a comparator and loop filter U3 and the result is integrated and shaped to form a request for energy for C2 (an equivalent value for I(L1)). Because of the large capacitor C2 and the closed loop system, this value is not critical. The time multiplexing controller U5 transfers this information to U1. During the flyback mode this energy is transferred via switch E into C2.

[0019] The current needs for each of load are materialized as a voltage that is transferred from the controller U5 to the PWM U1 through a mains separator U2, such as an optocoupler.

[0020] **Figure 2a** illustrates an exemplary temporal diagram for a direct flyback conversion power supply according to the preferred embodiment of the disclosure. Two full cycles are shown, a first one from T0 to T5 and a second cycle from T5 to T10. Guard-time between the cycles is not shown but is required. A guard-time ensures that the discharge of one LED-chain is terminated before the next charge phase for the next group of LEDs starts. This can be provided by time slots that are longer than the maximal charging time or by a variable timing controlled by supervising the discharge currents and waiting for complete discharge before switching to the next charge phase for the next group. Each cycle comprises 5 slots: one slot per group of LEDs (A, B, C and D) thus leading to 4 slots and a fifth slot for the general power supply (E). The slots are identified by the group letter A to E in the first line. The second line, labelled "requested light output", indicates the requested light output of the respective LED areas, as determined by controller U5 based on the brightness requirements for each group of LEDs for a given picture. The third line indicates energy needed for Vout. The fourth line shows the ramping up of the primary current I(L1). Further lines illustrate the load current in the different loads (A to D) and in the bottom line the output voltage Vout.

[0021] In this figure, a single column comprises the two-phases charging and supplying phases mentioned earlier. The slot between T1 and T2 is related to group B. As described below in the example illustrated in figures 3A and 3B, the group B requires 40% of the maximal energy. This value is converted into the corresponding duration for charging. The switch SW1 is activated (ON), all switches A, B, C, D, E are inactivated (OFF). Thus, the primary winding (L1) charges up according to a ramp-up current shown in third line (primary current I(L1)) of the diagram. When the charge reaches the desired value, the SW1 is inactivated (OFF) and the switch B is activated (ON). The charge is then transferred to the second winding (L2) and the group B is supplied with the energy according to the supply current shown in fifth line (current LED-area B). Similar to the charging, when the winding is discharged, the switch B is inactivated and the process continues with the next group.

[0022] The frequency of a complete cycle can be quite high, compared to the display refresh rate. Typical refresh rates are 50, 60, 100, 200 Hz, up to 600 or 800 Hz. Power supply can be switched at typically 65 to 200 kHz. With those figures, a large number of backlight areas can be addressed sequentially, or a smaller number repeatedly, during the display of a single image. As an example, a 200 kHz power supply switching provides 200000 charging cycles per second. When built into a receiver with a 100 Hz display refresh-rate it can address 2000 loads during one TV-field. Alternatively, it can address a lower number of loads more frequently. As an example, 64 LED areas can be addressed more than 30 times per display refresh.

[0023] **Figure 2b** illustrates another exemplary temporal diagram for a direct flyback conversion power supply according to an alternate embodiment of the disclosure. Instead of this steady change of load (A, B, C, D, E, A, B) the LED-areas could be addressed for multiple charging/supplying phases before changing to the next load circuit (A, A, A, A, B, B, B ...). Such an approach is illustrated in Fig. 2b. This approach can be extended by an adaptive amount of repetitions, respectively by leaving out the cycles of dark LED-areas.

[0024] **Figure 3a** illustrates an exemplary splitting of an image to be displayed into four rectangular areas with corresponding four backlight groups. The video picture analyser U6 splits the image into the four areas 300A, 300B, 300C, 300D corresponding to the four backlight groups, respectively the groups A, B, C, D mentioned earlier, and obtains data representative of the brightness of the image for each of the area (for example an image comprising the value of all pixels of the area). An expected level of brightness is then computed for each area, for example by taking the maximal brightness value or summing the brightness of all the pixels of the area. This level of expected brightness can be expressed in different ways, for example in percentage of brightness compared to a full white image, as illustrated by elements 301A, 301B, 301C, 301 D in **Figure 3b.**

[0025] The time-slots in Fig. 2a and 2b are drawn equidistant, given by a fixed frequency but an approach with a variable frequency and varying timeslots that matches the requested power works fine too.

[0026] **Figure 4** illustrates a detailed exemplary circuit diagram for a direct flyback conversion power supply according to an embodiment of the disclosure. A central element is the integrated circuit U1. Most functions of this integrated circuit are conventional regarding power supply integrated circuits. The start-up (power plugged to the AC mains) is maintained by R3 and C3. C3 is charged via R3 and a threshold circuit in U1 starts an oscillator and a power up routine with short pulses. Steady supply for U1 is maintained via winding L3 of TR1, D3 and Q4. R4, D4 and Q4 decouple C3 from the transformer when C3 is charged sufficiently. This decoupling is necessary to allow the later described circuitry to work properly. Without this decoupling transistor Q4 the secondary output voltage would be clamped to the primary supply voltage (multiplied by the winding ratio). Alternatively, the charge on C3 is synchronized with switch E not affecting the brightness of the LED areas.

[0027] The driver circuit for Q1 is built up with the 2 transistors Q91 and Q92 in a so called active load configuration to buffer the /PS-DRIVE signal and to shift the level to 12 Volts for a proper MOSFET drive. By closing Q1 (=SW1 in figure 1) periodically the primary winding L1 of TR1 is energized. The on-time of Q1 is terminated by the PWM unit (U1) whether by measuring the actual current I(L1) or deliberately by pre-programmed start-up and protecting routines. The current I(L1) is measured via a series resistor Rs for the transistor Q1 and comparator U7. To avoid inaccurate turn-off a "Leading Edge Blanking" (LEB) is provided by U1, inhibiting the comparator during a short period (for example 100ns) after turn-on of Q1.

[0028] The energy stored in TR1 is then selectively allocated to the different loads or storage means on the secondary side by transistors Q12, Q22, Q32, Q42 and thyristor Q52. Transistors Q12, Q22, Q32, Q42 are connected to 4 groups of 8 LEDs respectively D11 to D18 for area A, D21 to D28 for area B, D31 to D38 for area C and D41 to D48 for area D and are driven by the respective driver circuits Q11, Q21, Q31, Q41 and their bias resistors. The input signals of those drivers come from the controller U5 that is configured to provide multiplexer signals and basically contains a counter addressing the outputs A to E sequentially. This counter is synchronized by signal "PS-sync" derived from the transformer. In parallel the controller U5 analyses the video signal (thus integrating the video signal analysis function of U6 of figure 1) and determines the intensity of the light-output required for each LED-area (A to D). This light-output equates a certain amount of energy required for each LED-area. This energy value is transformed by the controller U5 into a signal representative of the needed current and this signal is provided to a comparator through the mains separator U2. Mains separator is preferably an optocoupler. This signal representative of the needed current is compared by the comparator U7 with a signal representative of the actual current I(L1) is used to generate a turn-off signal that turns Q1 off when the needed current is reached. During the flyback phase (Q1 open) that amount of energy is transferred to the respective group of backlight LEDs.

[0029] For increasing the accuracy of that light-output a closed loop system is advantageous. For the sake of simplicity, this closed loop is illustrated in figure 4 only for the fourth group of backlight LEDs but is preferably applied to all groups of LEDs. The pulse shaped current in at least one LED-area is measured through R47, filtered (actual value) and compared with the required value. An error value is derived and applied for a correction of the "energy-request" signal of each LED-area.

[0030] The DC voltage Vout is maintained by a closed loop. The voltage Vout is compared with a reference Vref and if Vout is lower, an amount of energy (in form of a current value) is requested via the controller U5.

[0031] During start-up (no secondary voltage developed) thyristor Q52 is driven by its own anode signal (via a resistor of 10k). Capacitor C51 is charged until the secondary supply voltage allows the control circuit to disable Q52 by pulling the gate to ground.

[0032] For standby operation the energy requests of A to D are set to zero and only current path E is used for charging C2, depending on the load, if needed in a burst-mode. Burst-mode is a known technique for charging empty capacitors when a power supply starts up or during standby the power supply is gated and small burst are used for charging avoiding audible noise.

[0033] **Figure 5** illustrates an exemplary circuit diagram for a generic direct flyback conversion power supply for a plurality of loads according to an embodiment of the disclosure. Indeed, the proposed circuitry is not restricted to supplying power to backlight LEDs but may also be used in other contexts with arbitrary loads. The advantage of this power supply is a very simple transformer with one winding for several loads. It adapts to different loads by adapting the time-slots according to the power requirements.

[0034] The controller U5 activates the switches SWa, SWb, SWc, SWd so that the loads Load A, Load B, Load C and Load D receive the appropriate flyback current in a time-multiplexed manner, as explained above. The information of needed current for each of the loads is obtained by the controller U5 and provided through the mains separator U2 to PWM controller U1 that integrates a comparator to adjust the charging phase by measuring the accumulated current in L1 through the series resistor Rs and comparing it to the voltage delivered by U2.

[0035] **Figure 6** illustrates an exemplary circuit diagram for a direct forward conversion power supply for a display backlight according to an embodiment of the disclosure. Indeed, the invention is not limited to flyback converters but applies also to forward converter. Most of the operations are similar to the operations of figure 5. The difference is related to the method for supplying the current to the loads. When switch SW1 and SWa are closed, a DC voltage is applied to the inductance. An upramping current appears in La and the load. Thus a certain energy is stored in La. This energy is then discharged into the load during the time when SWa is open. The current loop is closed by a diode Da. The same process repeats for all the other loads and uses similar temporal multiplexing of charging/supplying phases and cycles through the plurality of loads one after the other explained above. In such a configuration, SW1 is optional since SWa to SWd are in series and operate the switching directly. However, SW1 can still be used for further optimizations since it can be driven more precisely thanks to its positioning to ground potential.

[0036] In an alternate embodiment, SW1 is removed and the switching is only performed on the secondary side of the transformer. In this case, there is no more need to convey the information about needed current to U1. Thus, the mains separator U2 can also be removed resulting in a simpler design with less components, still using the time-multiplexing technique for supplying the current to the loads.

[0037] The description uses both the terms energy and current. In the context of this application, the two terms should be read as being interchangeable.

[0038] Although the description above is targeting LCD television or monitors using LED backlight technology, the principles apply to other type of devices having different load circuits such as OLED display devices, multichannel audio amplifiers, electric heaters, etc.

Claims

1. An electronic circuitry for supplying power to a plurality of loads comprising:

   - a transformer (TR1) comprising at least a first winding (L1) and a secondary winding (L2), wherein the first winding is connected at one side to a source of AC mains through a rectifier and to a capacitor (C1) to the ground;
   - a first switch (Q1) connected between the first winding and the ground through a series resistor (Rs);
   - a plurality of second switches (A, B, C, D, E) for the plurality of loads connected to the secondary winding through a diode and to the plurality of loads;
   - a controller (U5) configured to control a time-multiplexed cycle of, for each of the plurality of loads, a charging phase and a supplying phase, by controlling the activation of the first switch and of the plurality of second switches, and cycling over the plurality of loads,

   wherein for at least one load, the charging phase is started by activating the first switch and inactivating the plurality of second switches until a needed current value for the load has been accumulated, the charge phase is then stopped by inactivating the first switch and the supplying phase is started by activating one of the second switches to discharge the accumulated current into the load connected to the active second switch.

2. A display device comprising the electronic circuitry according to claim 1 wherein the plurality of loads comprises a plurality of light emitting components providing backlighting to a plurality of corresponding areas of the display.

3. The display device of claim 2 further comprising a first comparator (U7) configured to compare a value representing the needed current for a load and a value representing the current accumulated into the

first winding.

4. The display device according to claim 3 wherein the controller U5 is further configured to analyse brightness of the plurality of areas of an image to be displayed and determine a corresponding amount of needed current for the corresponding light emitting components.

5. The display device according to claim 4 further comprising a second comparator (U4) configured to compare a value representing the needed current for a load and a value representing the current provided to one load, and generating an error value to be added to a further value of needed current for the load in order to perform a correction.

6. The display device according to claim 5 further comprising a mains separator (U2) configured to provide a signal representative of the value of the needed current for a load and ensure separation from mains.

7. The display device according to any of claims 2 to 6 wherein one of the load is a plurality of electronic circuits requiring a continuous power supply.

8. The display device according to any of claims 2 to 6 wherein the controller U5 is further configured to cycle between the loads successively for the plurality of loads.

9. The display device according to any of claims 2 to 6 wherein the controller U5 is further configured to cycle between the loads according to the amount of needed current for each load attributing multiple successive charging phase and supplying phase to a load needing more current than at least another load needing less current.

10. A method for controlling a time-multiplexed cycle of, for each of the plurality of loads, a charging phase and a supplying phase, comprising controlling the activation of the first switch and of the plurality of second switches, and cycling over the plurality of loads, wherein for at least one load, the charging phase is started by activating a first switch and inactivating a plurality of second switches until a needed current value for the load has been accumulated, the charge phase is then stopped by inactivating the first switch and the supplying phase is started by activating one of the second switches to discharge the accumulated current into the load connected to the active second switch.

11. The method of claim 10 further comprising determining when a needed current value for the load has been accumulated by comparing a value representing the needed current for a load and a value representing the current accumulated into a first winding.

12. The method according to claim 10 or 11 further comprising analysing brightness of the plurality of areas of an image to be displayed and determining a corresponding amount of needed current for the corresponding light emitting components.

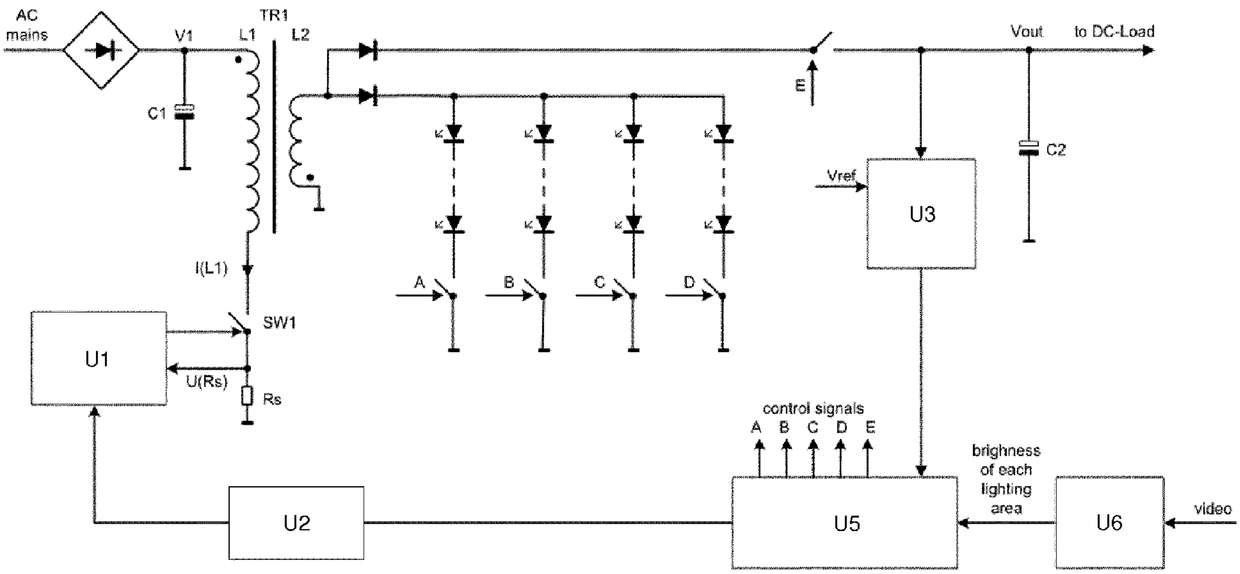

AC
mains
V1
TR1
L1
L2
C1
Vout
to DC-Load
E
C2
Vref
U3
I(L1)
A
B
C
D
SW1
U1
U(Rs)
Rs
control signals
A B C D E
brighness
of each
lighting
area
U2
U5
U6
video

Figure 1

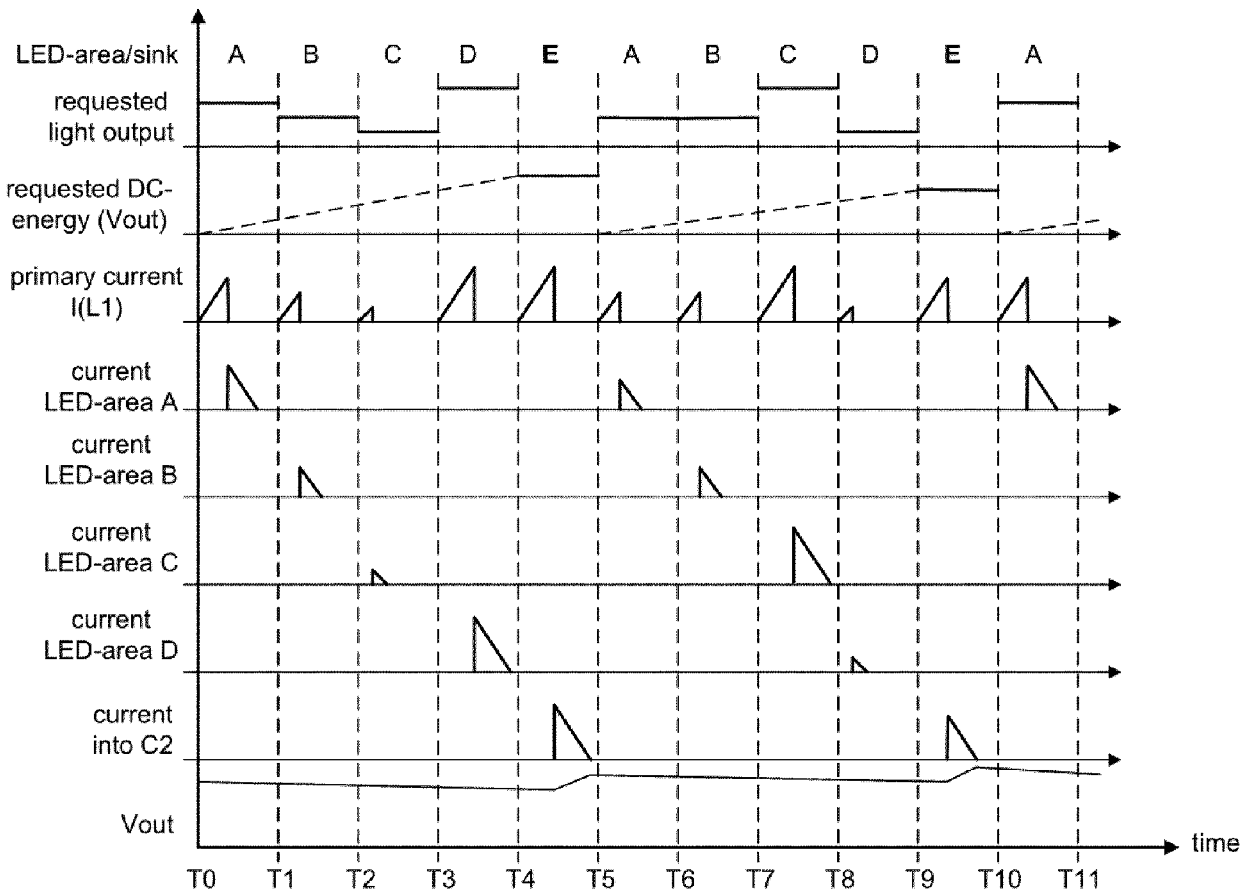
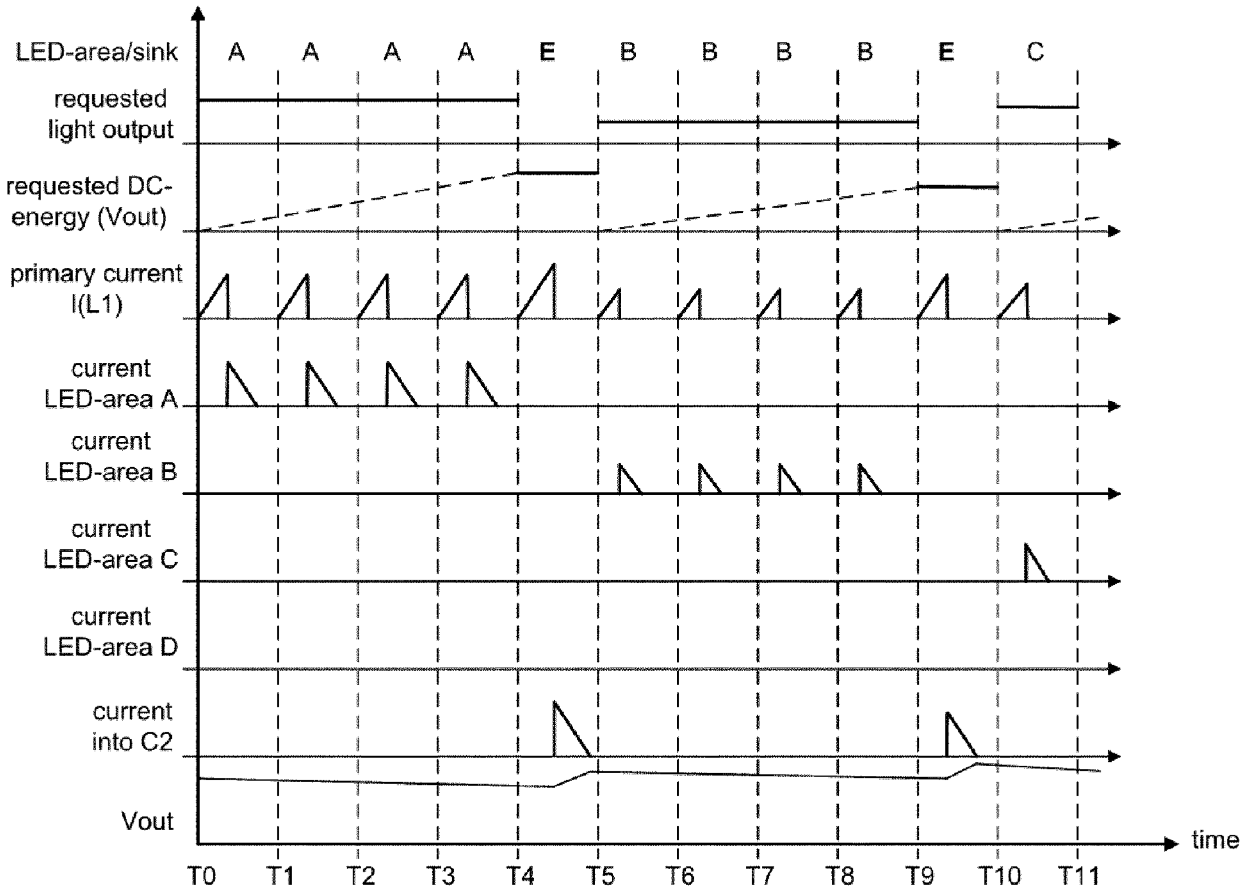

LED-area/sink
A
B
C
D
E
A
B
C
D
E
A
requested light output
requested DC-energy (Vout)
primary current I(L1)
current LED-area A
current LED-area B
current LED-area C
current LED-area D
current into C2
Vout
time
T0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11

Figure 2a


LED-area/sink
A
A
A
A
E
B
B
B
B
E
C
requested light output
requested DC-energy (Vout)
primary current I(L1)
current LED-area A
current LED-area B
current LED-area C
current LED-area D
current into C2
Vout
time
T0
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T2
T3
T4
T5
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T8
T9
T10
T11

Figure 2b

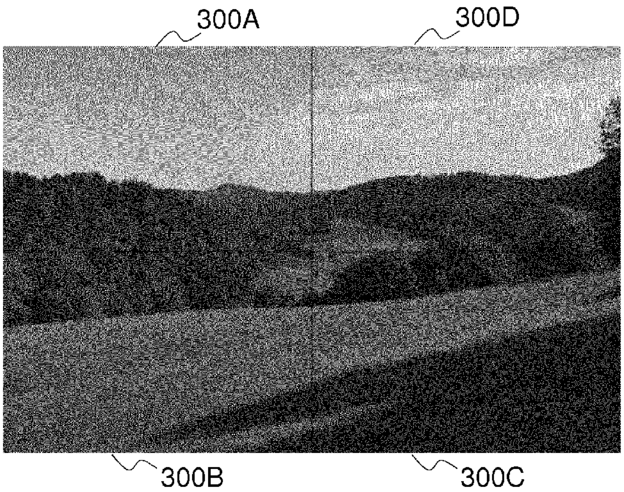


Figure 3a

Figure 3b

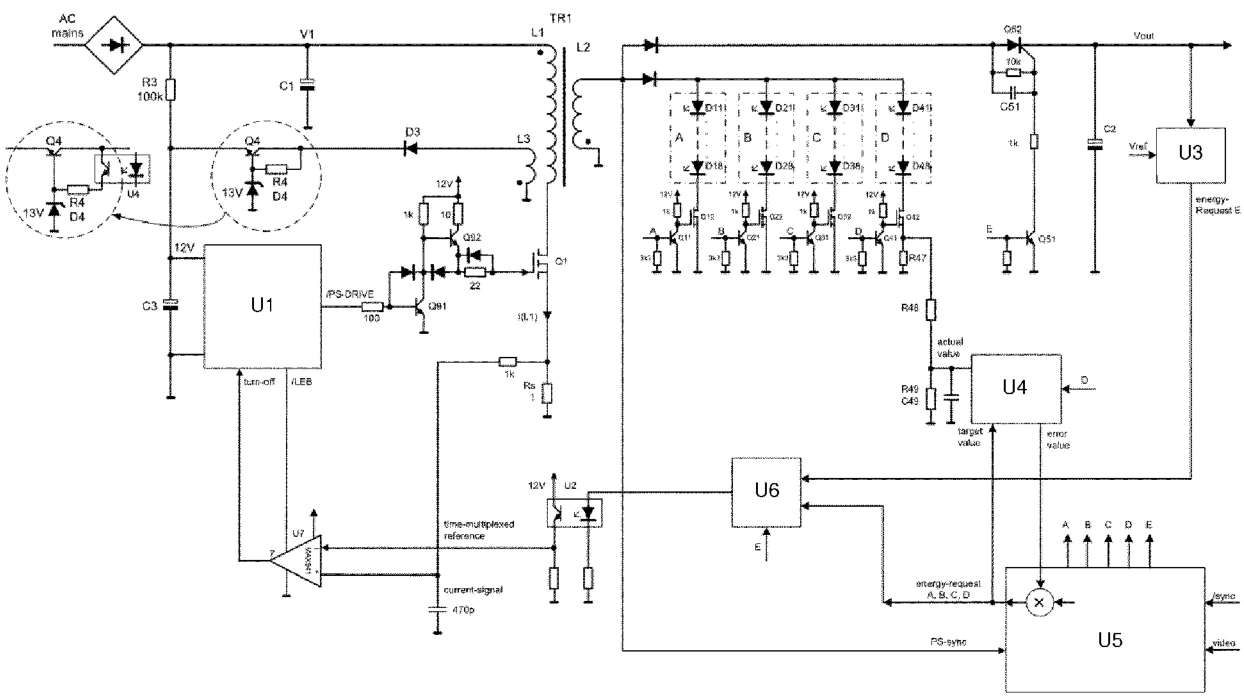
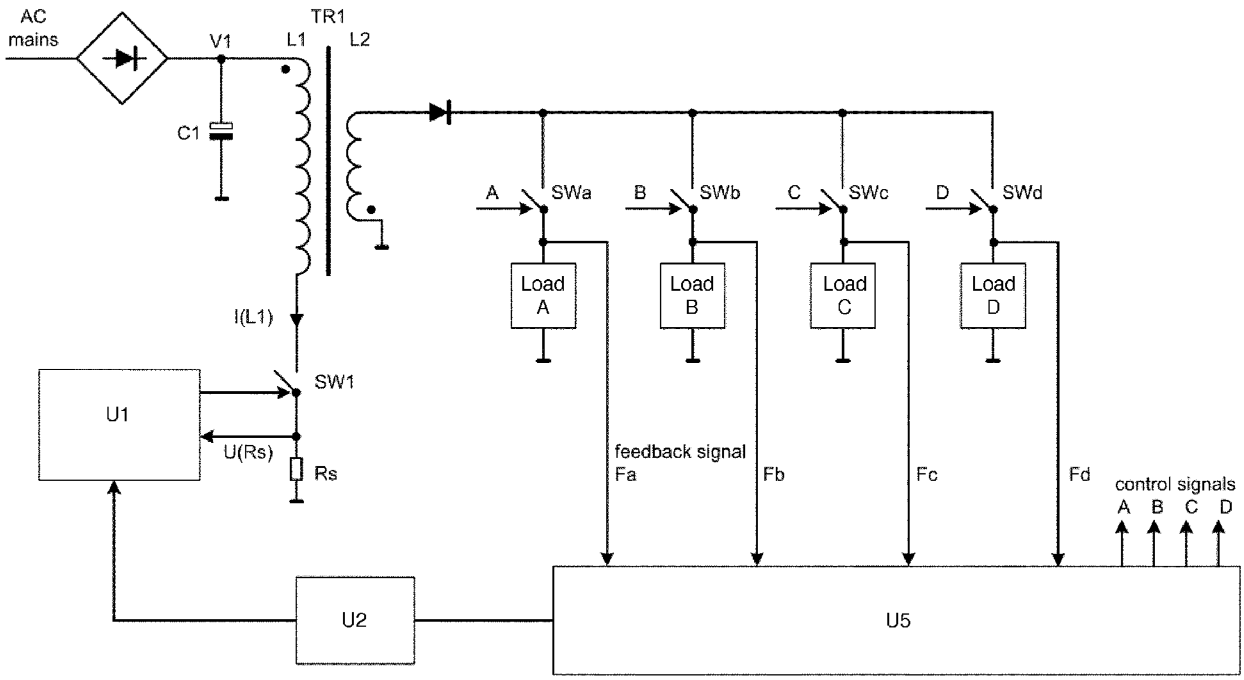

AC mains
V1
TR1
L1
L2
L3
R3 100k
C1
D3
Q4
R4
D4
13V
U4
12V
C3
U1
/PS-DRIVE
100
Q91
Q92
1k
10
22
Q1
i(L1)
Rs 1
turn-off
/LEB
U7
time-multiplexed reference
current-signal
470p
U2
U6
E
Vout
Q52
10k
C51
C2
Vref
U3
energy-Request E
Q51
D11
D18
D21
D28
D31
D38
D41
D48
A
B
C
D
R47
R48
actual value
R49
C49
U4
target value
error value
energy-request A, B, C, D
PS-sync
U5
/sync
video

Figure 4



AC mains
V1
TR1
L1
L2
C1
I(L1)
SW1
U1
U(Rs)
Rs
A
SWa
B
SWb
C
SWc
D
SWd
Load A
Load B
Load C
Load D
feedback signal Fa
Fb
Fc
Fd
control signals
A B C D
U2
U5

Figure 5

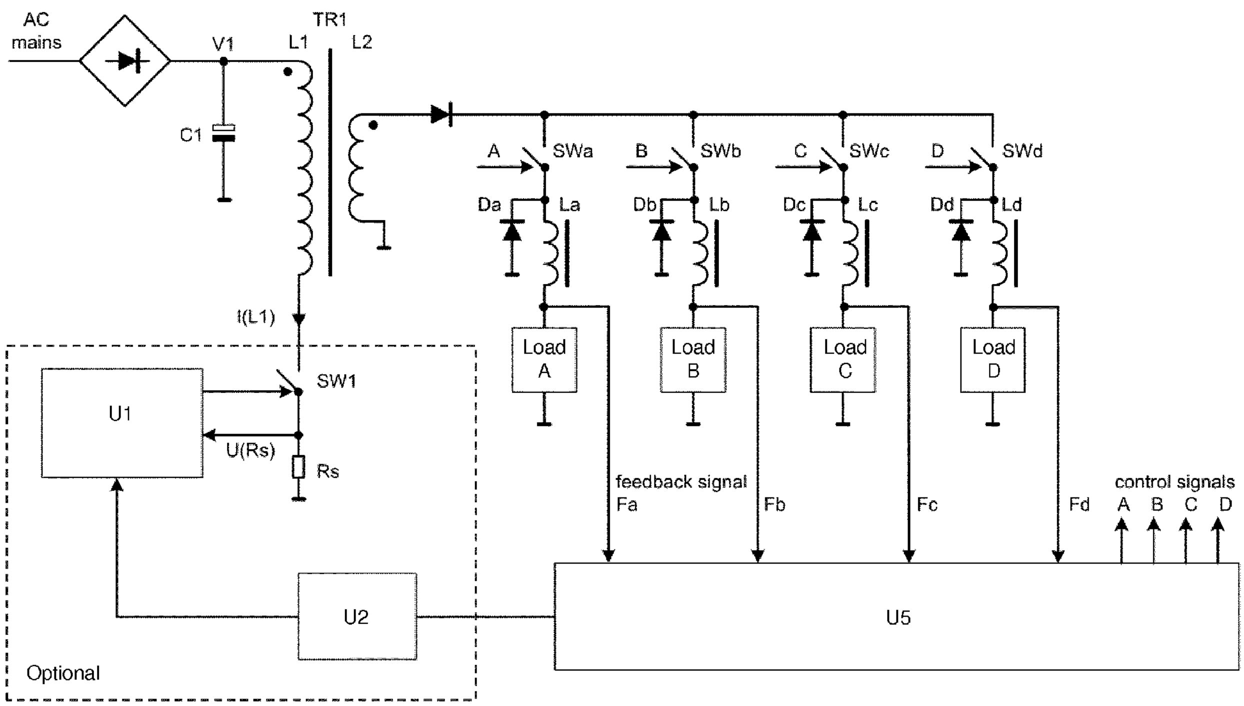

AC
mains
V1
TR1
L1
L2
C1
A
SWa
B
SWb
C
SWc
D
SWd
Da
La
Db
Lb
Dc
Lc
Dd
Ld
I(L1)
Load
A
Load
B
Load
C
Load
D
SW1
U1
U(Rs)
Rs
feedback signal
Fa
Fb
Fc
Fd
control signals
A B C D
U2
U5
Optional

Figure 6

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EUROPEAN SEARCH REPORT

Application Number
EP 17 30 6883

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 June 2018	Fanning, Neil

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05-06-2018

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