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(54) **Title:** A SYSTEM HAVING A BATTERY AND A METHOD OF CONTROLLING SUCH A SYSTEM

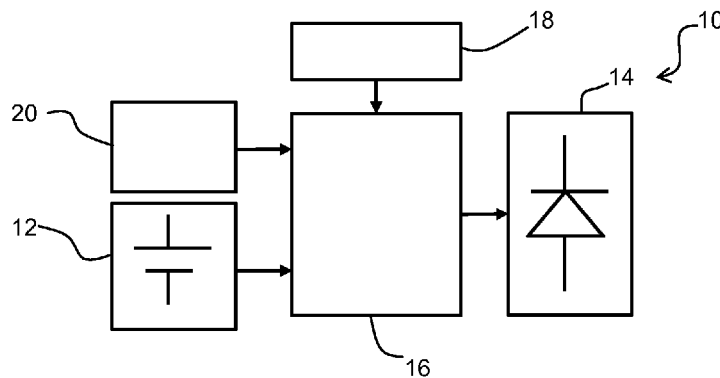


FIG. 1

(57) **Abstract:** A system comprises a battery, a load and a power converter for converting battery power from the battery into load power for application to the load. A system controller enables selection between a continuous discharge mode and a discontinuous discharge mode of the battery. In this way, the battery can be operated in different ways according to the most appropriate battery discharge characteristics.



A SYSTEM HAVING A BATTERY AND A METHOD OF CONTROLLING SUCH A SYSTEM

FIELD OF THE INVENTION

This invention relates to systems which include batteries.

BACKGROUND OF THE INVENTION

5 Rechargeable batteries are used in numerous applications. They are for example used as temporary energy storage devices in systems having time-varying power output and time-varying energy input. For example, lighting luminaires are increasingly being provided with integrated batteries. These may be charged by solar energy, which is typically available when the lighting is not needed, whereas lighting is needed when the solar
10 energy is not available. Thus, they function as energy storage elements to account for the time delay between the availability of energy for charging and the requirement for output power.

Particularly for outdoor luminaires, but more generally for outdoor systems, the battery will generally be exposed to the ambient temperature.

15 The performance of rechargeable batteries such as lithium-ion (LiFePo4) batteries depends on stress parameters such as the maximum charging voltage per cell, the charge and discharge currents, the depth of discharge (DOD) and the battery operating temperature during its course of usage. The cycle life of the battery reduces as the charge and discharge currents, DOD and maximum charging voltage per cell increase. The operating
20 temperature of the battery also shows a considerable impact on life, if battery is operating other than room temperatures.

For example, low temperature battery charging (e.g. less than 10 degrees Celsius) significantly affects the battery cycle life. It has been seen from experiment that if a LiFePo4 cycles at 25 degrees Celsius and offers a life time of 5500 cycles, then if the same
25 battery is cycled at 10 degrees Celsius, it will offer 3750 cycles, and if the same battery is cycled at -10 degrees Celsius, it will offer only 146 cycles.

The table below shows the number of cycles N_f of the battery life time at different temperatures (with 100% depth of charge).

Temperature	N _f
-10°C	146±15
10°C	3750±60
25°C	5550±500
35°C	4930±1000
50°C	1950±350

In the case of outdoor luminaires with integrated batteries, the battery will experience extremely low temperatures in many regions. Even for interior luminaires for example for office spaces, the battery will be placed above the luminaire and hence in a less insulated part of a building. Again, the battery may experience extremely low or elevated temperatures.

There is a need to improve the efficiency of utilization of batteries generally, and particularly in conditions where the battery is exposed to significant temperature variations and particularly cold temperatures.

10

SUMMARY OF THE INVENTION

The invention is defined by the claims.

Examples in accordance with the invention provide a system comprising:

15 a battery;

a load;

15

a power converter for converting battery power from the battery into load power for application to the load; and

20

a system controller, wherein the system controller is adapted to enable selection between a continuous discharge mode and a discontinuous discharge mode of the battery.

25

A discontinuous discharge mode of a battery may be used to improve battery utilization, in particular utilization of available energy storage, cycle life, specific energy and specific power. The discontinuities introduce faster relaxation which assists in battery performance optimization. This may for example be of particular interest for low temperature operation.

The power converter may comprise a switch mode power converter which comprises an energy storage and a switching arrangement for controlling the switching of battery power to the energy storage and from the energy storage to the load.

In a first example, the controller is adapted to control a switching frequency of the switching arrangement. By controlling the switching frequency, the time available for charging and discharging cycles is changed. As a result, the current waveform may transition between a continuous mode and a discontinuous mode.

5 In a second example, the controller may be adapted to control an impedance of the energy storage.

By controlling the impedance, the charging and discharging time constants are altered, which has the effect of changing the slopes of the battery current waveform. This may be used to control the overall current level, so that the average (or rms) current delivered
10 remains the same when switching between the operating modes.

The energy storage may comprise first and second inductors in parallel, and a switch for selectively connecting or disconnecting one of the inductors. The energy storage may thus be configured as a single inductor or a pair of inductors in parallel. This provides one way to control the impedance of the energy storage.

15 The controller may instead (or additionally) be adapted to control coupling of a smoothing output capacitor to the power converter. By controlling the output smoothing, it is again possible to select between a continuous mode and a discontinuous mode.

The controller may be adapted to implement an equal rms output current when switching between the continuous discharge mode and a discontinuous discharge mode. In
20 this way, the load sees the same rms current, so that the control transitions are not perceived by a user of the system.

The system may comprise an input for connection to an external power supply, and the controller is adapted to provide a continuous power to the load during the discontinuous discharge mode by using the external power supply during the discontinuities.
25 This maintains a continuous power supply to the load, while ensuring discontinuous battery discharging. The external power supply is for example a mains supply.

The system may comprise a plurality of batteries, and the controller is adapted to select at least two batteries to deliver the output power to the load alternately, thereby to implement the discontinuous discharge mode of the at least two batteries. This provides an
30 alternative way to achieve discontinuous battery discharging but a continuous supply to the load.

The power converter for example comprises a buck converter or a boost converter.

The load is for example a lighting arrangement and the system comprises a LED luminaire.

The system is thus a battery-integrated luminaire. The battery may for example be charged by solar energy, which is typically available when the lighting is not
5 needed, whereas lighting is needed when the solar energy is not available. Thus, the battery functions as an energy storage element to account for the time delay between the availability of energy for charging and the requirement for output power. The discontinuous mode may be of particular interest during lighting in cold periods, such as during the night in winter. The battery may instead be charged by mains power and has the purpose of time shifting as a
10 function of the demand levels hence pricing levels of mains electricity.

The invention also provides a method of controlling a system which comprises a battery, a load and a power converter for converting battery power from the battery into load power for application to the load, wherein the method comprises:

15 selecting between a continuous discharge mode and a discontinuous discharge mode of the battery.

The power converter may comprise a switch mode power converter which comprises an energy storage and a switching arrangement for controlling the switching of battery power to the energy storage and from the energy storage to the load, wherein the method comprises implementing the selection by:

20 controlling an impedance of the energy storage of the switch mode power converter; and/or

controlling a switching frequency of a switching arrangement of the switch mode power converter; and/or

25 controlling coupling of a smoothing output capacitor to the switch mode power converter.

The method may comprise providing a continuous power to the load during the discontinuous discharge mode by using an external power supply during the discontinuities. The method may comprise selecting at least two batteries from a plurality of batteries to deliver the output power alternately, thereby to implement the discontinuous
30 discharge mode of the at least two batteries.

The method is preferably for controlling a LED luminaire.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

5 Fig. 1 shows a system 10 comprising a battery, load 14 and a power converter;

Fig. 2 shows one example of a possible power converter;

Fig. 3 shows waveforms for the continuous mode of operation of the power converter of Fig. 2;

Fig. 4 shows waveforms for the discontinuous mode of operation of the power converter of Fig. 2;

10 Fig. 5 shows a power converter in the form of a modified boost converter in which the energy storage (inductor) is formed as two parallel inductors;

Fig. 6 shows the normal continuous operating mode of the power converter of Fig. 5;

15 Fig. 7 shows the effect of a reduced inductance of the power converter of Fig. 5;

Fig. 8 shows the effect on the waveform of Fig. 6 of removing the output capacitor;

Fig. 9 shows a power converter based on a buck converter;

20 Fig. 10 shows timing diagrams to explain the function of the circuit of Fig. 9 during normal operation, which is the discontinuous mode; and

Fig. 11 shows a method of controlling the system.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The invention will be described with reference to the Figures.

25 It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and methods of the present invention will become better understood from the following
30 description, appended claims, and accompanying drawings. It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

The invention provides a system which comprises a battery, a load and a power converter for converting battery power from the battery into load power for application to the load. A system controller enables selection between a continuous discharge mode and a discontinuous discharge mode of the battery. In this way, the battery can be operated in different ways according to the most appropriate battery discharge characteristics.

The concept of pulse discharging of a battery is based on successive changes in current rate and/or direction rather than using a constant discharging current. Basically, the current can either be interrupted, introducing a shorter rest period, or replaced by a short charge pulse. These short rest periods are believed to increase the speed of relaxation, and short current inversions may enable both faster relaxation and reverse the electrochemical process direction within the battery.

Some literature suggests that pulsed currents or voltages can affect the transport mechanisms of li-ion batteries. The depolarizing pulses can enable a considerable enhancement of the battery charging and discharging performance. For example C. F. Chiasserini and R. R. Rao, "Pulsed battery discharge in communication devices," in Proc. 5th Annu. ACM/IEEE Int. Conf. Mobile Comput. Netw., Seattle, WA, 1999, pp. 88–95 shows use of a pulse discharge profile with carefully selected amplitudes and rest periods, in order to increase both the specific energy and the specific power of a cell. Furthermore, other studies indicate that pulsing the potential of the electrode enables a control of the thickness of the equivalent diffusion layer and hence limits the concentration of over-potentials. Pulse discharging (and optionally also charging) can thus be considered as an interesting candidate for battery performance optimization.

The interfacial resistance is highest at low temperatures and at the end of discharge. For a given state-of-charge, the interfacial resistance grows exponentially with decreasing temperature. Thus, the need for efficient battery use is particularly important at low temperatures.

Figure 1 shows system 10 comprising a battery 12, a load 14, a power converter 16 for converting battery power from the battery into load power for application to the load and a system controller 18.

The system controller 18 is adapted to enable selection between a continuous discharge mode and a discontinuous discharge mode of the battery. The discontinuous discharge mode of a battery is used to improve battery utilization, in particular utilization of available energy storage, cycle life, specific energy and specific power. The discontinuities introduce faster relaxation which assists in battery performance optimization.

Figure 1 shows a further external power supply 20. In one example, this is a mains supply. In such a case, the battery may be used to deliver power at peak times (and hence cost) of the mains power, and the mains power may be used to recharge the battery. In another example, the supply 20 is a solar energy supply. In such a case, the battery is used to provide power when direct solar power is not available.

Figure 2 shows one example of a possible power converter 16 comprising a switch mode power converter. The switch mode power converter comprises an energy storage 22 and a switching arrangement 24, 26 for controlling the switching of battery power to the energy storage and from the energy storage to the load.

This example is a boost converter, in which the switching arrangement comprises a high frequency main switching transistor 24 and diode 26, and an inductor 22 as the energy storage. A smoothing capacitor 28 is provided in parallel with the output load 14.

In a first example, the controller 18 is adapted to control a switching frequency of the main transistor 24. By controlling the switching frequency, the time available for charging and discharging cycles is changed. As a result, the current waveform may transition between a continuous mode and a discontinuous mode.

Figure 3 shows waveforms for the continuous mode of operation.

The top plot shows the current drawn from the battery, I_B , and the bottom plot shows the pulse width modulation (PWM) signal applied by the controller 18 to the main transistor gate. The energy conversion ratio is controlled based on the duty cycle of the PWM signal. The increasing current ramps correspond to inductor charging and the decreasing current ramps correspond to inductor discharge to the load.

This continuous operation may be achieved by operating at a first frequency, such as 50kHz.

Figure 4 shows waveforms for the discontinuous mode of operation.

The top plot again shows the current drawn from the battery, I_B , and the bottom plot shows the pulse width modulation (PWM) signal applied by the controller 18 to the transistor gate. This discontinuous operation may be achieved by operating at a second, lower, frequency, such as 30kHz. The effect is that the decreasing current drawn from the battery drops to zero because the energy storage is fully depleted.

The discontinuous mode for example has a switching frequency between 10% and 70% of the continuous mode switching frequency, for example half the switching frequency.

This type of boost converter is for example often used in a battery integrated LED luminaires as in most cases the battery voltage is below the required LED string voltage. When the converter is operated at a high frequency as shown in Figure 3, for example in the range 50 to 100kHz, the battery current is continuous because the converter
5 will operate in a continuous conduction mode (CCM) giving rise to a continuous DC battery current. By keeping the maximum inductor current within the saturation limit, the operating frequency can be reduced such that the battery current becomes discontinuous or at the boundary conduction mode.

A consequence of this frequency reduction method to implement a
10 discontinuous conduction mode is that the output current i.e. LED current may need to be reduced because the power delivery from the battery to LED string will be limited by the inductor saturation limit. The frequency reduction may for example be used during a dimming mode of operation to improve battery performance.

Figure 5 shows a modified boost converter in which the energy storage
15 (inductor) is formed as two parallel inductors 22a, 22b, with a switch 22c for controlling the connection of the second inductor 22b. The inductance is thus switchable between two values. The different inductance value changes the temporal characteristics of the circuit. The switching is controlled by the system controller 18.

The switchable inductor is used to overcome the inductor saturation limit and
20 maintain the same LED current despite the reduced frequency.

Figure 6 shows the normal continuous operating mode with only the first inductor 22a. During this normal high frequency (50-100kHz) operating mode, the battery current is continuous and DC in nature and inductor 22a carries the battery current.

Figure 7 shows the effect of a reduced inductance by having both inductors in
25 parallel and also reducing the switching frequency. The slope of the current profile is increased as a result of the reduced inductance and the discontinuous mode results from the frequency reduction.

The benefit of this combined approach is that the rms current is able to be maintained at a constant level. The increase in current compensates for the reduced time
30 when current flows. By switching the two inductors in parallel the current delivery limit is enhanced by two times even at low frequency operation.

In both approaches, the LED current will be continuous as a result of the output capacitor filter. By controlling the impedance, the charging and discharging time constants are altered, which has the effect of changing the slopes of the battery current

waveform. The two inductors in parallel enable double the peak current to be carried so that the pauses between peaks can be longer.

The controller 18 may instead or additionally be adapted to control coupling of the smoothing output capacitor 28 to the power converter. By controlling the output
5 smoothing, it is again possible to select between a continuous mode and a discontinuous mode.

Figure 8 shows the effect on the waveforms of Figure 6 of removing the output capacitor for example by opening a switch 30 in series with the output capacitor. The result is that the LED experiences a pulsating current I_{LED} with the same frequency as the
10 battery pulsating current.

During inductor charging (with the main switch 24 closed), current flows from the battery to the inductor whereas during inductor discharging (with the main switch 24 open), current I_{LED} flows to the LED load.

Figure 9 shows an implementation based on a buck converter. This is suitable
15 for an application where the battery voltage is higher than the LED string voltage. The same components are given the same reference as in the boost converter. There is an input filter circuit across the battery, comprising a filter capacitor 90 in parallel with the battery 12 and a series switch 92. When the main switch 24 is closed, the current flows from the capacitor 90 to the inductor through the switch 24 and when the switch 24 is open the depleted charge in
20 the capacitor is replenished by the battery.

A series resistance (or inductance) may be provided between battery 12 and the capacitor 90. The current path from the capacitor into the down converter is by a low ohmic connection. When the series switch 92 is opened the recharging by the battery is interrupted and the current ripple of the down converter is fully supported by the battery.

Figure 10 shows timing diagrams to explain the circuit function during the
25 normal operation, which is the discontinuous mode.

The battery experiences a pulsating current I_B . To maintain the same LED current at different frequencies and duty cycles, inductor switching is employed as explained above.

30 The LED current I_{LED} is continuous as shown.

As shown in Figure 1, the system has an input for connection to an external power supply 20. This may be used to ensure that a continuous power is provided to the load during the discontinuous discharge mode by using the external power supply during the discontinuities. The external power supply is for example a mains supply. In this way, the

battery current and mains supply (or charger) current may be interleaved. The load current pulsations are then made independent of the battery current pulsations. Also during charging of the battery, the LEDs may be used to intermittently load the battery causing a current ripple.

5 Alternatively, the system may comprise a plurality of batteries, and the controller 18 is then adapted to select at least two batteries to deliver the output power to the load alternately. This implements the discontinuous discharge mode of the at least two batteries while maintaining a continuous supply to the load. Two or more batteries may be used to transfer current between them to provide another way to shape the current pulses.

10 Figure 11 shows a method of controlling a system which comprises a battery, a load and a power converter for converting battery power from the battery into load power for application to the load. The method comprises in step 110 selecting between a continuous discharge mode and a discontinuous discharge mode of the battery. The load is powered in step 112 according to the selected operating mode.

15 As explained above, the mode selection may be based on one or more of:
controlling an impedance of the energy storage of the switch mode power converter;

controlling a switching frequency of a switching arrangement of the switch mode power converter;

20 controlling coupling of a smoothing output capacitor to the switch mode power converter.

The invention provides a system which can switch between a continuous and discontinuous conduction mode. There is of tradeoff between the two modes. The discontinuous mode improves battery performance but reduces power delivery capability hence it can be implemented during dimming mode operation not at the rated power operation of the LED string. The addition of inductor switching however allows the rated current output to be maintained.

25 The pulsed battery discharge may not always improve battery performance. This may depend on various operating conditions, such as temperature (DCM is efficient at low temperature operation) and battery chemistry. Therefore, by providing a driver with the capability to switch between continuous and discontinuous modes, the driver is future proof and can be applied for battery performance improvement at any external operating conditions for any battery chemistry. This also enables a single driver design to be compatible with multiple applications such as low temperature areas as well as high temperature areas.

It can be seen that the decision to switch between modes may be based on a variety of sources of information, such as:

- the temperature;
- the dimming level of the LED luminaire;
- 5 the type of connected battery;
- the state of charge of the battery;
- the state of health of the battery.

A battery impedance may be measured during periods of current ripple. This may be used state of charge and state of health evaluation. As the current ripple is generated
10 intentionally, the impedance can be directly monitored by measuring the battery terminal voltage waveforms which result from the current pulses.

Battery impedance measurements give interesting information about state of charge as well as state of health of many battery systems. However, the ohmic resistance of a battery is often very small and hence the phase shifts seen between voltage and current can be
15 very small or be dominated by the cabling. In battery integrated lamps, the battery cabling is often very short and hence impedance effects can be often monitored.

The examples of a buck converter and boost converter have been given above. However, the converter may be a buck-boost converter, a push-pull converter, a forward converter, or a half-bridge or full bridge inverter.

20 The LED current may for example be generated using a purely resistive circuit with the consequence that the battery current is the same as the LED current. At high frequency, the resulting ripple will be acceptable as it will not be seen to the naked eye, assuming a flicker rate above about 400Hz. Slower flicker may also be acceptable in some applications such as street lighting. A local energy such as a capacitor and/or inductance may
25 be used not as part of a switch mode power supply, again to give the freedom to generate a battery current discharge ripple independently of an LED flux ripple.

The invention is of interest for outdoor solar luminaires, where during winter season and at night, low temperature discharging is expected so that pulse discharging will be effective. The battery may instead be used for time-shifting i.e. demand responsive lighting.
30 During high demand periods, luminaires normally operate at a dimming mode, and again battery performance can be improved with DCM discharging.

The invention may however be applied more generally to battery operated loads.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent 5 claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A system (10) comprising:
 - a battery (12);
 - a load (14);
 - a power converter (16) for converting battery power from the battery into load5 power for application to the load; and
 - a system controller (18), wherein the system controller is adapted to enable selection between a continuous discharge mode and a discontinuous discharge mode of the battery, wherein the controller (18) is adapted to implement an equal rms output current when switching between the continuous discharge mode and a discontinuous discharge mode.10
2. A system as claimed in claim 1, wherein the power converter (16) comprises a switch mode power converter which comprises an energy storage (22) and a switching arrangement (24) for controlling the switching of battery power to the energy storage and from the energy storage to the load.
153. A system as claimed in claim 2, wherein the controller (18) is adapted to control a switching frequency of the switching arrangement.
4. A system as claimed in claim 2 or 3, wherein the controller (18) is adapted to
20 control an impedance of the energy storage.5. A system as claimed in claim 4, wherein the energy storage comprises first and second inductors (22a, 22b) in parallel, and a switch (22c) for selectively connecting or disconnecting one of the inductors.
256. A system as claimed in any preceding claim, wherein the controller (18) is adapted to control coupling of a smoothing output capacitor (28) to the power converter.

7. A system as claimed in any preceding claim, comprising an input for connection to an external power supply (20), and wherein the controller is adapted to provide a continuous power to the load during the discontinuous discharge mode by using the external power supply during the discontinuities.

5

8. A system as claimed in any preceding claim, comprising a plurality of batteries, and wherein the controller is adapted to select at least two batteries to deliver the output power to the load alternately, thereby to implement the discontinuous discharge mode of the at least two batteries.

10

9. A system as claimed in any preceding claim, wherein the load (14) is a lighting arrangement and the system comprises a LED luminaire.

10. A method of controlling a system which comprises a battery (12), a load (14) and a power converter (16) for converting battery power from the battery into load power for application to the load, wherein the method comprises:

15

(110) selecting between a continuous discharge mode and a discontinuous discharge mode of the battery.

11. A method as claimed in claim 10, wherein the power converter (16) comprises a switch mode power converter which comprises an energy storage and a switching arrangement for controlling the switching of battery power to the energy storage and from the energy storage to the load, wherein the method comprises implementing the selection by:

20

controlling an impedance of the energy storage of the switch mode power converter; and/or

25

controlling a switching frequency of a switching arrangement of the switch mode power converter; and/or

controlling coupling of a smoothing output capacitor to the switch mode power converter.

30

12. A method as claimed in claim 10 or 11, comprising providing a continuous power to the load during the discontinuous discharge mode by using an external power supply during the discontinuities.

13. A method as claimed in claim 10, 11 or 12, comprising selecting at least two batteries from a plurality of batteries to deliver the output power alternately, thereby to implement the discontinuous discharge mode of the at least two batteries.
- 5 14. A method as claimed in any one of claims 10 to 13 comprising controlling a LED luminaire.

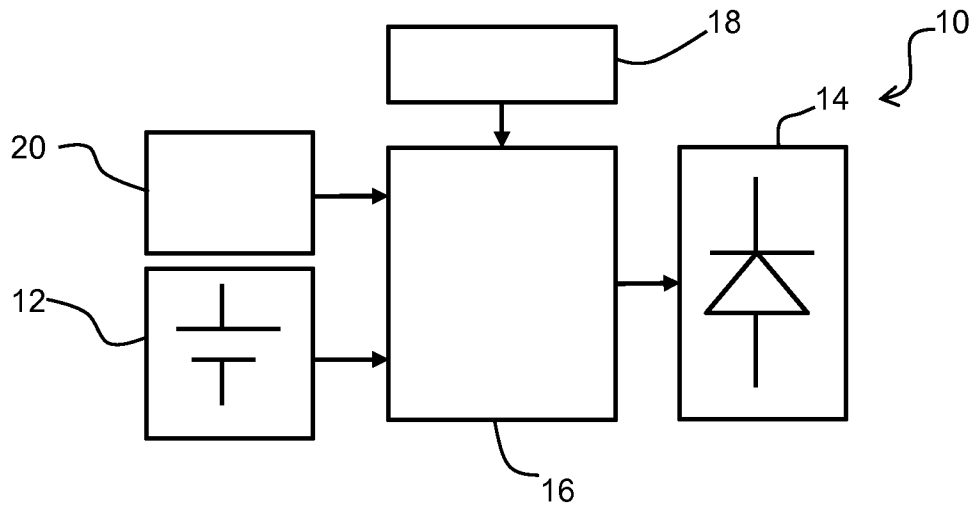


FIG. 1

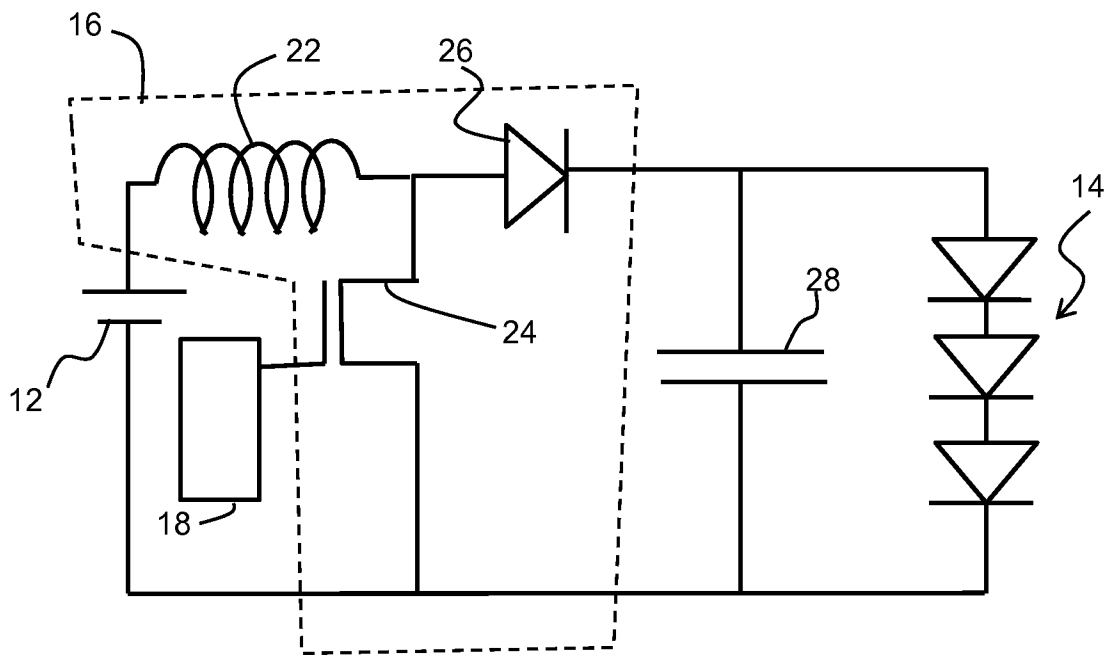


FIG. 2

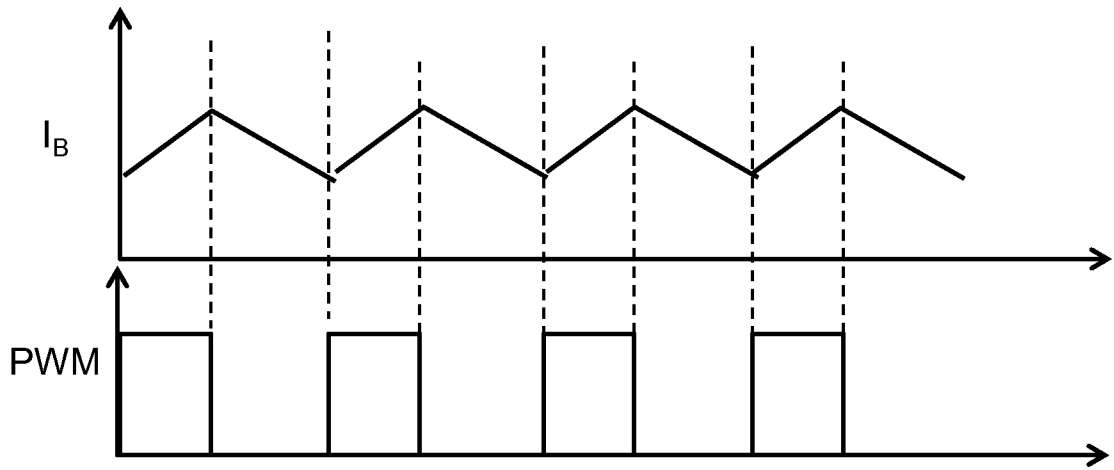


FIG. 3

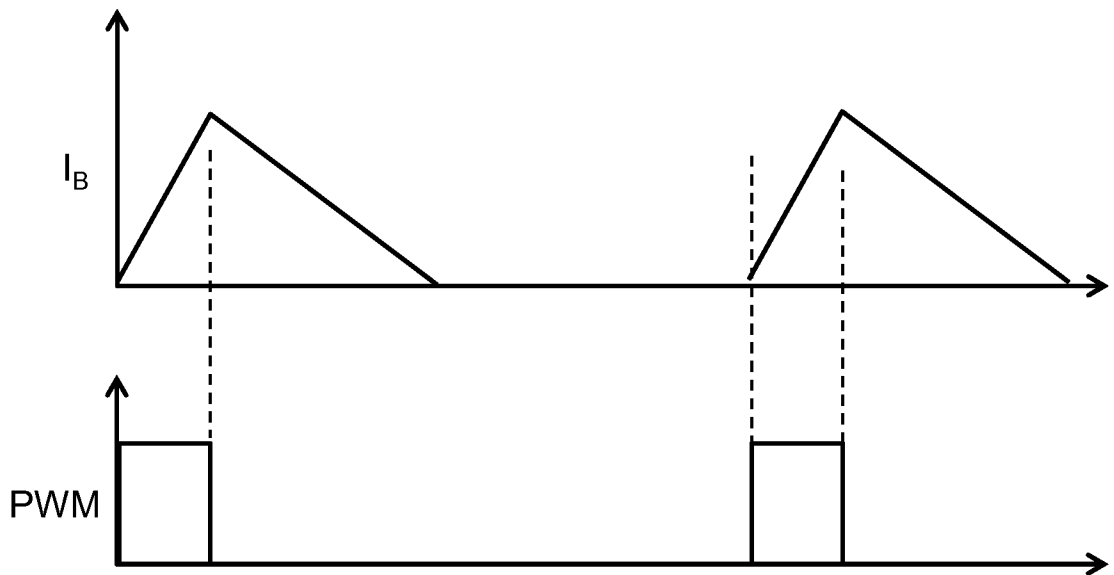


FIG. 4

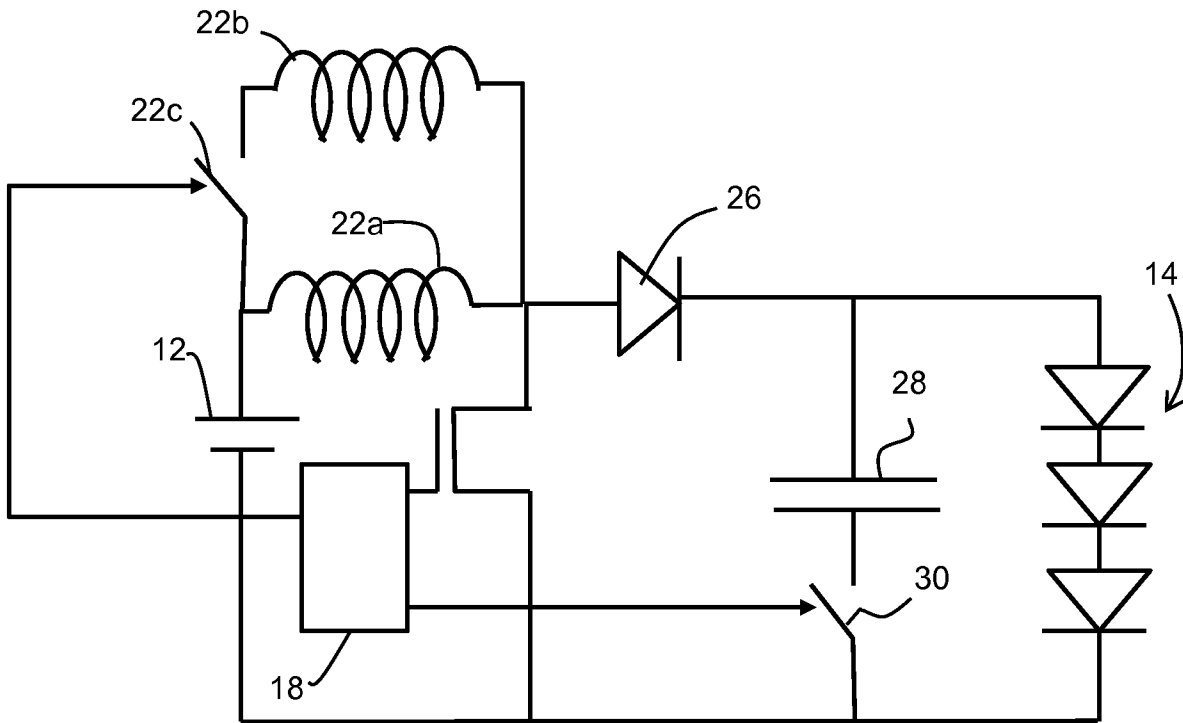


FIG. 5

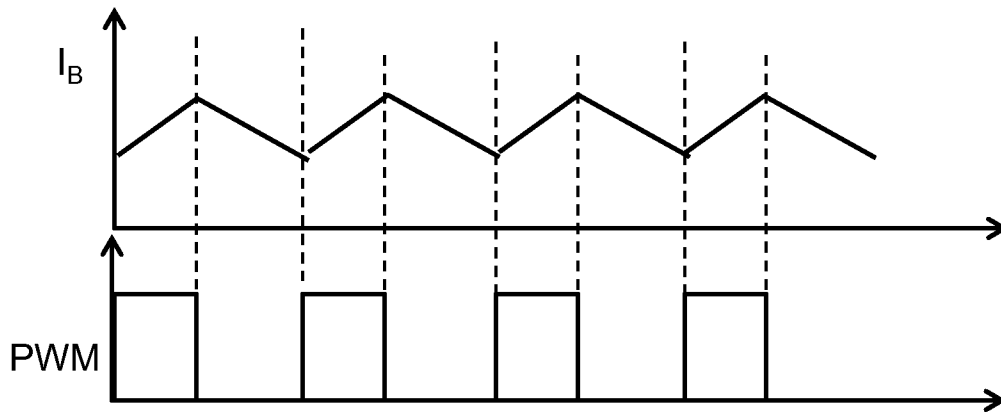


FIG. 6

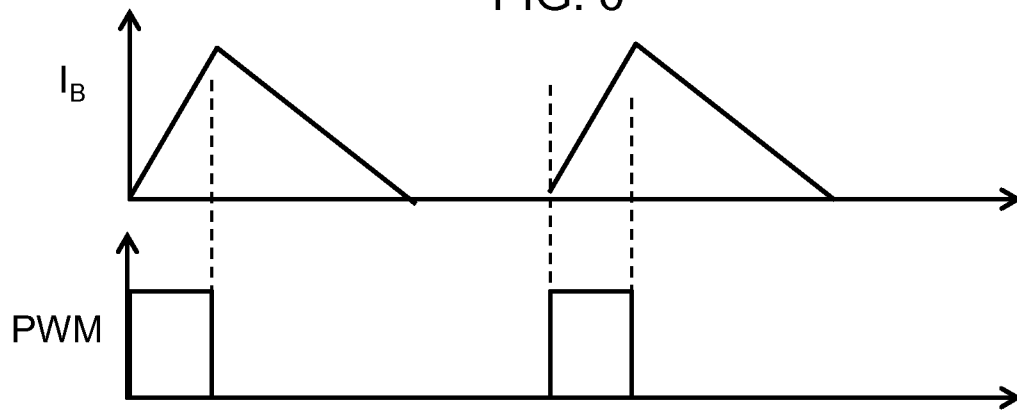


FIG. 7

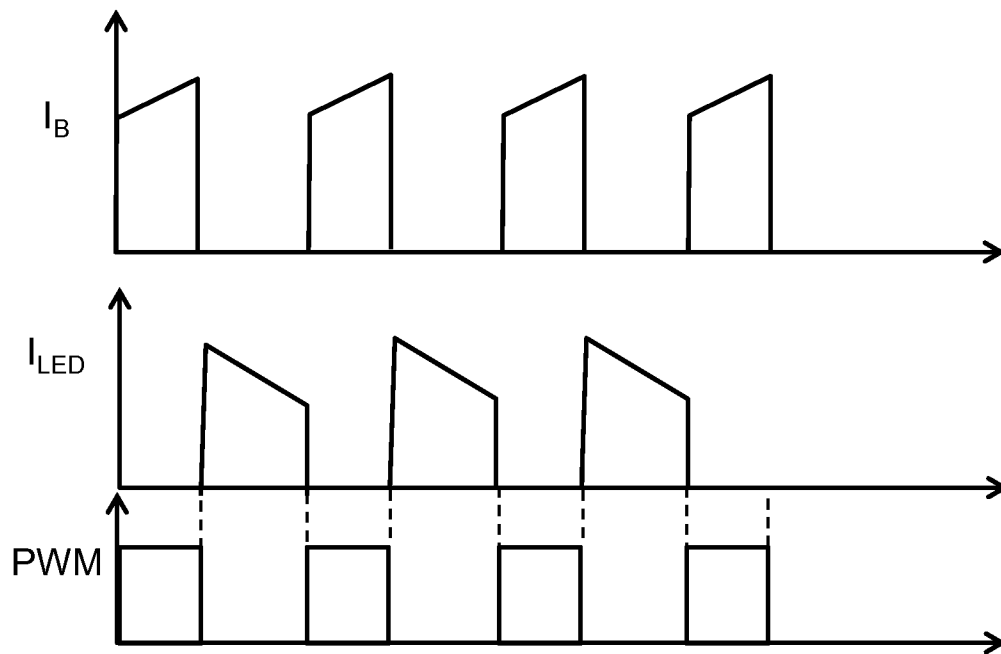


FIG. 8

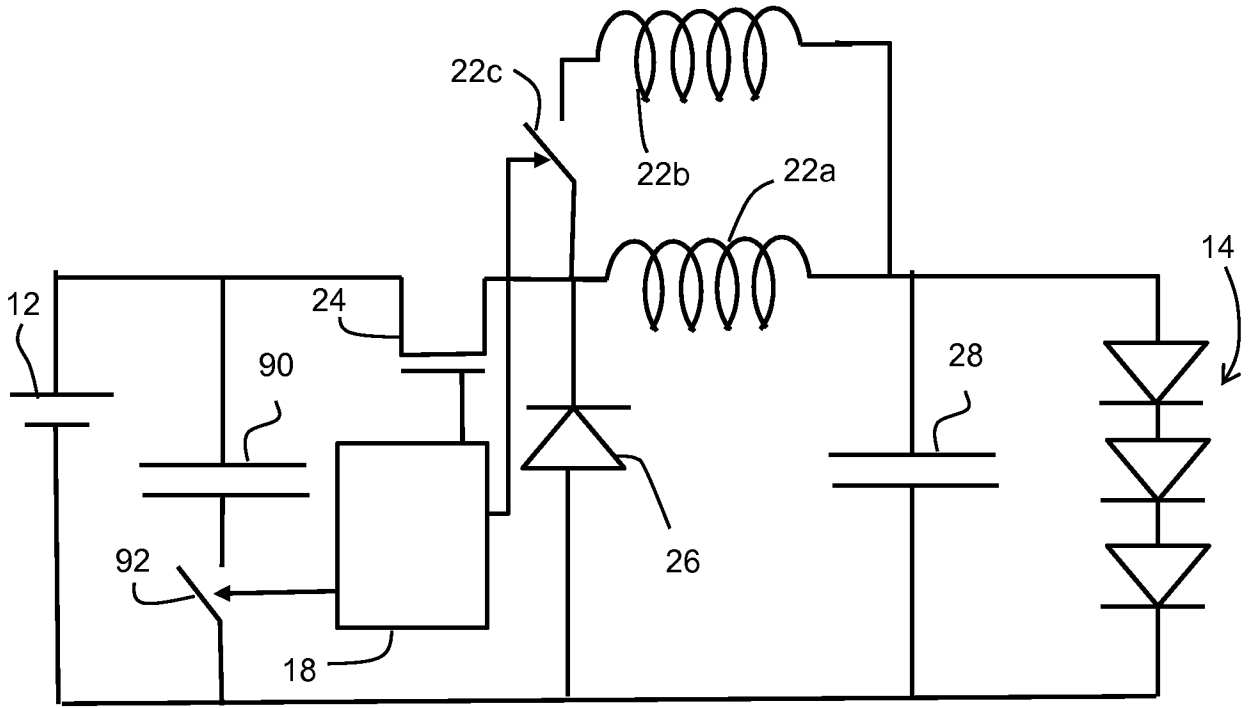


FIG. 9

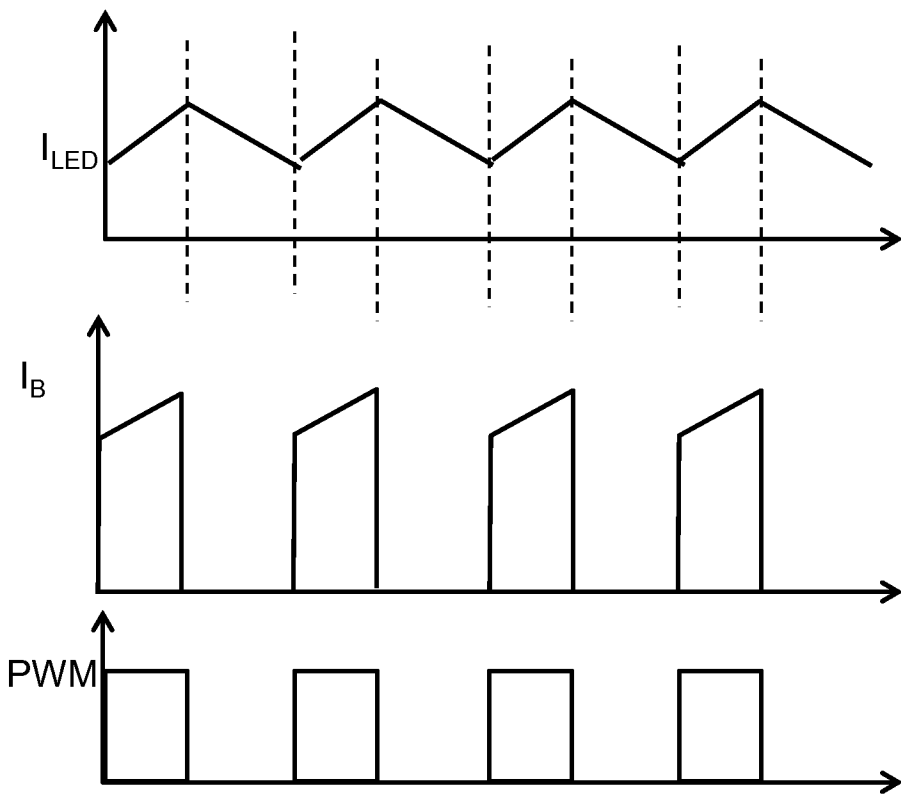


FIG. 10

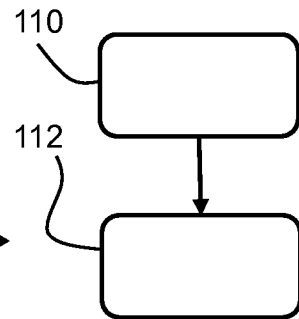


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/058503

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02J7/00 H05B33/08
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
H02J H05B
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/249421 A1 (CAVALLINI PIER [GB] ET AL) 26 September 2013 (2013-09-26)	10,14
Y	abstract paragraphs [0001] - [0017], [0027] - [0088]; figures 1-5	1-9, 11-13
X	US 2012/133205 A1 (ADAMS PAUL [US] ET AL) 31 May 2012 (2012-05-31) abstract; figures 6,7,8 paragraphs [0003] - [0007], [0042] - [0062]	10,14
X	US 2009/184665 A1 (FERRO ALBERTO [IT]) 23 July 2009 (2009-07-23) abstract; figures 1-3 paragraphs [0021] - [0043]	10,14
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 29 May 2019	Date of mailing of the international search report 07/06/2019
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Lorenzo Feijoo, S
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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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