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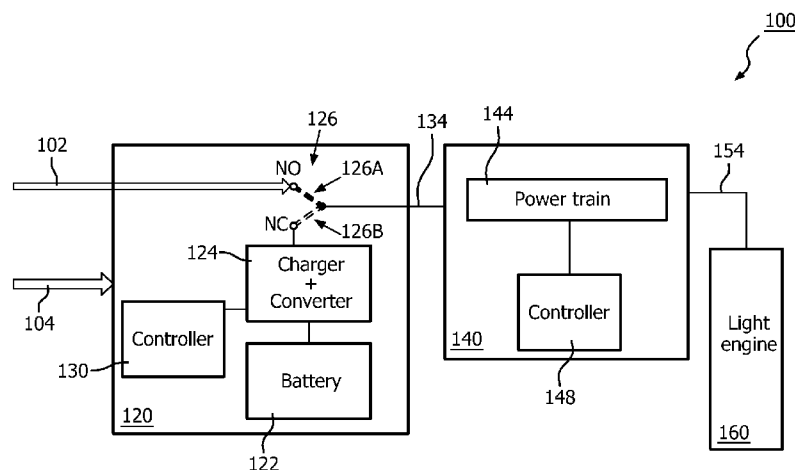
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(54) Title: METHODS AND APPARATUS FOR EMERGENCY POWERING OF A LIGHT SOURCE

**FIG. 1**

(57) Abstract: Methods and apparatus disclosed herein relate to emergency lighting in which a lighting driver (140, 240, 340, 540, 640) may be powered by a mains input during normal operating conditions and the same lighting driver (140, 240, 340, 540, 640) may be powered by a direct current output during emergency operating conditions. An emergency lighting device (120, 220, 320, 420, 520, 620) provides the direct current output from a battery (122, 222, 322, 422, 522, 622) to the driver (140, 240, 340, 540, 640) during emergency operating conditions.

METHODS AND APPARATUS FOR EMERGENCY POWERING OF A LIGHT SOURCE

Technical Field

[0001] The present invention is directed generally to emergency lighting. More particularly, various inventive methods and apparatus disclosed herein relate to an emergency lighting system and a lighting driver therefor.

Background

[0002] In some environments, it is desired and/or required by law to provide certain levels of light output for a certain period of time during power failures. Emergency lighting systems typically include an emergency lighting driver powered by a battery, e.g. a nickel-cadmium (Ni-Cd) battery. In some conventional approaches, the emergency lighting driver is implemented in parallel with a standard lighting driver. The standard lighting driver provides power to a light source during normal conditions and the emergency lighting driver provides power to the light source during power failures (while the standard lighting driver provides no power during power failures). In other known approaches, the emergency lighting driver is implemented with a separate emergency light source. In that case, the standard lighting driver provides power to a standard light source during normal conditions and the emergency lighting driver provides power to the emergency light source during power failures (while the standard lighting driver provides no power during power failures).

[0003] Existing emergency lighting systems providing lighting during power failure have one or more drawbacks. For example, they may necessitate utilization of a separate emergency lighting driver, a separate emergency light source, and/or an abundance of electrical wiring. Also, for example, existing emergency lighting systems may require wholesale redesign of components thereof for different design specifications and not be conducive for modular implementation with various standard lighting drivers. Also, for example, existing emergency lighting systems may have undesirable power conversion efficiency and/or may be incompatible with certain LED drivers.

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[0004] Thus, there is a need in the art to provide emergency lighting methods and apparatus that may optionally be utilized to overcome one or more of the drawbacks of existing emergency lighting systems.

Summary

[0005] The present disclosure is directed to inventive methods and apparatus for emergency lighting. More specifically, methods and apparatus disclosed herein relate to emergency lighting in which a lighting driver may be powered by a mains input during normal operating conditions and the same lighting driver may be powered by a direct current output during emergency operating conditions. An emergency lighting device provides the direct current output from a battery to the driver during emergency operating conditions.

[0006] Generally, in one aspect, the invention focuses on an emergency lighting system that includes at least one light source, a driver electrically coupled to and powering the at least one light source, and an emergency lighting device. The emergency lighting device has a battery, a mains input, and an emergency lighting device output. The mains input at least selectively charges the battery through a charging circuit. The emergency lighting device output is electrically coupled to and at least selectively powers the driver. The driver is powered by an alternating current mains input during a normal operating condition and the emergency lighting device provides a direct current output from the battery to the driver over the emergency lighting device output during an emergency operating condition.

[0007] In some embodiments, the emergency lighting device provides the mains input to the driver over the emergency lighting device output during the normal operating condition. In some versions of those embodiments, the emergency lighting device includes at least one switch interposed between the mains input and the emergency lighting device output and interposed between the battery and the emergency lighting device output.

[0008] In some embodiments, the driver detects the direct current output from the battery over the emergency lighting device output and decreases power provided to the at least one light source in response to detecting the direct current output over the emergency lighting device output. In some versions of those embodiments the power provided to the light source

is decreased at least 75% in response to detecting the direct current output over the emergency lighting device output. The emergency operating condition may include a power loss and/or at least one of a demand response condition and a brownout condition.

[0009] In some embodiments, the emergency lighting system further includes a communications link between the driver and the emergency lighting device. In some versions of those embodiments, the emergency lighting device receives at least one value from the driver via the communications link and adjusts at least one parameter of the emergency lighting device based on the at least one value.

[0010] The direct current output may be intermittently interrupted for at least a direct current arc interruption time period. Also, the direct current output may be electrically coupled directly into a direct current input of a DC to DC converter of the driver or into a mains input of the driver.

[0011] Generally, in another aspect, the invention focuses on an emergency lighting device. The emergency lighting device includes a mains input, a battery at least selectively electrically coupled to the mains input through a charging circuit, a direct current to direct current converter at least selectively electrically coupled to the battery and producing a direct current output via power from the battery; and an emergency lighting device output. The emergency lighting device output is electrically coupled to the mains input during a normal operating condition and the emergency lighting device is electrically coupled to the direct current output during an emergency operating condition.

[0012] In some embodiments, the direct current output is intermittently interrupted for at least a direct current arc interruption time period.

[0013] In some embodiments, the emergency lighting device output may be electrically coupled to a lighting driver having a lighting AC fuse and the direct current output may have an output impedance that causes the AC fuse to see less than one thousand amps when the emergency lighting device is electrically coupled to the direct current output.

[0014] The emergency lighting device may further include at least one switch interposed between the mains input and the emergency lighting device output and interposed between the direct current to direct current converter and the emergency lighting device output.

[0015] The emergency lighting device may additionally include a driver communications input receiving at least one of a driver voltage value and a driver current value during the emergency operating conditions. The direct current output is adjusted based on at least one of the driver voltage value and the driver current value.

[0016] Generally, in another aspect, a method of providing emergency lighting is provided and includes the steps of: providing, during a normal operating condition, an alternating current mains power supply to a driver powering at least one light source; providing, during an emergency operating condition, a direct current output powered by a battery to the driver; decreasing power provided by the driver to the at least one light source in response to detecting the emergency operating condition.

[0017] In some embodiments, the alternating current mains power supply and the direct current output are provided to the driver over a common output.

[0018] In some embodiments, the method further includes intermittently interrupting the direct current output for at least a direct current arc interruption time period during the step of providing, during the emergency operating condition, the direct current output power by the battery to the driver.

[0019] As used herein for purposes of the present disclosure, the term “LED” should be understood to include any electroluminescent diode or other type of carrier injection/junction-based system that is capable of generating radiation in response to an electric signal. Thus, the term LED includes, but is not limited to, various semiconductor-based structures that emit light in response to current, light emitting polymers, organic light emitting diodes (OLEDs), electroluminescent strips, and the like. In particular, the term LED refers to light emitting diodes of all types (including semi-conductor and organic light emitting diodes) that may be configured to generate radiation in one or more of the infrared spectrum, ultraviolet spectrum, and various portions of the visible spectrum (generally including radiation wavelengths from approximately 400 nanometers to approximately 700 nanometers). For example, one implementation of an LED configured to generate essentially white light (e.g., a white LED) may include a number of dies which respectively emit different spectra of electroluminescence that, in combination, mix to form essentially white light. In another implementation, a white light

LED may be associated with a phosphor material that converts electroluminescence having a first spectrum to a different second spectrum. In one example of this implementation, electroluminescence having a relatively short wavelength and narrow bandwidth spectrum “pumps” the phosphor material, which in turn radiates longer wavelength radiation having a somewhat broader spectrum.

[0020] The term “light source” should be understood to refer to any one or more of a variety of radiation sources, including, but not limited to, LED-based sources (including one or more LEDs as defined above), incandescent sources (e.g., filament lamps, halogen lamps), fluorescent sources, phosphorescent sources, high-intensity discharge sources (e.g., sodium vapor, mercury vapor, and metal halide lamps), lasers, other types of electroluminescent sources, pyro-luminescent sources (e.g., flames), candle-luminescent sources (e.g., gas mantles, carbon arc radiation sources), and photo-luminescent sources (e.g., gaseous discharge sources).

[0021] A given light source may be configured to generate electromagnetic radiation within the visible spectrum, outside the visible spectrum, or a combination of both. Hence, the terms “light” and “radiation” are used interchangeably herein. Additionally, a light source may include as an integral component one or more filters (e.g., color filters), lenses, or other optical components. Also, it should be understood that light sources may be configured for a variety of applications, including, but not limited to, indication, display, and/or illumination. An “illumination source” is a light source that is particularly configured to generate radiation having a sufficient intensity to effectively illuminate an interior or exterior space. In this context, “sufficient intensity” refers to sufficient radiant power in the visible spectrum generated in the space or environment (the unit “lumens” often is employed to represent the total light output from a light source in all directions, in terms of radiant power or “luminous flux”) to provide ambient illumination (i.e., light that may be perceived indirectly and that may be, for example, reflected off of one or more of a variety of intervening surfaces before being perceived in whole or in part).

[0022] The terms “lighting fixture” or “luminaire” are used interchangeably herein to refer to an implementation or arrangement of one or more lighting units in a particular form factor, assembly, or package. The term “lighting unit” is used herein to refer to an apparatus including

one or more light sources of same or different types. A given lighting unit may have any one of a variety of mounting arrangements for the light source(s), enclosure/housing arrangements and shapes, and/or electrical and mechanical connection configurations. Additionally, a given lighting unit optionally may be associated with (e.g., include, be coupled to and/or packaged together with) various other components (e.g., control circuitry) relating to the operation of the light source(s). An “LED-based lighting unit” refers to a lighting unit that includes one or more LED-based light sources as discussed above, alone or in combination with other non LED-based light sources.

[0023] The term “controller” is used herein generally to describe various apparatus relating to the operation of one or more light sources. A controller can be implemented in numerous ways (e.g., such as with dedicated hardware) to perform various functions discussed herein. A “processor” is one example of a controller which employs one or more microprocessors that may be programmed using software (e.g., microcode) to perform various functions discussed herein. A controller may be implemented with or without employing a processor, and also may be implemented as a combination of dedicated hardware to perform some functions and a processor (e.g., one or more programmed microprocessors and associated circuitry) to perform other functions. Examples of controller components that may be employed in various embodiments of the present disclosure include, but are not limited to, conventional microprocessors, application specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs).

[0024] In various implementations, a processor or controller may be associated with one or more storage media (generically referred to herein as “memory,” e.g., volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM, floppy disks, compact disks, optical disks, magnetic tape, etc.). In some implementations, the storage media may be encoded with one or more programs that, when executed on one or more processors and/or controllers, perform at least some of the functions discussed herein. Various storage media may be fixed within a processor or controller or may be transportable, such that the one or more programs stored thereon can be loaded into a processor or controller so as to implement various aspects of the present invention discussed herein. The terms “program” or “computer

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program” are used herein in a generic sense to refer to any type of computer code (e.g., software or microcode) that can be employed to program one or more processors or controllers.

[0025] The term “network” as used herein refers to any interconnection of two or more devices (including controllers or processors) that facilitates the transport of information (e.g. for device control, data storage, data exchange, etc.) between any two or more devices and/or among multiple devices coupled to the network. As should be readily appreciated, various implementations of networks suitable for interconnecting multiple devices may include any of a variety of network topologies and employ any of a variety of communication protocols. Additionally, in various networks according to the present disclosure, any one connection between two devices may represent a dedicated connection between the two systems, or alternatively a non-dedicated connection. In addition to carrying information intended for the two devices, such a non-dedicated connection may carry information not necessarily intended for either of the two devices (e.g., an open network connection). Furthermore, it should be readily appreciated that various networks of devices as discussed herein may employ one or more wireless, wire/cable (including mains wires), and/or fiber optic links to facilitate information transport throughout the network.

[0026] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

Brief Description of the Drawings

[0027] In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

[0028] FIG. 1 illustrates a schematic view of an embodiment of an emergency lighting system.

[0029] FIG. 2 illustrates a schematic view of another embodiment of an emergency lighting system.

[0030] FIG. 3 illustrates an embodiment of an LED-based lighting fixture having an emergency lighting system.

[0031] FIG. 4 illustrates an upper perspective view of an embodiment of an emergency lighting device.

[0032] FIG. 5 illustrates a schematic view of another embodiment of an emergency lighting system that has an emergency lighting device and driver integrated as a cohesive package.

[0033] FIG. 6 illustrates a functional block diagram of the emergency lighting device of FIG. 5.

[0034] FIG. 7 illustrates another embodiment of an emergency lighting system that has wireless non-emergency switching of mains power.

Detailed Description

[0035] In some environments, it is desired and/or required (e.g. by law) to provide certain levels of light output for a certain duration during power failures. Emergency lighting systems typically include an emergency lighting driver that is powered by a nickel-cadmium (Ni-Cd) or other type of battery and that is provided in combination with a separate standard lighting driver. In some known approaches, the emergency lighting driver is implemented in parallel with a standard lighting driver. The standard lighting driver provides power to a light source during normal conditions and the emergency lighting driver provides power to the light source during power failures (while the standard lighting driver provides no power during power

failures). In other implementations the emergency lighting driver is implemented with a separate emergency light source and the standard lighting driver provides power to a standard light source during normal conditions while the emergency lighting driver provides power to the emergency light source during power failures (while the standard lighting driver provides no power during power failures). Although existing emergency lighting systems are generally capable of providing desired emergency lighting during power failures, they may have one or more drawbacks. Thus, the Applicants have recognized and appreciated that there is a need to provide emergency lighting methods and apparatus that may optionally be utilized to overcome one or more of the drawbacks of existing emergency lighting systems.

[0036] More generally, Applicants have recognized and appreciated that it would be beneficial to provide emergency lighting in which a lighting driver may be powered by a mains input during normal operating conditions and the same lighting driver may be powered by a direct current output during emergency operating conditions.

[0037] Referring to FIG. 1, a schematic view of an embodiment of an emergency lighting system 100 is illustrated. The emergency lighting system 100 includes an emergency lighting device 120, a driver 140, and a lighting unit or light engine 160. The emergency lighting device 120 has an emergency lighting device output 134 that is electrically coupled to a power train 144 of the driver 140. During normal operating conditions a switch 126 is in a mains position indicated by dashed lines 126A causing switched hot mains 102 to be electrically coupled to and provided over emergency lighting device output 134. Accordingly, during normal operating conditions when mains power is provided over switched hot mains 102, the mains power will be provided over emergency lighting device output 134 to driver 140. During emergency operating conditions the switch 126 is in a battery position indicated by dashed lines 126B causing a battery output generated by battery 122 and a converter of charger and converter circuit 124 to be electrically coupled to and provided over emergency lighting device output 134. Emergency lighting conditions include, for example, a power failure condition, a brownout condition, and/or a demand response condition (*e.g.*, as communicated from a utility or local controller).

[0038] An unswitched hot mains 104 is also supplied to the emergency lighting device 120. The unswitched hot mains 104 is electrically coupled to the charger and converter circuit 124. The charger and converter circuit 124 at least selectively converts the incoming unswitched hot mains 104 to an appropriate voltage and generates an appropriate current to charge the battery 122. For example, in some embodiments the charger and converter circuit 124 may supply a trickle charge to battery 122 whenever unswitched hot mains 104 is active. One of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that charger and converter circuit 124 may include various circuit components and/or discrete components that may be selected and designed to, for example, achieve desired performance characteristics, desired costs, and/or other criteria. In some embodiments, the battery 122 may be a Lithium-Ion (Li-ion) battery. In some versions of those embodiments, the battery 122 may include a 3.6V Li-ion battery. In some embodiments a single battery may be provided. In some other embodiments, series and/or parallel configurations of multiple batteries may be provided. In some embodiments, it may be desirable to provide electrical isolation between the battery 122 and the charger and converter circuit 144 in case the battery 122 can be touched and/or is not contained in the same housing as the other LED circuit parts. Although only a single line illustrates each of the mains inputs 102, 104 and a single line illustrates the emergency lighting device output 134 in FIG. 1, it is understood that such connections and other connections illustrated herein with a single line may implement multiple wires. For example, the mains inputs 102, 104 may each have at least a hot wire and a neutral wire.

[0039] During an emergency condition (*e.g.*, when unswitched mains 104 is experiencing a power failure or a brownout condition), the charger and converter circuit 124 will supply a DC output to emergency lighting device output 134. The charger and converter circuit 124 will convert the DC output of the battery 122 to a higher voltage DC output appropriate for the driver 140. In some embodiments the AC voltage supplied over the emergency lighting device output 134 via switched mains 102 is approximately 230 Volts AC. In some versions of those embodiments the DC voltage supplied over the emergency lighting device output 134 via battery 122 and charger and converter circuit 124 is approximately 200 Volts DC. One of

ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that other AC and/or DC voltages may be utilized. For example, differing AC and/or DC voltages may be utilized to conform to a voltage provided over a mains supply and/or to conform to a LED driver configuration.

[0040] An Emergency Lighting Device (ELD) controller 130 is electrically coupled to the charger and converter circuit 124. The ELD controller 130 may be powered by the battery 122 and optionally by converted power from the unswitched hot mains 104 when active and/or switched mains 102 when active. The ELD controller 130 may optionally adjust one or more parameters of the charger and converter circuit 124. For example, the controller 130 may optionally adjust one or more parameters based on the status of the battery 122 (*e.g.*, to substantially maintain a desired DC output over Emergency Lighting Device (ELD) output 134 as battery 122 drains). Also, for example, the ELD controller 130 may optionally adjust one or more parameters based on the configuration of the driver 140 (*e.g.*, as communicated by the driver 140 or as programmed via a user interface) to provide appropriate DC output to the driver 140 over emergency lighting device output 134. The ELD controller 130 may additionally or alternatively optionally generate one or more signals to actuate the position of the switch 126 between at least the switch in mains position 126A and the switch in battery position 126B. For example, when ELD controller 130 detects desired power conditions provided over unswitched mains 104, it may provide a signal (or, alternatively, no signal) to switch 126 to cause the switch 126 to be in the switch in mains position 126A and when ELD controller 130 detects undesirable power conditions or no power over unswitched hot mains 104, it may remove a signal (or, alternatively, provide a signal) to cause the switch 126 to be in the switch in battery position 126B. In some embodiments the charger and converter circuit 124 and/or other circuit may be utilized to actuate the switch 126. For example, the charger and converter circuit 124 may provide a signal (optionally converted) from unswitched hot mains 104 when it is active to cause the switch 126 to be in the switch in mains position 126A and when unswitched hot mains 104 is no longer active the signal will be removed to cause the switch 126 to be in the switch in battery position 126B. One of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that other switches, circuits,

and/or other devices may be utilized to switch between at least a mains hot input and a direct current output generated via a battery.

[0041] The power train 144 of the driver 140 is electrically coupled to the emergency lighting device output 134 and outputs refined power to light engine 160 over LED driver output 154. The power train 144 of the driver 140 is able to accept a DC output provided over lighting device output 134. In some embodiments the lighting device output 134 is transmitted over a single pair of wires to a single hot input of the driver 140. In some alternative embodiments the lighting device output 134 may include one output for AC mains output and a separate output for DC battery output and/or the driver 140 may include separate AC and DC hot inputs. A driver controller 148 is in electrical communication with the power train 144. In some embodiments the driver controller 148 monitors the input voltage provided to power train 144 (*e.g.*, directly or via one or more internal circuit values from power train 144) and adjusts one or more characteristics of power that is output to the light engine 160. For example, in some embodiments the driver controller 148 may detect when DC voltage is provided to power train 144 and send a signal to power train 144 to reduce the power provided over LED driver output 154 to thereby effectuate dimming of the light engine 160. In some versions of those embodiments the light engine 160 may be dimmed to reduce the light output to less than approximately 25% (*e.g.*, approximately 5%) of light output during normal operating conditions. Optionally, the degree of dimming may be determined based on achieving reduced energy consumption while ensuring appropriate lighting output is generated to produce at least minimum required emergency light level output. The driver controller 148 may additionally or alternatively optimize performance of power train 144 based on factors such as, for example, lighting load, instantaneous voltage, and/or instantaneous current.

[0042] In some embodiments, it may be desirable to alter one or more aspects of the DC output provided to the driver 140. For example, components in the driver 140 that may not carry a DC rating may be exposed to DC voltage. Providing unaltered DC output to the driver 140 may be a concern in some implementations since an AC fuse of the driver 140 may not interrupt the continuous arc of a DC output when the fusible link of the AC fuse melts and/or the AC fuse may not open as quickly in response to a DC output (as compared to an AC output).

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In some embodiments circuitry may be provided to intermittently briefly interrupt the DC output prior to it being provided to the driver 140. For example, in some embodiments such circuitry may be implemented with the charger and converter circuit 124. The duration of the interruption of the DC output would be at least the minimum time period necessary to interrupt the DC arc. In some embodiments the output impedance provided by the DC output over the emergency lighting device output 134 may be adjusted and/or designed so that the inrush fault current through an AC fuse of the driver 140 is easily cleared by the AC fuse. The instantaneous fault current an AC fuse sees when connected to switched mains 102 may be over 10,000 amps, which must be interrupted by the AC fuse. However, with the AC fuse supplied by the DC output over the emergency lighting device output 134 the fault current is limited by the output impedance such that the AC fuse sees hundreds of amps rather than thousands of amps and can successfully open the fault current.

[0043] FIG. 2 illustrates a schematic view of another embodiment of an emergency lighting system 200. The emergency lighting system 200 includes an emergency lighting device having an emergency lighting device main housing 221 and an external battery 222. The emergency lighting device main housing 221 may enclose a controller, a charger circuit, and/or a converter circuit. A mains hot input and a mains neutral input may be electrically coupled to the emergency lighting device 220. An emergency lighting device output 234A and an emergency lighting device neutral output 234B are electrically coupled between the emergency lighting device main housing 221 and an LED driver 240. The LED driver 240 is electrically coupled to an LED light source load 260. During normal operating conditions when mains power is provided to the emergency lighting device 220, the mains power will be provided over emergency lighting device outputs 234A, 234B to the driver 240. During emergency operating conditions a DC output generated by the battery 222 and a converter of the emergency lighting device 220 will be provided over emergency lighting device outputs 234A, 234B to driver 240.

[0044] A communications link 236 is also provided between the emergency lighting device 220 and the LED driver 240. The communications link 236 may include one or more wired and/or wireless communication mediums and utilize one or more communications protocols. For example, the communication mediums may include any physical medium, including, for

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example, twisted pair coaxial cables, fiber optics, or a wireless link using, for example, infrared, microwave, or encoded visible light transmissions and any suitable transmitters, receivers or transceivers to effectuate communication in the network. Also, for example, the communications protocols may include any suitable protocol for data transmission, including, for example, TCP/IP, variations of Ethernet, Universal Serial Bus, Bluetooth, FireWire, Zigbee, DMX, Dali, 802.11b, 802.11a, 802.11g, token ring, a token bus, serial bus, power line networking over mains or low voltage power lines, and/or any other suitable wireless or wired protocol.

[0045] The communications link 236 may enable communication of various parameters between controllers of the emergency lighting device 220 and the LED driver 240. For example, real-time information on performance characteristics (*e.g.*, voltage of the battery 222, voltage of the output of driver 240, current of the battery 222, current of the output of driver 240, and/or information related to LED light source load 260) may be transmitted via communications link 236. One or more aspects of the emergency lighting device 220 may be adjusted by a controller thereof based on parameters received via LED driver 240 and/or one or more aspects of the LED driver 240 may be adjusted by a controller thereof based on parameters received via emergency lighting device 220. Such optional communications between the LED driver 240 and the emergency lighting device 220 enables real-time information on performance characteristics of both of the units to facilitate fully customized power control and increased efficiency. Increased efficiency may enable lower battery costs, longer runtimes, and/or increased reliability due to reduced heat dissipation.

[0046] FIG. 3 illustrates an embodiment of an LED-based lighting fixture 300 having an emergency lighting system. The LED-based lighting fixture 300 includes a housing 370 that surrounds a LED light engine having a plurality of LEDs 364 mounted on a LED circuit board 362. A cover lens 366 is provided across a light output opening of the housing 370. The emergency lighting system includes an emergency lighting device 320 having an internal battery, a controller, a charger circuit, and/or a converter circuit. A mains input 302 is electrically coupled to the emergency lighting device 320. An emergency lighting device output 334 is electrically coupled between the emergency lighting device 320 and the LED driver 340. The LED driver

340 is electrically coupled to the LEDs 364. In some embodiments the emergency lighting device 320 may be a stand-alone module and may be implemented with the lighting fixture 300 after manufacture and/or installation of the lighting fixture 300. For example, in some embodiments the emergency lighting device 320 may be installed in combination with an already manufactured lighting fixture and/or in combination with an already installed lighting fixture. During normal operating conditions when mains power is provided to the emergency lighting device 320, the mains power will be provided over emergency lighting device output 334 to LED driver 340. During emergency operating conditions a DC output generated by a battery of the emergency lighting device 320 and a converter of the emergency lighting device 320 will be provided over emergency lighting device output 334 to LED driver 340.

[0047] FIG. 4 illustrates an upper perspective view of an embodiment of an emergency lighting device 420. The illustrated embodiment is a linear, slim, and light weight form factor having a linearly extending housing 421 and an internal battery. A plurality of inputs are provided and include switched mains inputs 432A, 432B, unswitched mains inputs 433A, 433B, and communications input 431. An emergency lighting device output 434 is also generally indicated and may include a hot emergency lighting device output and optionally a neutral emergency lighting device output. The illustrated emergency lighting device 420 is only one example of an emergency lighting device implementation and one of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that other emergency lighting device implementations may be provided. For example, in some embodiments emergency lighting devices may have a different form factor, an external battery, and/or a differing number of inputs and/or outputs. Also, for example, in some embodiments the emergency lighting device may be integrated as a package with other components of an emergency lighting system (*e.g.*, a driver).

[0048] FIG. 5 illustrates a schematic view of another embodiment of an emergency lighting system 500 that has an emergency lighting device 520 and LED driver 540 integrated as a cohesive package. The emergency lighting device 520 has an emergency lighting device output 534 that is electrically coupled directly to a DC bus of the LED driver 540. The emergency lighting device output 534 is electrically coupled to the DC bus between an AC to DC converter

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542 and a DC to DC converter 544 of a power train of the LED driver 540. The AC to DC converter 542 is electrically coupled to the switched hot mains 502. The charger and converter circuit 524 is electrically coupled to the unswitched hot mains 504 and to the battery 522 and the controller 530. During normal operating conditions the charger and converter circuit 524 does not supply power to the driver 540 over emergency lighting device output 534.

Accordingly, during normal operating conditions when mains power is provided over switched hot mains 502, the mains power will be provided directly to the driver 540. During emergency operating conditions the DC battery output generated by battery 522 and the converter of charger and converter circuit 524 is provided over emergency lighting device output 534 to downstream of the AC to DC converter 542 and upstream of the DC to DC converter 544 of the driver 540. Electrically coupling the emergency lighting device output 534 to the DC bus of the LED driver 540 instead of upstream of the AC to DC converter 542 may avoid power factor correction loss from AC to DC converter 542. The power train of the LED driver 540 outputs refined power to the LED lighting unit or light engine 560 over LED driver output 554 when it is supplied with input power (originating from the switched hot mains 502 in normal conditions and originating from the battery 522 in emergency conditions). Although the emergency lighting device 520 and LED driver 540 are illustrated as integrated as a cohesive package in FIG. 5, in alternative embodiments they may be provided as separate components and optionally have a similar configuration as that illustrated in FIG. 5. The lighting device output 534 may be non-isolated and have a 200V DC output in some embodiments.

[0049] The charger and converter circuit 524 at least selectively converts the incoming unswitched hot mains 504 to an appropriate voltage and generates an appropriate current to charge the battery 522. In some embodiments the battery 522 may be a Li-ion battery.

[0050] The controller 530 may be powered by the battery 522 and optionally by converted power from the unswitched hot mains 504 when active. The controller 530 may optionally adjust one or more parameters of the charger and converter circuit 522. For example, the controller 530 may optionally adjust one or more parameters based on the status of the battery 522 and/or based on the configuration of the driver 540 (*e.g.*, as communicated by the driver 540) to provide appropriate DC output to the driver 540 over emergency lighting device output

534. For example, when the controller 530 detects desired power conditions provided over unswitched mains 504, it may prevent any DC output from being provided over the emergency lighting device output 534. Also, for example, when the controller 530 detects an emergency condition (*e.g.*, via status of the unswitched hot mains 504 or as communicated via the driver 540), it may cause DC output to be provided over the emergency lighting device output 534. In other embodiments the charger and converter circuit 524 may directly provide or omit DC output over emergency lighting device output 534 based on the status of the unswitched hot mains 504. One of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that other switches, circuits, and/or other devices may be utilized to selectively apply a direct current output generated via the battery 522.

[0051] A driver controller 550A is in electrical communication with the power train of the driver 540 and is also in communication with the controller 530 of the emergency lighting device via secondary controller 550B and intra module communications link 536. In some embodiments the driver controller 550A monitors the input voltage provided to power train and adjusts one or more characteristic of power that is output to the light engine 560. For example, in some embodiments the driver controller 550A may detect when DC voltage is provided and send a signal to DC to DC converter 544 to reduce the power provided over LED driver output 554 to thereby effectuate dimming of the light engine 560. The communications link 536 may enable communication of various parameters between controllers 530, 550A, 550B of the emergency lighting device 520 and the LED driver 540. For example, real-time information on performance characteristics may be transmitted via communications link 536. One or more aspects of the emergency lighting device 520 may be adjusted by the controller 530 thereof based on parameters received via controller 550B and/or one or more aspects of the LED driver 540 may be adjusted by the controller 550A thereof based on parameters received via controller 530. A DALI input 501 is also illustrated in FIG. 5 along with a Dali communications module 541. The DALI communications module 541 is in direct communication with the controller 550A and is also in communication with controller 550B through link 536. Communications from a lighting network may be received via Dali input 501 and utilized by the controller 550A to adjust one or more parameters of the LED driver 540. For

example, communications may be utilized to adjust the dimming levels of the LED light engine 560 that occur during power failures and/or during demand response events. Also, for example, communications may be utilized for simple on-off functionality and/or scene setting control with building management systems integration.

[0052] One or more parameters of the emergency lighting device 520 may also be adjusted utilizing the DALI input 501 and communications between controller 550B and controller 530. For example, testing of the emergency lighting device 520 may be performed via signals sent to the DALI input 501 and transmitted to the controller 530. Also, for example, demand response events from a lighting network may be sent via the DALI input 501 and transmitted to the controller 530 to have the emergency lighting device 520 operate in an emergency mode for a demand response event. Also, for example, configuration of the emergency lighting device 520 may be performed via communications sent via the DALI input 501 and transmitted to the controller 530. Relay of network communications from the LED driver 540 to the emergency lighting device 520 avoids the use of separate network connectivity modules separately for the emergency lighting device 520. Although a DALI input and DALI module are discussed, one of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and appreciate that other network communication protocols and/or communication mediums may be utilized.

[0053] FIG. 6 illustrates a functional block diagram of the emergency lighting device 520. A battery charger 524A of the charger and converter circuit 524 is electrically coupled to the unswitched mains 504 and to the battery 522 and the controller 530. An EMI/surge filter 521 is provided upstream of the battery charger 524A for protection of downstream components. The battery charger 524A at least selectively converts the incoming unswitched hot mains 504 to an appropriate voltage and generates an appropriate current to charge the battery 522. Connections between the battery charger 524A and the controller 530 may allow the controller 530 to enable and/or disable the battery charger 524A and/or alter one or more characteristics of the battery charger 524A (*e.g.*, alter the PWM frequency of the provided charge). Connections between the battery charger 524A and the controller 530 may additionally or alternatively allow the battery charger 524A to provide information to the controller 530 (*e.g.*,

sensed battery voltage value, sensed charging current value). An optional line sense circuit 522 is also illustrated that can detect brown-out and/or black-out conditions quickly and notify controller 530 so that controller 530 can cause appropriate switching to direct current output being supplied to LED driver 540. The line sense circuit 522 may additionally and/or alternatively be utilized to monitor the quality of unswitched mains 504. A logic supply circuit 525 is illustrated electrically coupled to the battery charger 524A. The logic supply circuit 525 generates one or more DC supply voltages for utilization by other components of the emergency lighting device (*e.g.*, the controller 530).

[0054] In some embodiments, the battery 522 may be a Li-ion battery, *e.g.* a Li-ion battery pack having an approximately 12 Volt capacity. A cell balancer 523 can be electrically coupled to the battery 522 and interface with the battery 522 for smart balancing of the cells of the battery 522 for optimized capacity management and protection. The cell balancer 523 may optionally be in communication with the controller 530 receiving commands for balancing the cells of the battery 522.

[0055] The controller 530 is in communication with a DC to DC converter 524B of the charger and converter circuit 524. Connections between the DC to DC converter 524B and the controller 530 may allow the controller 530 to enable and/or disable the DC to DC converter 524B and/or alter one or more characteristics of the DC to DC converter 524B (*e.g.*, alter the PWM frequency of the provided DC output). Connections between the DC to DC converter 524B and the controller 530 may additionally or alternatively allow the DC to DC converter 524B to provide information to the controller 530 (*e.g.*, sensed DC output voltage value, sensed DC output current value).

[0056] A status LED 529 is also illustrated in communication with the controller 530. The controller 530 may illuminate the status LED 529 to indicate a good working condition and/or one or more problems (*e.g.*, a solid light to indicate good working condition and one or more blinking sequences to indicate various problems such as malfunctioning battery 522). An isolated test button switch 507 is also in communication with the controller 530. The isolated test button switch 507 may be manually actuated by a user to cause a manual test of the

functioning of the emergency lighting device 520 (*e.g.*, providing DC output generated via battery 522 to power the LED driver 540 in lieu of mains output).

[0057] FIG. 7 illustrates another embodiment of an emergency lighting system 600 having an emergency lighting device 620, a LED driver 640, and a LED lighting unit or light engine 660. The emergency lighting system 600 utilizes wireless non-emergency switching of mains power and does not require a separate switched hot mains input to the emergency lighting device 620. The emergency lighting device 620 has an emergency lighting device output 634 that is electrically coupled to a power train 644 of the driver 640. During normal operating conditions, a switch 626 is in a mains position indicated by dashed lines 626A causing unswitched hot mains 604 to be electrically coupled to and provided over emergency lighting device output 634. LED light engine 660 may be switched off utilizing input received at DALI communications module 641 and/or utilizing input from wireless module 608. The wireless module 608 may communicate directly with LED driver 640 and/or emergency lighting device 620. In some embodiments the wireless module 608 may utilize the Zigbee protocol. In some embodiments a controller 650A of LED driver 640 may prevent power train 644 from providing power output over LED driver output 654 based on a switch off signal received via wireless module 608 and/or input received at DALI communications module 641. Also, for example, in some embodiments a switch off signal may be sent by wireless module 608 to controller 650A and/or 650B. Secondary controller 650B may communicate with the controller 630 via communications link 636 to cause the controller 630 to prevent power from being provided over emergency lighting device output 634 (*e.g.*, by actuating switch 626 to a common position). Also, for example, in some embodiments a switch off signal may be sent by wireless module 608 directly to the controller 630 via communications link 636 to cause the controller 630 to prevent power from being provided over emergency lighting device output 634.

[0058] During normal operating conditions when mains power is provided over unswitched hot mains 604, the mains power will be provided over emergency lighting device output 634 to driver 640. During emergency operating conditions the switch 626 is in a battery position indicated by dashed lines 626B causing a battery output generated by battery 622 and a

converter of charger and converter circuit 624 to be electrically coupled to and provided over emergency lighting device output 634.

[0059] The unswitched hot mains 604 is electrically coupled to the charger and converter circuit 624. The charger and converter circuit 624 at least selectively converts the incoming unswitched hot mains 604 to an appropriate voltage and generates an appropriate current to charge the battery 622. In some embodiments the battery 622 may be a Lithium-Ion (Li-ion) battery. During an emergency condition (*e.g.*, when unswitched mains 604 is experiencing a power failure or a brownout condition), the charger and converter circuit 624 will supply a DC output to emergency lighting device output 634. The charger and converter circuit 624 will convert the DC output of the battery 622 to a higher voltage DC output appropriate for the LED driver 640.

[0060] The controller 630 may optionally adjust one or more parameters of the charger and converter circuit 624. For example, the controller 630 may optionally adjust one or more parameters based on the status of the battery 622 and/or based on the configuration of the LED driver 640 (*e.g.*, as communicated by the LED driver 640). The controller 630 may additionally or alternatively optionally generate one or more signals to actuate the position of the switch 626. In some embodiments the charger and converter circuit 624 and/or other circuit may be utilized to actuate the switch 626. One of ordinary skill in the art, having had the benefit of the present disclosure, will recognize and readily appreciate that other switches, circuits, and/or other devices may be utilized to switch between at least a mains hot input and a direct current output generated via a battery.

[0061] The power train 644 receives an input from the emergency lighting device output 634 and outputs refined power to light engine 660 over the LED driver output 654. The power train 644 of the driver 640 is able to accept a DC output provided over lighting device output 634. The driver controller 650A is in electrical communication with the power train 644. In some embodiments the driver controller 650A monitors the input voltage provided to power train 644 and adjusts one or more characteristic of power that is output to the light engine 660. The controllers 650A and/or 650B may additionally or alternatively adjust characteristics of the power train 644 based on factors such as, for example, lighting load, instantaneous voltage,

instantaneous current, input received from DALI communications module 641, input received from wireless module 608, and/or input received from controller 630. The controller 630 may also optionally adjust characteristics of the emergency lighting device 620 based on factors such as, for example, lighting load, instantaneous voltage, instantaneous current, input received from DALI communications module 641, input received from wireless module 608, and/or input received from controllers 650A, 650B through link 636.

[0062] While several inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed.

[0063] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[0064] The indefinite articles “a” and “an,” as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean “at least one.”

[0065] The phrase “and/or,” as used herein in the specification and in the claims, should be understood to mean “either or both” of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements

listed with “and/or” should be construed in the same fashion, i.e., “one or more” of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the “and/or” clause, whether related or unrelated to those elements specifically identified. As used herein in the specification and in the claims, “or” should be understood to have the same meaning as “and/or” as defined above. In general, the term “or” as used herein shall only be interpreted as indicating exclusive alternatives (i.e. “one or the other but not both”) when preceded by terms of exclusivity, such as “either,” “one of,” “only one of,” or “exactly one of.” “Consisting essentially of,” when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[0066] As used herein in the specification and in the claims, the phrase “at least one,” in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase “at least one” refers, whether related or unrelated to those elements specifically identified. It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

[0067] Also, reference numerals appearing between parentheses in the claims, if any, are provided merely for convenience and should not be construed as limiting in any way.

[0068] In the claims, as well as in the specification above, all transitional phrases such as “comprising,” “including,” “carrying,” “having,” “containing,” “involving,” “holding,” “composed of,” and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases “consisting of” and “consisting essentially of” shall be closed or semi-closed transitional phrases, respectively.

CLAIMS:

1. An emergency lighting system, comprising:
 - at least one light source (160, 260, 560, 660, 364);
 - a driver (140, 240, 340, 540, 640) electrically coupled to and powering said at least one light source (160, 260, 560, 660, 364);
 - an emergency lighting device (120, 220, 320, 420, 520, 620) having a battery (122, 222, 522, 622), a mains input, and an emergency lighting device output; said mains input at least selectively charging said battery (122, 222, 522, 622) through a charging circuit; said emergency lighting device output electrically coupled to and at least selectively powering said driver (140, 240, 340, 540, 640);
 - wherein said driver (140, 240, 340, 540, 640) is powered by an alternating current mains input during a normal operating condition; and
 - wherein said emergency lighting device (120, 220, 320, 420, 520, 620) provides a direct current output from said battery (122, 222, 522, 622) to said driver (140, 240, 340, 540, 640) over said emergency lighting device output during an emergency operating condition.
2. The emergency lighting system of claim 1, wherein said emergency lighting device (120, 220, 320, 420, 520, 620) provides said mains input to said driver (140, 240, 340, 540, 640) over said emergency lighting device output during said normal operating condition.
3. The emergency lighting system of claim 2, wherein said emergency lighting device (120, 220, 320, 420, 520, 620) includes at least one switch interposed between said mains input and said emergency lighting device output and interposed between said battery (122, 222, 522, 622) and said emergency lighting device output.
4. The emergency lighting system of claim 1, wherein said driver (140, 240, 340, 540, 640) detects said direct current output from said battery (122, 222, 522, 622) over said emergency lighting device output and decreases power provided to said at least one

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light source (160, 260, 560, 660, 364) in response to detecting said direct current output over said emergency lighting device output.

5. The emergency lighting system of claim 4, wherein power provided to said light source (160, 260, 560, 660, 364) is decreased at least 75% in response to detecting said direct current output over said emergency lighting device output.
6. The emergency lighting system of claim 1, wherein said emergency operating condition includes power loss.
7. The emergency lighting system of claim 1, wherein said emergency operating condition includes at least one of a demand response condition and a brownout condition.
8. The emergency lighting system of claim 1, wherein said battery (122, 2222, 522, 622) is a lithium-ion battery.
9. The emergency lighting system of claim 1, further comprising a communications link between said driver (140, 240, 340, 540, 640) and said emergency lighting device (120, 220, 320, 420, 520, 620).
10. The emergency lighting system of claim 8, wherein said emergency lighting device (120, 220, 320, 420, 520, 620) receives at least one value from said driver (140, 240, 340, 540, 640) via said communications link and adjusts at least one parameter of said emergency lighting device (120, 220, 320, 420, 520, 620) based on said at least one value.
11. The emergency lighting system of claim 1, wherein said direct current output is intermittently interrupted for at least a direct current arc interruption time period.
12. The emergency lighting system of claim 1, wherein said direct current output is electrically coupled directly into a direct current input of a DC to DC converter of said driver (140, 240, 340, 540, 640).

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13. The emergency lighting system of claim 1, wherein said direct current output is electrically coupled directly into a mains input of said driver (140, 240, 340, 540, 640).
14. An emergency lighting device, comprising:
- a mains input;
 - a battery (122, 2222, 522, 622) at least selectively electrically coupled to said mains input through a charging circuit;
 - a direct current to direct current converter at least selectively electrically coupled to said battery (122, 2222, 522, 622) and producing a direct current output via power from said battery (122, 2222, 522, 622);
 - an emergency lighting device output;
 - wherein said emergency lighting device output is electrically coupled to said mains input during a normal operating condition; and
 - wherein said emergency lighting device is electrically coupled to said direct current output during an emergency operating condition.
15. The emergency lighting device of claim 14, wherein said direct current output is intermittently interrupted for at least a direct current arc interruption time period.
16. The emergency lighting device of claim 14, wherein said emergency lighting device output is electrically couplable to a lighting driver having a lighting AC fuse and wherein said direct current output has an output impedance that causes said AC fuse to see less than one thousand amps when said emergency lighting device is electrically coupled to said direct current output.
17. The emergency lighting device of claim 14, further comprising at least one switch interposed between said mains input and said emergency lighting device output and interposed between said direct current to direct current converter and said emergency lighting device output.

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18. The emergency lighting system of claim 14, further comprising a driver communications input, said driver communications input receiving at least one of a driver voltage value and a driver current value during said emergency operating conditions, wherein said direct current output is adjusted based on at least one of said driver voltage value and said driver current value.
19. A method of providing emergency lighting, comprising:
- providing, during a normal operating condition, an alternating current mains power supply to a driver powering at least one light source;
 - providing, during an emergency operating condition, a direct current output powered by a battery to said driver;
 - decreasing power provided by said driver to said at least one light source in response to detecting said emergency operating condition.
20. The method of claim 19, wherein said alternating current mains power supply and said direct current output are provided to said driver over a common output.
21. The method of claim 19, further comprising intermittently interrupting said direct current output for at least a direct current arc interruption time period during said step of providing, during said emergency operating condition, said direct current output power by said battery to said driver.

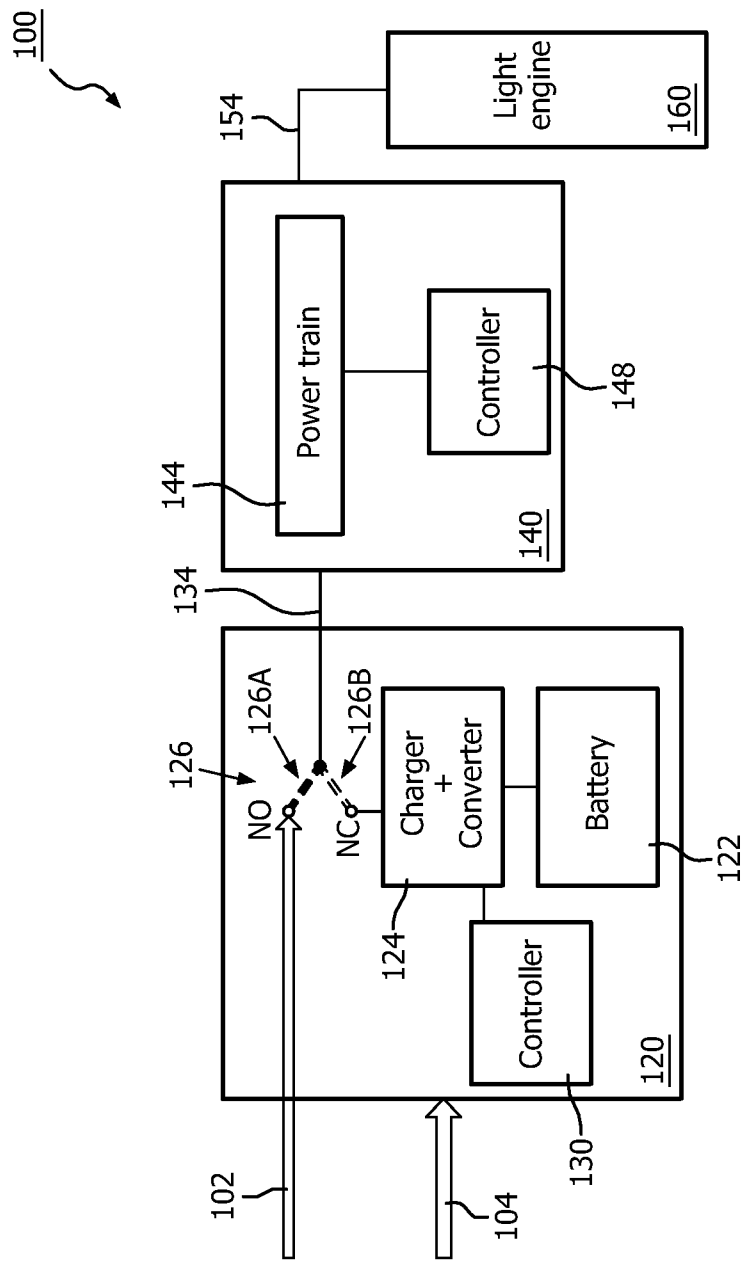


FIG. 1

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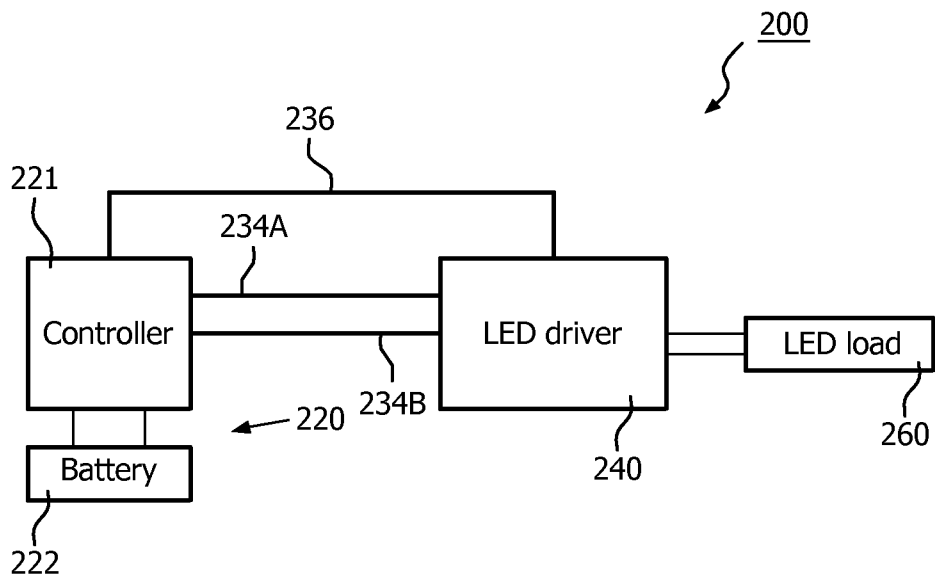


FIG. 2

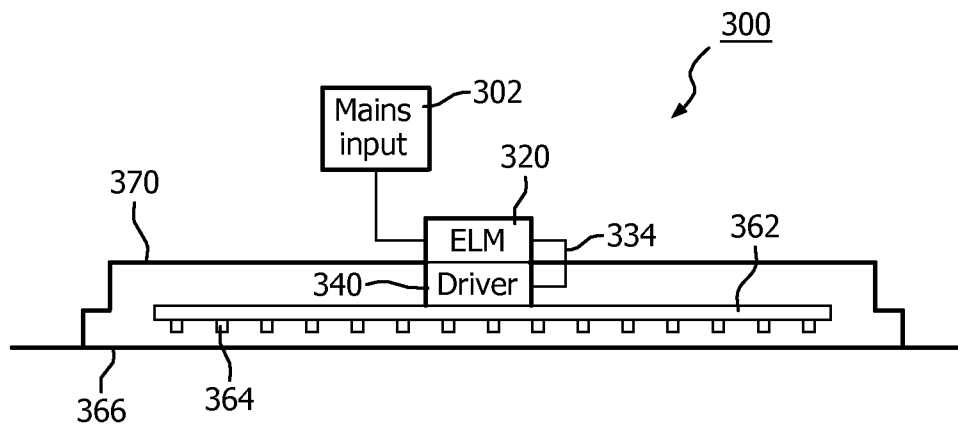


FIG. 3

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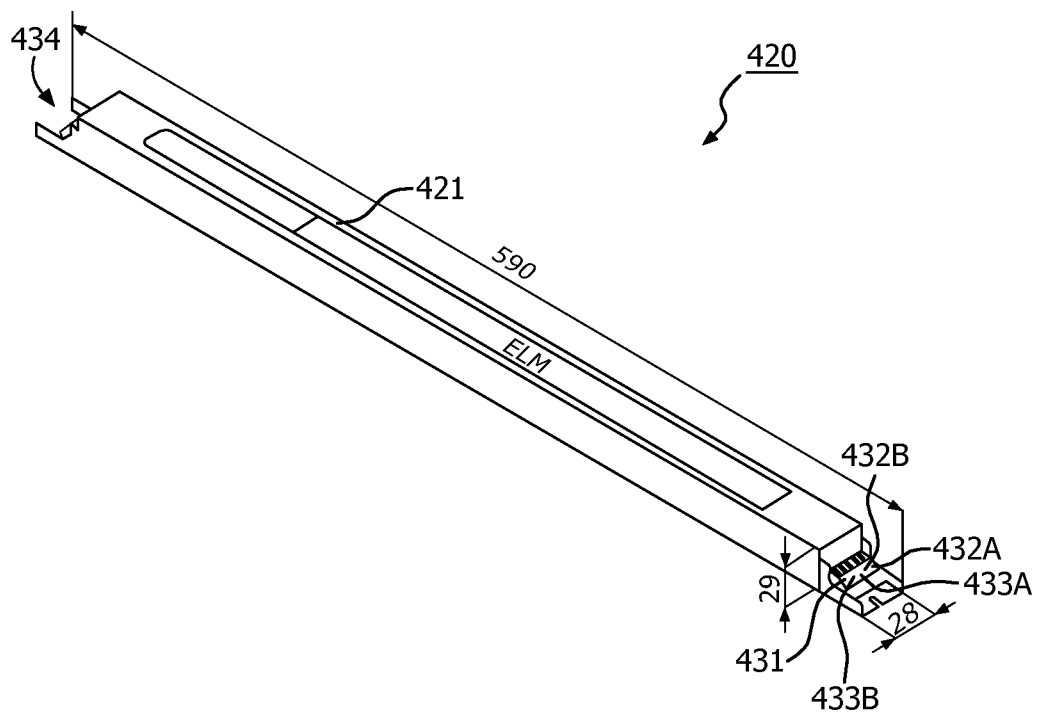


FIG. 4

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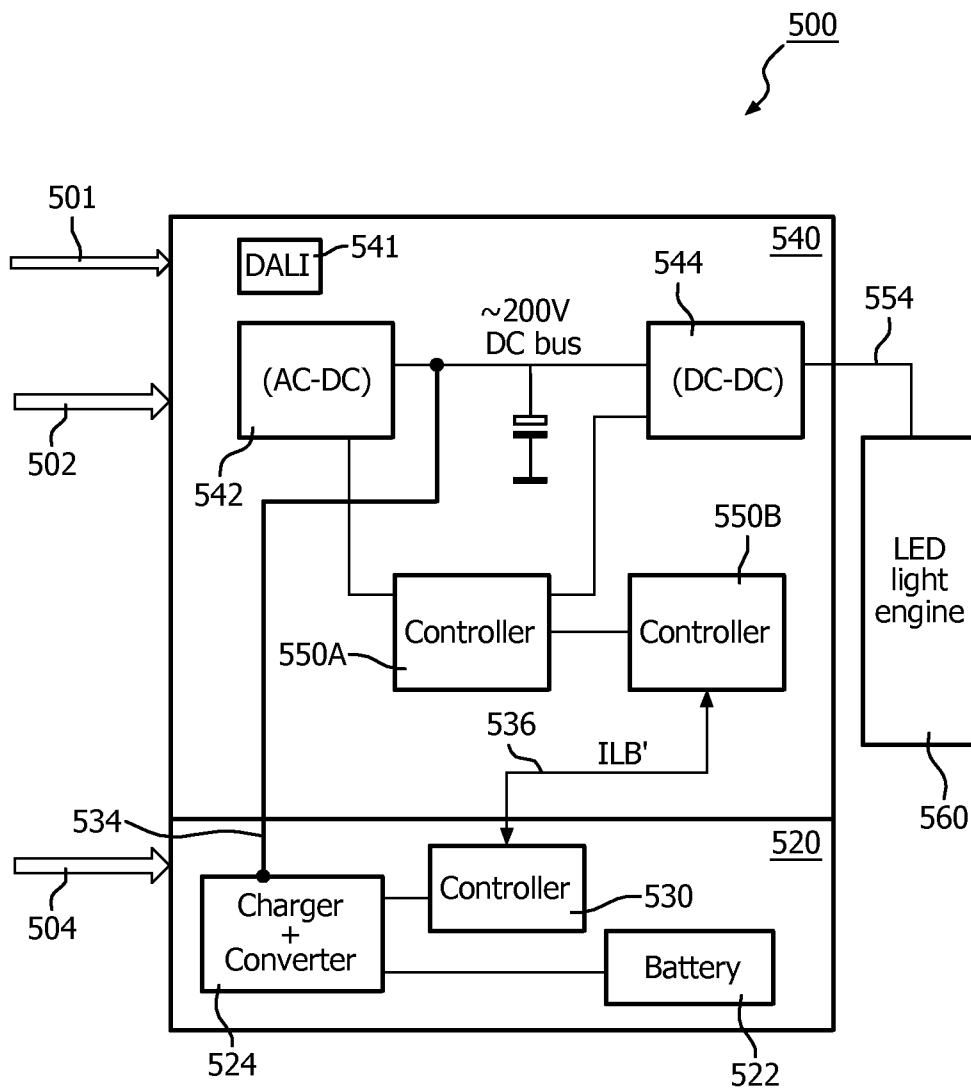


FIG. 5

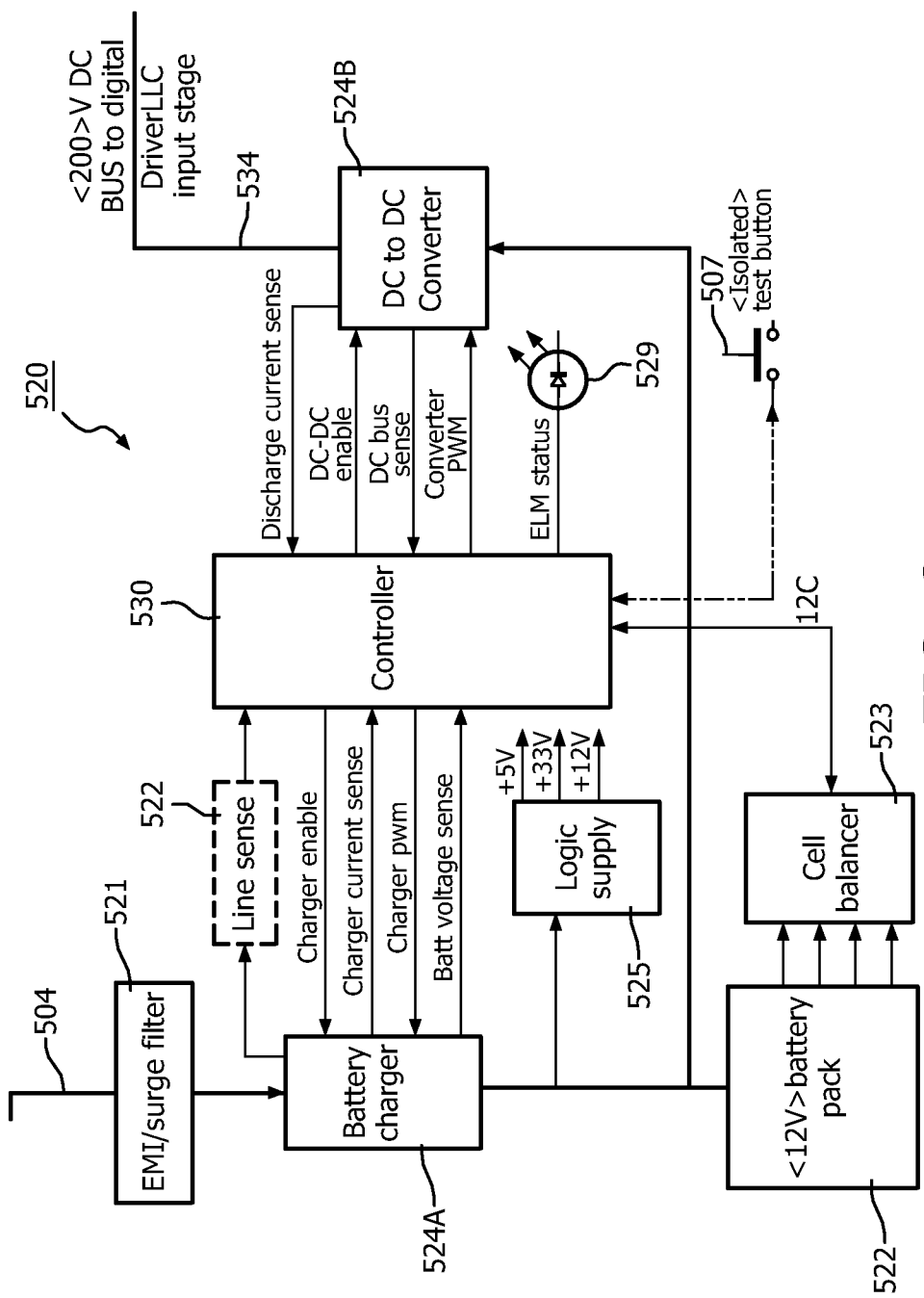


FIG. 6

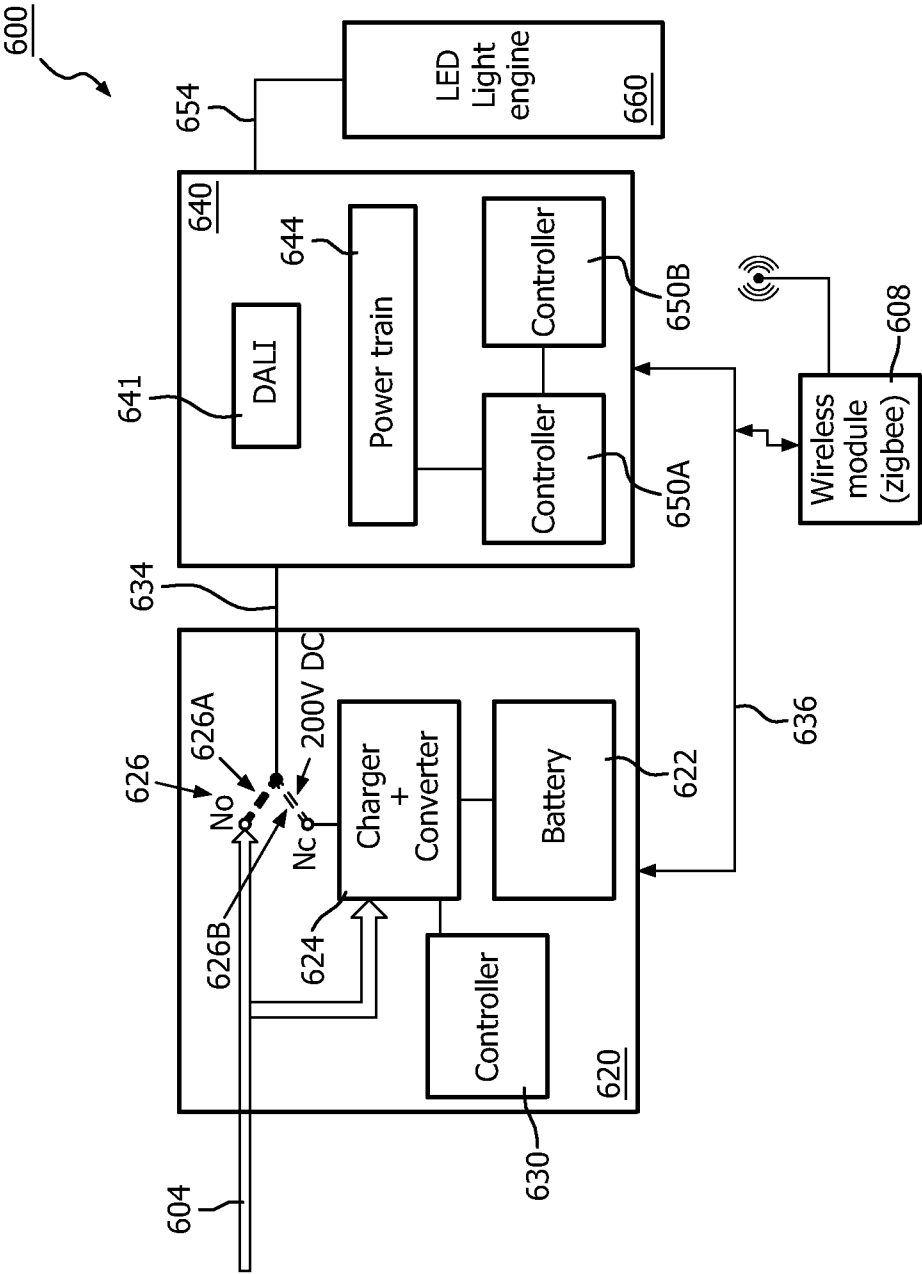


FIG. 7