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Automatic configuration of a load control system

Abstract

A control module is able to be installed with electrical devices, such as, for example electrical loads (e.g., lighting loads) and/or load regulation devices. The control module may determine whether an LED driver for an LED light source is responsive to one or more of a plurality of control techniques. The control module may be able to automatically determine an appropriate control technique to use to control the connected LED driver and/or LED light source. The control module may sequentially attempt to control the LED driver and/or LED light source using each of the plurality of control techniques and determine if the LED driver and/or LED light source is responsive to the present control technique. The plurality of control techniques may include one or more analog control techniques and one or more digital control techniques.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. Non-Provisional patent application Ser. No. 17/589,632, filed Jan. 31, 2022; which is a continuation of U.S. Non-Provisional patent application Ser. No. 16/238,951, filed on Jan. 3, 2019, now U.S. Pat. No. 11,240,896, issued Feb. 1, 2022; which is a continuation of U.S. Non-Provisional patent application Ser. No. 16/016,799, filed on Jun. 25, 2018, now U.S. Pat. No. 10,219,337, issued Feb. 26, 2019; which is a continuation of U.S. Non-Provisional patent application Ser. No. 15/422,723, filed on Feb. 2, 2017, now U.S. Pat. No. 10,009,969, issued Jun. 26, 2018; which is a continuation of U.S. Non-Provisional patent application Ser. No. 14/808,909, filed Jul. 24, 2015, now U.S. Pat. No. 9,595,880, issued Mar. 14, 2017; all of which claim the benefit of U.S. Provisional Application No. 62/029,177, filed Jul. 25, 2014, which is incorporated by reference herein as if fully set forth.

BACKGROUND

(1) A user environment, such as a residence or an office building for example, may be configured using various types of load control systems. A lighting control system may be used to control the lighting loads in the user environment. A motorized window treatment control system may be used to control the natural light provided to the user environment. An HVAC system may be used to control the temperature in the user environment. Each load control system may include various control devices, including control-source devices and control-target devices. The control-target devices may receive digital messages, which may include load control instructions, for controlling an electrical load from one or more of the control-source devices. The control-target devices may be capable of directly controlling an electrical load. The control-source devices may be capable of indirectly controlling the electrical load via the control-target device. Examples of control-target devices may include lighting control devices (e.g., a dimmer switch, an electronic switch, a ballast, or a light-emitting diode (LED) driver), a motorized window treatment, a temperature control device (e.g., a thermostat), an AC plug-in load control device, and/or the like. Examples of control-source devices may include remote control devices, occupancy sensors, daylight sensors, temperature sensors, and/or the like.

(2) A load regulation device (e.g., such as a driver or ballast) and/or an electrical load (e.g., such as an incandescent light source, an LED light source, gas-discharge lamp, etc.) may be configured to respond to one of a variety of control techniques. The control technique may be an analog control technique or a digital control technique. The analog control technique may include a 0-10V control technique, a 10-0V control technique, an analog pulse-width modulated (PWM) control technique, and/or the like. The digital control technique may include a digital PWM control technique, a digital messaging control technique (e.g., such as the digital addressable lighting interface (DALI) protocol, an ECOSYSTEM protocol, etc.), and/or the like. However, a control module may not be aware of the particular control technique used by a load regulation device and/or electrical load to which it is connected. If the control module is configured to control the load regulation devices and/or electrical load with the incorrect control technique, the load regulation devices and/or electrical load may not respond (e.g., may not respond properly). As such, there exists a need for a control module that is configured to determine (e.g., automatically determine) to which of a plurality of control techniques a load regulation device and/or electrical load is responsive.

SUMMARY

(3) The present application relates to a load control system and/or a control module for controlling the amount of power delivered to one or more electrical loads, and more particularly, to a load control system (e.g., a wireless load control system) and/or control module able to be automatically configured to one of a plurality of control techniques based on the connected electrical load (e.g., driver and/or lighting load).

(4) A control module may comprise a processor, a memory, a control circuit, a control connection, and/or a power measurement circuit. The control module may be configured to control an electrical load. The electrical load may comprise a driver for controlling a light load (e.g., a light emitting diode (LED) driver for controlling an LED light source). For example, the electrical load may receive power from a power source, for example, via the control module. The power measurement circuit may be configured to measure the amount of power being delivered to the driver.

(5) The control connection may be adapted to provide a control signal to the electrical load in accordance with a plurality of control techniques. The plurality of control techniques may comprise one or more analog control techniques and/or one or more digital control techniques. The one or more analog control techniques may comprise a 0-10V control technique, a 10-0V control technique, an analog PWM control technique, a switching-only control technique, a phase-control control technique, and/or the like. The one or more digital control techniques may comprise a digital PWM control technique, a digital messaging control technique (e.g., such as the digital

addressable lighting interface (DALI) protocol, an ECOSYSTEM protocol, etc.), and/or the like.
(6) The control circuit may be configured to sequentially generate the control signal at the control connection according to each of the plurality of control techniques, for example, in any order or combination. The control circuit may be configured to determine if the electrical load is responsive to at least one of the plurality of control techniques, for example, by monitoring a parameter of the electrical load (e.g., the driver and/or the lighting load). For example, the control circuit may be configured to attempt to adjust an intensity of the lighting load to a predetermined intensity using one of the control techniques, and measure the power being consumed by the driver and/or the lighting load at the predetermined intensity to determine if the driver is responsive to the control technique. If the control circuit determines that the driver is not responsive to the control technique, the control circuit may attempt to adjust the intensity of the lighting load to the predetermined intensity using another one of the control techniques, and determine if the driver is responsive. The predetermined intensity may be a high-end intensity and/or a low-end intensity. For example, the control circuit may be configured to attempt to adjust the intensity of the lighting load to the high-end intensity and/or to the low-end intensity using one of the control techniques, and to measure the power being consumed by the driver and/or the lighting load at the high-end intensity and/or at the low-end intensity to determine if the driver is responsive to the selected control technique.
(7) The control circuit may be configured to transmit a digital message, in accordance with a digital control technique, to the driver via the control connection. The control circuit may be configured to determine if the driver transmits a response to the digital message to determine if the driver is responsive to the control technique. The control circuit may be configured to receive a digital message according to a digital control technique, the digital message indicating a measured intensity of the lighting load, and to determine if the driver is responsive to the control technique based on the measured intensity.
(8) If the control circuit determines that the electrical load is responsive to a specific control technique, the control circuit may be configured to control the electrical load using the specific control technique during normal operation. If the control circuit determines that the electrical load is not responsive to the control techniques other than a switching-only control technique, the control circuit may be configured to control the electrical load using the switching-only control technique during normal operation.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a simple wiring diagram of a load control system having a plurality of controllable lighting fixtures, each with a control module, a load regulation device (e.g., a driver), and a lighting source, for illuminating a space.
(2) FIG. **2** is a simplified block diagram of a control module for controlling a driver for a light source.
(3) FIGS. **3**A and **3**B are simplified flowcharts of an example procedure executed by a control module that is adapted to control load regulation devices by a plurality of different control methods or techniques to determine the appropriate control technique to use.
DETAILED DESCRIPTION
(4) FIG. **1** is a simple wiring diagram of a load control system **100** comprising a plurality of controllable lighting fixtures **110** for illuminating a space. Each lighting fixture **110** may comprise a lighting load, e.g., a light-emitting diode (LED) light source **112**, and/or a respective load regulation device, e.g., an LED driver **114**, for controlling the lighting load. Each light fixture **110** may comprise a respective control module **115** that is adapted to be coupled to a power source, e.g., an alternating-current (AC) power source providing a line voltage. The control module **115** may be

configured to provide power to the driver **114** via power wiring **118**. The control module **115** may be configured to generate one or more control signals, which may be provided to the driver **114** via control wiring **119** for controlling the LED light source **112**. The control module **115** may be mounted to an internal or external surface of the respective fixture **110** or to a junction box located adjacent to the fixture. An example of an assembly of a control module is described in greater detail in commonly-assigned U.S. Patent Application Publication No. 2012/0313456, published Dec. 13, 2012, entitled LOAD CONTROL DEVICE HAVING AN ELECTRICALLY ISOLATED ANTENNA, the entire disclosure of which is hereby incorporated by reference.

(5) The driver **114** may be configured to control the power delivered to the light source **112**, and thus the intensity of the light source **112** in response to the control signals received via the control wiring **119**. The driver **114** may be configured to turn the light source **112** on and off and to adjust the intensity of the light source **112** between a low-end (minimum) intensity L_{LE} and a high-end (maximum) intensity L_{HE}. The driver **114** may be configured to control the power delivered to the light source **112**, for example, by regulating the voltage generated across the light source and/or regulating the current conducted through the light source. Examples of LED drivers are described in greater detail in commonly-assigned U.S. Pat. No. 8,492,987, issued Jul. 23, 2013, entitled LOAD CONTROL DEVICE FOR A LIGHT-EMITTING DIODE LIGHT SOURCE, and U.S. Patent Application Publication No. 2014/0009084, published Jan. 9, 2014, entitled FORWARD CONVERTER HAVING A PRIMARY-SIDE CURRENT SENSE CIRCUIT, the entire disclosures of which are hereby incorporated by reference.

(6) The control module **115** may be configured to control a plurality of different types of drivers **114**. The control module **115** may be configured to generate appropriate control signals for controlling drivers **114** having different types of control inputs (e.g., control techniques). The driver **114** that is coupled to the control module **115** in each lighting fixture **110** may be responsive to a subset of control signals (e.g., a single type, or more than one control signal) received via the control wiring **119**.

(7) The driver **114** may be responsive to an analog control signal, such as a 0-10V control signal, a 10-0V control signal, an analog PWM control signal, and/or other types of analog control signal, received via the control wiring **119**. An analog PWM control signal may have, for example, a duty cycle that indicates the target intensity for the respective lighting source **112**. For example, the driver **114** may control the respective light source **112** to the low-end intensity L_{LE} when the analog PWM control signal has a duty cycle of 0%, to the high-end intensity L_{HE} when the analog PWM control signal has a duty cycle of 100%, and to an intensity that is linearly scaled between the low-end intensity L_{LE} and the high-end intensity L_{HE} when the analog PWM control signal has a duty cycle between 0% and 100%.

(8) A 0-10V control signal and a 10-0V control signal may have a DC magnitude that ranges between zero and ten volts and indicates a target intensity for the respective light source **112**. When receiving a 0-10V control signal, the driver **114** may control the respective light source **112** to the low-end intensity L_{LE} when the 0-10V control signal has a magnitude of one volt, to the high-end intensity L_{HE} when the 0-10V control signal has a magnitude of ten volts, and to an intensity that is linearly scaled between the low-end intensity L_{LE} and the high-end intensity L_{HE} when the 0-10V control signal has a magnitude between one and ten volts. When receiving a 10-0V control signal, the driver **114** may control the respective light source **112** to the low-end intensity L_{LE} when the 10-0V control signal has a magnitude of ten volts, to the high-end intensity L_{HE} when the 10-0V control signal has a magnitude of one volt, and to an intensity that is linearly scaled between the low-end intensity L_{LE} and the high-end intensity L_{HE} when the 10-0V control signal has a magnitude between ten and one volts.

(9) The driver **114** may be responsive to a digital control technique. For example, the driver **114** may be responsive to a digital control signal, such as a digital message, a digital PWM control signal, and/or other digital control signal, received via the control wiring **119**. The digital PWM

control signal may have digital information encoded in the pulse-width and/or frequency of the signal.

(10) The control module **115** may transmit a digital message to the driver **114** via the control wiring **119**, e.g., using a standard protocol, such as the DALI protocol, or a proprietary protocol, such as the ECOSYSTEM protocol. The DALI and ECOSYSTEM protocols may be related, such that if a driver is responsive to commands from the ECOSYSTEM protocol, the driver will also be responsive to commands from the DALI protocol. However, a driver that is responsive to commands from a standard protocol may not be responsive to commands from a proprietary protocol, and vice versa. For example, a driver that is responsive to commands from the DALI protocol may not be responsive to commands from the ECOSYSTEM protocol. The driver **114** may be responsive to digital messages transmitted according to other protocols that are not related to each other.

(11) The driver **114** may be responsive to a control signal received via the power wiring **118**, e.g., a phase-control signal or a power-line communication (PLC) signal. For example, the driver **114** may not be responsive to an analog control signal or digital control signal received via the control wiring **119**, but may be responsive to a control signal received via the power wiring **118**. The driver **114** may not be responsive to control signals received via the power wiring **118** or the control wiring **119**, e.g., the driver **114** may simply be responsive to switching control only via the power wiring **118**.

(12) The lighting fixture **110** may comprise a different type of light source other than an LED light source (e.g., a fluorescent lamp), and the driver **114** may comprise an appropriate load regulation circuit for the different light source (e.g., an electronic dimming ballast circuit). Examples of ballasts are described in greater detail in commonly-assigned U.S. Pat. No. 7,489,090, issued Feb. 10, 2009, entitled ELECTRONIC BALLAST HAVING ADAPTIVE FREQUENCY SHIFTING, and U.S. Pat. No. 8,593,076, issued Nov. 29, 2013, entitled ELECTRONIC DIMMING BALLAST HAVING ADVANCED BOOST CONVERTER CONTROL, the entire disclosures of which are hereby incorporated by reference. The lighting fixture **110** may comprise a light source that may be driven directly by the control module **115** via the power wiring **118**, e.g., an incandescent or halogen lamp, such that the driver **114** is not required.

(13) The lighting fixture **110** may comprise a sensor device **116** that may be electrically coupled to the respective control module **115**. The sensor device **116** may be mounted to the lighting fixture **110** (e.g., on a lower or outward-facing surface of the lighting fixture) or external to the lighting fixture **110** (e.g., on a ceiling or wall of the space in which the lighting fixtures are installed).

(14) The sensor device **116** may be configured to detect occupancy and vacancy conditions in the space in which the respective lighting fixture **110** is installed. The control module **115** may be configured to control the respective driver **114** in response to the sensor device **116** determining that the space is occupied or vacant. For example, the control module **115** may be configured to turn on the light source **112** in response to determining that the space is occupied and to turn off the light source in response to determining that the space is unoccupied (e.g., as with an "occupancy" sensor). The control module **115** may be configured to only turn off the light source in response to determining that the space is unoccupied, i.e., turn on the light source in response to determining that the space is occupied (e.g., as with an "vacancy" sensor). Examples of load control systems having occupancy and vacancy sensors are described in greater detail in commonly-assigned U.S. Pat. No. 8,228,184, issued Jul. 24, 2012, entitled BATTERY-POWERED OCCUPANCY SENSOR, the entire disclosure of which is hereby incorporated by reference.

(15) The control module **115** may perform daylighting. The sensor device **116** may be configured to measure a light intensity at the sensor in which the respective lighting fixture **110** is installed. The control module **115** may be configured control the respective driver **114** in response to the light intensity measured by the sensor device **116**. Examples of load control systems having daylight sensors are described in greater detail in commonly-assigned U.S. Pat. No. 8,410,706, issued Apr.

2, 2013, entitled METHOD OF CALIBRATING A DAYLIGHT SENSOR, the entire disclosure of which is hereby incorporated by reference.

(16) The control module **115** may be configured to communicate (i.e., transmit and receive) wireless signals, e.g., radio-frequency (RF) signals **106**, with the other control modules **115** of the load control system **100**. The control modules **115** may be operable to transmit and receive the RF signals **106** with a system controller **120** (e.g., a load controller or a central controller). The control module **115** may be configured to control the respective driver **114** in response to digital messages received via the RF signals **106**. The control module **115** may be configured to transmit digital messages including feedback information via the RF signals **106**, e.g., to the system controller **120**.

(17) The load control system **110** may comprise one or more remote control devices **130** (e.g., a handheld battery-powered remote control) for controlling the light sources **112** of the lighting fixtures **110**. The remote control device **130** may be configured to transmit RF signals to the control modules **115** in response to the actuation of one or more actuators **132** (e.g., one or more of an on button, an off button, a raise button, a lower button, and a preset button). Examples of battery-powered remote control devices are described in greater detail in commonly-assigned U.S. Pat. No. 8,330,638, issued Dec. 11, 2012, entitled WIRELESS BATTERY-POWERED REMOTE CONTROL HAVING MULTIPLE MOUNTING MEANS, and U.S. Patent Application Publication No. 2012/0286940, published Nov. 12, 2012, entitled CONTROL DEVICE HAVING A NIGHTLIGHT, the entire disclosures of which are hereby incorporated by reference.

(18) The load control system **100** may comprise a wireless occupancy sensor **140** configured to transmit digital messages to the control modules **115** via the RF signals in response to detecting an occupancy or vacancy condition in the space. The control module **115** may be configured to control the respective light source **112** in response to the RF signals received from the occupancy sensor **140** in a similar manner as the control module is responsive to the sensor device **116**. Examples of wireless occupancy and vacancy sensors are described in greater detail in commonly-assigned U.S. Pat. No. 8,009,042, issued Aug. 30, 2011 Sep. 3, 2008, entitled RADIO-FREQUENCY LIGHTING CONTROL SYSTEM WITH OCCUPANCY SENSING, and U.S. Pat. No. 8,199,010, issued Jun. 12, 2012, entitled METHOD AND APPARATUS FOR CONFIGURING A WIRELESS SENSOR, the entire disclosures of which are hereby incorporated by reference.

(19) The load control system **100** may comprise a wireless daylight sensor **150** configured to measure the light intensity at the sensor and to transmit a digital message including the measured light intensity to the control modules **115** via the RF signals. Each control module **115** may be configured to control the respective light source **112** in response to the RF signals received from the daylight sensor **150** in a similar manner as the control module is responsive to the sensor device **116**. Examples of wireless daylight sensors are described in greater detail in commonly-assigned U.S. Pat. No. 8,451,116, issued May 28, 2013, entitled WIRELESS BATTERY-POWERED DAYLIGHT SENSOR, the entire disclosure of which is hereby incorporated by reference.

(20) The load control system **100** may comprise other types of input devices, such as, for example, temperature sensors, humidity sensors, radiometers, cloudy-day sensors, pressure sensors, smoke detectors, carbon monoxide detectors, air-quality sensors, motion sensors, security sensors, proximity sensors, fixture sensors, partition sensors, keypads, kinetic or solar-powered remote controls, key fobs, cell phones, smart phones, tablets, personal digital assistants, personal computers, laptops, timeclocks, audio-visual controls, safety devices, power monitoring devices (such as power meters, energy meters, utility submeters, utility rate meters), central control transmitters, residential, commercial, or industrial controllers, or any combination of these input devices.

(21) The control module **115** in each lighting fixture **110** may be configured to determine (e.g., automatically determine) the appropriate type of control signal for controlling the driver **114** that is installed in the lighting fixture **110** with the control module **115**. For example, the control module **115** may be configured to determine the appropriate type of control signal for controlling the driver

114 upon first being powered up. The control module 115 may be configured to step through one or more possible control techniques (e.g., one or more analog control techniques and/or one or more digital control techniques), attempt to control the driver 114 using the selected control technique, and determine if the driver is responsive to the selected control technique. For example, the control module 115 may attempt to control the driver 114 by generating different control signals (e.g., the 0-10V control signal, the 10-0V control signal, and/or the analog PWM control signal) on the control wiring 119. The control module 115 may also attempt to transmit digital messages to the driver 114 via the control wiring 119 using different protocols (e.g., the DALI protocol and the ECOSYSTEM protocol). Upon determining that the driver 114 is responsive to one of the control signals or digital messages, the control module 115 may select the present control technique for use during normal operation of the load control system 100. If the control module 115 determines that the driver 114 is not responsive to any of the control signals or digital messages, the control module may determine to use a switching-only control technique during normal operation (i.e., the control module will only switch the light source 112 on and off, and not dim the light source 112).

(22) The load control system 100 may comprise one or more other types of load control devices, such as, for example, a screw-in luminaire including a dimmer circuit and an incandescent or halogen lamp; a screw-in luminaire including a ballast and a compact fluorescent lamp; a screw-in luminaire including an LED driver and an LED light source; an electronic switch, controllable circuit breaker, or other switching device for turning an appliance on and off; a plug-in load control device, controllable electrical receptacle, or controllable power strip for controlling one or more plug-in loads; a motor control unit for controlling a motor load, such as a ceiling fan or an exhaust fan; a drive unit for controlling a motorized window treatment or a projection screen; motorized interior or exterior shutters; a thermostat for a heating and/or cooling system; a temperature control device for controlling a setpoint temperature of an HVAC system; an air conditioner; a compressor; an electric baseboard heater controller; a controllable damper; a variable air volume controller; a fresh air intake controller; a ventilation controller; a hydraulic valves for use radiators and radiant heating system; a humidity control unit; a humidifier; a dehumidifier; a water heater; a boiler controller; a pool pump; a refrigerator; a freezer; a television or computer monitor; a video camera; an audio system or amplifier; an elevator; a power supply; a generator; an electric charger, such as an electric vehicle charger; and an alternative energy controller.

(23) FIG. 2 is a simplified block diagram of a control module 200 for controlling a driver for a light source, which may be deployed as the control module 115 in the load control system 100 shown in FIG. 1. The control module 200 may comprise an input hot terminal H1 and an input neutral terminal N1 adapted to be electrically coupled to an AC power source for receiving a line voltage. The control module 200 may also comprise an output power connection including an output hot terminal H2 and an output neutral terminal N2 adapted to be coupled to an external load regulation device for a lighting load (e.g., to the LED driver 114 via the power wiring 118 shown in FIG. 1). Alternatively, the output hot terminal H2 and the output neutral terminal N2 may be coupled directly to an external lighting load.

(24) The control module 200 may comprise a controllably conductive device 210 coupled in series electrical connection between the input hot terminal H1 and the output hot terminal H2 for controlling the power delivered to the external driver and/or external lighting load. The controllably conductive device 210 may comprise, for example, a relay, a bidirectional semiconductor switch (e.g., such as, a triac, a FET in a rectifier bridge, two FETs in anti-series connection, or one or more insulated-gate bipolar junction transistors), or any other suitable switching circuit. The controllably conductive device 210 may be configured to conduct a load current I.sub.LOAD to the driver and/or lighting load. The input neutral terminal N1 may be coupled directly to the output neutral terminal N2. The control module 200 may alternatively comprise a single neutral terminal adapted to be coupled to the AC power source and the driver and/or lighting load.

(25) The control module 200 may comprise a control circuit 220 that may be coupled to the

controllably conductive device **210** for rendering the controllably conductive device conductive and/or non-conductive to control the power delivered to the driver and/or lighting load. For example, the control circuit **220** may comprise a microcontroller, a programmable logic device (PLD), a microprocessor, an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or any suitable processing device, controller, or control circuit. The control module **200** may comprise memory (not shown). The memory may be implemented as an external integrated circuit (IC) or as an internal circuit of the control circuit **220**. The memory may operate to store information such as computer-executable instructions, configuration settings associated with operation of the control module **200** (e.g., the responsive control technique), and/or the like. The memory may include one or more components of volatile and/or non-volatile memory, in any combination.

(26) The control module **200** may comprise a power supply **222** coupled between the input hot terminal H**1** and the input neutral terminal N**1** for generating a direct-current (DC) supply voltage V.sub.CC for powering the control circuit **220** and the other low-voltage circuitry of the control module **200**. The DC supply voltage V.sub.CC may be referenced to a circuit common, which may comprise a non-isolated circuit common (e.g., referenced to the input hot terminal H**1** and/or the input neutral terminal N**1**) or an isolated circuit common.

(27) The control module **200** may comprise one or more power measurement circuits, for example, a current measurement circuit **230** and/or a voltage measurement circuit **232**. The control module **200** may comprise a current measurement circuit **230** coupled in series electrical connection between the input hot terminal H**1** and the output hot terminal H**2** for measuring the magnitude of the load current I.sub.LOAD conducted through the driver and/or lighting load. The current measurement circuit **230** may generate a current feedback signal V.sub.FB-I indicating the magnitude of load current I.sub.LOAD presently being conducted through the driver and/or lighting load. For example, the current measurement circuit **230** may comprise a sense resistor (not shown) for generating a sense voltage (e.g., the current feedback signal V.sub.FB-I) in response to the load current I.sub.LOAD being conducted through the sense resistor. The control circuit **220** may receive the current measurement signal V.sub.FB-I for determining the magnitude of the load current I.sub.LOAD being conducted through the driver and/or lighting load.

(28) The control module **200** may comprise a voltage measurement circuit **232** coupled between the input hot terminal H**1** and the input neutral terminal N**1** for measuring the magnitude of the line voltage of the AC power source. The voltage measurement circuit **232** may generate a voltage feedback signal V.sub.FB-V indicating the present magnitude of the line voltage of the AC power source. For example, the voltage measurement circuit **232** may comprise a resistor divider for generating a scaled voltage (e.g., the voltage feedback signal V.sub.FB-V). The control circuit **220** may receive the voltage measurement signal V.sub.FB-V and may calculate the amount of power presently being consumed by the driver and/or lighting load using the present magnitude of the line voltage and the present magnitude of load current I.sub.LOAD as measured by the current measurement circuit **230**. The control circuit **220** may assume a present magnitude of the line voltage (e.g., 120 V) to calculate the amount of power presently being consumed by the driver and/or lighting load using the present magnitude of load current I.sub.LOAD, and, for example, may not receive the voltage measurement signal V.sub.FB-V.

(29) The control module **200** may comprise a control connection including first and second control terminals C**1**, C**2** adapted to be coupled to the driver (e.g., via the control wiring **119** shown in FIG. **1**). The control circuit **220** may comprise a control output **224** coupled to the control terminals C**1**, C**2** through a driver communication circuit **240**. The driver communication circuit **240** may comprise a buffer circuit **242** and a current limit circuit **244** coupled between the control output **224** of the control circuit and the first control terminal C**1**. The second control terminal C**2** may be coupled to circuit common (e.g., an isolated circuit common). The driver communication circuit **240** may comprise a capacitor **246** and a controllable switching circuit **246**, which may be coupled

in series between the control output **224** of the control circuit **220** and circuit common. The controllable switching circuit **248** may comprise, for example, a bipolar junction transistor (BJT), a field-effect transistor (FET), or other suitable controllable switch. The control circuit **220** may generate an average enable control signal V.sub.EN for rendering the controllable switching circuit **248** conductive and/or non-conductive. The control circuit **220** may be configured to generate an analog control signal (e.g., a 0-10V control signal, a 10-0V control signal, or an analog PWM control signal) and/or a digital control signal (e.g., a digital message) at the control output **224** for controlling the driver coupled to the control terminals C**1**, C**2**. The first control terminal C**1** may be coupled to the control circuit **220**, such that the control circuit may be configured to receive analog feedback (e.g., in case of a miswire condition at the control terminals C**1**, C**2**) as well as digital messages from the driver.

(30) The control module **200** may further comprise a sensor port **250** adapted to be electrically coupled to an external sensor device (e.g., the sensor device **116** shown in FIG. **1**). For example, the sensor port **250** may comprise a four-pin connector. The sensor port **250** may comprise two pins S**1**, S**4** for coupling the supply voltage V.sub.CC and circuit common to the external sensor device for powering the external sensor device. The sensor port **250** may comprise an occupancy control signal pin S**2** for receiving an occupancy control signal V.sub.OCC from the sensor device, which may indicate an occupancy or vacancy condition detected by the external sensor device. The control circuit **220** may receive the occupancy control signal V.sub.OCC and may control the driver and/or lighting load in response to the external sensor device detecting an occupancy condition or a vacancy condition. The sensor port **250** may comprise a daylight control signal pin S**3** for receiving a daylight control signal V.sub.DAY from the sensor device, which for example, may indicate a light intensity measured by the external sensor device. The control circuit **220** may receive the daylight control signal V.sub.DAY and may control the driver and/or lighting load in response to the light intensity measured by the external sensor device. Although not illustrated, the sensor port **250** may comprise a two-pin connector. If the sensor port **250** comprises a two-pin connector, then the two-pins may be used for coupling the supply voltage V.sub.CC and circuit common to the external sensor device for powering the external sensor device, and for receiving an occupancy control signal V.sub.OCC from the sensor device and/or for receiving a daylight control signal V.sub.DAY from the sensor device.

(31) The control module **200** may comprise a wireless communication circuit, for example, including an RF transceiver **260** coupled to an antenna **262** for transmitting and receiving RF signals (e.g., the RF signals **106** shown in FIG. **1**). The control circuit **220** may be coupled to the RF transceiver **260** for receiving digital messages via the RF signals **106** from wireless control devices (e.g., the system controller **120**, the remote control device **130**, the occupancy sensor **140**, and/or the daylight sensor **150** shown in FIG. **1**). The control circuit **220** may be configured to control the driver and/or lighting load in response to the received digital messages. The control circuit **220** may be configured to transmit digital messages via the RF signals **106**, for example, to provide feedback information to the system controller **120**. For example, the feedback information may include a status of the control module **220**, the driver, and/or the lighting load, the amount of power being consumed by the driver and/or lighting load, a present intensity of the lighting load, an occupancy or vacancy condition detected by the external sensing device, a light intensity measured by the external sensor device, and/or the like.

(32) The control circuit **220** may be configured to generate a plurality of different types of control signals at the control output **224** for controlling external drivers and/or external lighting loads that may require different types of control signals (e.g., using different control techniques or methods). The control circuit **220** may be configured to generate different types of analog control signals (e.g., a 0-10V control signal, a 10-0V control signal, an analog PWM control signal, or other type of dimming control signal) at the control output **224**. Since the 0-10V control signal and the 10-0V control signal are DC voltages, the control circuit **220** may render the controllable switching circuit

248 conductive to couple the capacitor **246** between the control output **224** and circuit common when generating the 0-10V control signal or the 10-0V control signal. The control circuit **220** may be configured to generate a PWM signal that is filtered by the capacitor **246** to generate the appropriate DC voltage at the control output **224**. The buffer circuit **242** may operate to prevent the capacitor **246** from charging through the current limit circuit **244** or the driver when generating the 0-10V control signal or the 10-0V control signal. When the control circuit **220** is generating the analog PWM control signal at the control output **224**, the control circuit **220** may be configured to render the controllable switching circuit **248** non-conductive using the average enable control signal V.sub.EN, such that the capacitor **244** is not coupled between the control output **224** and circuit common.

(33) The control circuit **220** may be configured to generate a digital control signal, such as a digital message, at the control output **224**, e.g., using a standard protocol, such as the DALI protocol, and/or a proprietary protocol, such as the ECOSYSTEM protocol. When transmitting a digital message to the driver coupled to the control terminals C**1**, C**2** via the control output **224**, the control circuit **220** may render the controllable switching circuit **248** non-conductive, such that the capacitor **246** is not coupled between the control output **224** and circuit common. To transmit digital messages according to the DALI protocol or the ECOSYSTEM protocol, the control circuit **220** may be configured to short the control terminals C**1**, C**2** together to transmit a logic "1" bit and to not short the control terminals C**1**, C**2** together to transmit a logic "0" bit. For example, the control circuit **220** may transmit digital messages according to the DALI protocol or the ECOSYSTEM protocol using Manchester encoding. In a similar manner, the driver may short the control terminals C**1**, C**2** together to transmit digital messages according to the DALI protocol or the ECOSYSTEM protocol to the control module **200**. The current limit circuit **244** may operate to protect the circuitry of the control module **200** when the driver shorts the control terminals C**1**, C**2** together. In addition, the current limit circuit **244** may operate to protect the circuitry of the control module **200** in the event of an installation mistakes, for example, if too many drivers are coupled to the control terminals C**1**, C**2**.

(34) Accordingly, the control circuit **220** may control the driver coupled to the control terminals C**1**, C**2** by generating the appropriate analog or digital control signals at the control output **224**. In addition, the control circuit **220** may control the controllably conductive device **210** to render the controllably conductive device conductive and non-conductive to turn the driver and lighting load on and off.

(35) The control circuit **220** may be configured to control the controllably conductive device **210** to generate a phase-control signal at the output hot terminal H**2** (e.g., if the controllably conductive device comprises a bidirectional semiconductor switch, such as, a triac, a FET in a rectifier bridge, two FETs in anti-series connection, or one or more insulated-gate bipolar junction transistors). In this case, the driver may not be coupled to the control terminals C**1**, C**2**, but may be responsive to the phase-control signal to adjust the intensity of the lighting load in response to a firing angle of the phase-control signal. Further, the control circuit **220** may be configured to control the controllably conductive device **210** to render the controllably conductive device conductive and non-conductive to turn the external driver and the lighting load on and off. Such a driver may not be coupled to the control terminals C**1**, C**2**. The control circuit **220** may be configured to generate the phase-control signal using a standard phase-control dimming technique, such as forward or reverse phase-control dimming.

(36) A lighting load (e.g., an incandescent lamp) may be coupled directly to the output hot and neutral terminals H**2**, N**2**. The control circuit **220** may control the controllably conductive device **210** to generate the phase-control signal at the output hot terminal H**2** and may adjust the firing angle of the phase-control signal to adjust the intensity of the lighting load. Further, the control circuit **220** may be configured to control the controllably conductive device **210** to render the controllably conductive device conductive and non-conductive to turn the external lighting load on

and off.

(37) The control circuit **220** may be configured to determine (e.g., automatically determine) the appropriate type of control signal for controlling the driver that is coupled to the output hot and neutral terminals H**2**, N**2**, for example, when the control module **200** is first powered up, when placed in an advanced programming mode, etc. The control circuit **220** may be configured to step through each of a plurality of control techniques and attempt to control the driver using the selected control technique. For example, the plurality of control techniques may include at least one analog control technique and at least one digital control technique. The control circuit **220** may, for example, attempt to control the driver by generating different control signals (e.g., the 0-10V control signal, the 10-0V control signal, and the analog PWM control signal) at the control terminals C**1**, C**2**. The control module **115** may also attempt to transmit digital messages to the driver via the control terminals C**1**, C**2** using different protocols (e.g., the DALI protocol or the ECOSYSTEM protocol).

(38) The control circuit **220** may then determine if the driver is responsive to the selected control technique (e.g., an analog control technique and/or a digital control technique), for example, by monitoring a parameter of the external driver and/or lighting load. The control circuit **220** may monitor, for example, the magnitude of the load current I.sub.LOAD and/or the power being consumed by the driver and/or lighting load (e.g., using the current feedback signal V.sub.FB-I and/or the voltage feedback signal V.sub.FB-V) to determine if the driver responded appropriately to the present control signal. For example, the control circuit **220** may control the driver and/or lighting load to the high-end intensity L.sub.HE and to the low-end intensity L.sub.LE using a single control technique. The control circuit **220** may measure the power being consumed by the driver and/or lighting load at the high-end intensity L.sub.HE and at the low-end intensity L.sub.LE and determine if these values are in appropriate ranges to determine if the driver is responsive to the selected control technique. The control circuit **220** may be configured to measure the light intensity of the lighting load (e.g., via the sensor device **116** and/or the wireless daylight sensor **150**) at one or more intensities to determine if the driver is responsive to the selected control technique. In addition, the control circuit **220** may be configured to receive a digital message back from the driver via the control terminals C**1**, C**2** to determine that the driver is response to a digital message transmitted to the driver. Further, the driver may be configured to monitor and/or measure the parameter and transmit a digital message including the parameter to the control module **200** via the control terminals C**1**, C**2**.

(39) Upon determining that the driver is responsive to one of the control signals or digital messages, the control circuit **220** may select the present control technique for use during normal operation. If the control circuit **220** determines that the driver is not responsive to any of the control signals or digital messages, the control circuit may decide to use switching control during normal operation. For example, the control circuit **220** may control the controllably conductive device **201** to switch the driver and/or lighting load on and off, but not dim the driver and/or lighting load.

(40) FIGS. **3**A and **3**B are simplified flowcharts of an example procedure **300** executed by a control module that is adapted to control load regulation devices by a plurality of different control methods or techniques (e.g., the control module **115** for controlling the driver **114** of FIG. **1** and/or the control module **200** of FIG. **2**). The procedure **300** may be executed by a control circuit (e.g., the control circuit **220** of FIG. **2**) when the control module first powers up and the control circuit starts up at **310**. The procedure **300** may be performed at a time other than when the control module first powers up and the control circuit starts up, for example, when the control module is entered into an advanced programming mode and the initiated to perform the procedure **300** by a user.

(41) The control circuit may step through a plurality of control techniques and determine whether the load regulation device is responsive to any of the plurality of control techniques. The plurality of control techniques may include one or more analog control techniques and one or more digital control techniques, for example, in any order and combination. The control circuit may use a

variable n to keep track of a present control technique during the procedure **300**. For example, the control module may be configured to use a number N_{CT} of control techniques, for example, six control techniques as follows:

(42) TABLE-US-00001 n Control Technique 1 0-10 V Control 2 10-0 V Control 3 ECOSYSTEM Protocol 4 DALI Protocol 5 Analog PWM Control 6 Switching Control Only

(43) At **312**, the control circuit may set the variable n equal to one, for example, such that the control technique is initially set to 0-10V Control. At **314**, the control circuit may render a controllably conductive device (CCD) conductive for supplying power to the driver (e.g., the controllably conductive device **210** of FIG. **2**).

(44) The control circuit may attempt to control the driver to the high-end intensity L_{HE} using the present control technique at **316**. At **318**, the control circuit may sample one or more feedback signals that indicate the power being consumed by the driver and/or lighting load (e.g., the current feedback signal V_{FB-I} and/or the voltage feedback signal V_{FB-V} shown in FIG. **2**). The control circuit may store a high-end power measurement value P_{HE} in memory at **320** in response to the sampled value of the feedback signal. The control circuit may attempt to control the driver to the low-end intensity L_{LE} using the present control technique at **322**, sample the feedback signal at **324**, and store a low-end power measurement value P_{LE} in memory at **326**.

(45) If the high-end power measurement value P_{HE} is greater than the low-end power measurement value P_{LE} at **328** and the variable n is not equal to three at **330**, the control circuit may select the present control technique at **332**, before the procedure **300** exits. For example, when the high-end power measurement value P_{HE} is greater than the low-end power measurement value P_{LE} at **328** and the variable n is equal to one at **330**, the control circuit may decide to use the 0-10V Control technique during normal operation. If the high-end power measurement value P_{HE} is not greater than the low-end power measurement value P_{LE} at **328** and the variable n is equal to one at **334**, the control circuit may increment the variable n by one at **336** and determine if the high-end power measurement value P_{HE} is less than the low-end power measurement value P_{LE} at **338**. If so, the control circuit may select the present control technique at **340** (i.e., 10-0V Control), before the procedure **300** exits. If the high-end power measurement value P_{HE} is not less than the low-end power measurement value P_{LE} at **338**, the control circuit may increment the variable n by one at **342** and the control circuit may attempt to control the connected driver and/or lighting control using the next control technique at **316**.

(46) If the high-end power measurement value P_{HE} is greater than the low-end power measurement value P_{LE} at **328** and the variable n is equal to three at **330**, the control circuit may attempt to transmit a digital message using a proprietary protocol (e.g., the ECOSYSTEM protocol) to the driver at **344**. For example, the digital message may be a query command that is unique to the ECOSYSTEM protocol (e.g., not included in the DALI protocol). If the driver responds to the digital message at **346**, the control circuit may select the present control technique at **332** (i.e., ECOSYSTEM protocol) and the procedure **300** exits. If the driver does not respond to the digital message transmitted using the ECOSYSTEM protocol at **346,** the control circuit may increment the variable n by one at **348** and attempt to transmit a digital message using a standard protocol (e.g., the DALI protocol) to the driver at **350**. If the driver responds to the digital message at **352**, the control circuit may select the present control technique at **332** (i.e., DALI protocol) and the procedure **300** exits. If the driver did not respond to the digital message transmitted using the DALI protocol at **352**, the control circuit may increment the variable n by one at **354** and the control circuit may attempt to control the connected driver and/or lighting control using the next control technique at **316**.

(47) If the high-end power measurement value P_{HE} is not greater than the low-end power measurement value P_{LE} at **328** and the variable n is not equal to one at **334**, the control circuit may determine if the variable n is greater than or equal to the number N_{CT} of control

techniques at **356**. If not, the control circuit increments the variable n by one at **358** and control circuit may attempt to control the connected driver and/or lighting control using the next control technique at **316**. If the variable n is greater than or equal to the number N.sub.CT of control techniques at **356**, the control circuit may select switching-only control at **360** and the procedure **300** exits.

(48) The control circuit may use the magnitude of the load current I.sub.LOAD at high-end and low-end to determine if the driver is responding correctly to the present control technique, for example, rather than calculating and using power measurement values P.sub.HE, P.sub.LE in the procedure **300** of FIGS. **3**A and **3**B.

(49) While not shown in FIGS. **3**A and **3**B, the control module may attempt to control the driver and/or lighting load using a phase-control signal and determine if the driver and/or lighting load responds correctly. For example, the control module may measure the peak value and the root-mean-square (RMS) value of the load current conducted through the driver and/or lighting load to determine a current crest factor (CCF), and stop generating the phase-control signal if the current crest factor is too large. The control module may be forced into a mode in which the control module generates the phase-control signal. For example, the installer of the control module could short the control terminals C**1**, C**2** together (e.g., with a wire), and the control module may determine to use the phase-control technique if the control module determines that the control terminals are continuously shorted together. The control module may attempt to control the driver and/or lighting load using the phase-control signal and determine if the driver and/or lighting load responds correctly before, during, or after attempting the plurality of control techniques.

(50) Further, the control module may comprise a programming input, e.g., a dual-inline package (DIP) switch, for setting the appropriate control technique for use by the control module (e.g., which may be referred to as an advanced programming mode). The DIP switch may comprise enough individual mechanical switches or positions to provide a unique switch setting for each of the plurality of control techniques that the control module is capable of generating. For example, the installer of the control module may adjust the DIP switch to the unique switch setting for the desired control technique during installation of the control module. At startup, the control circuit may read the unique switch setting to determine which control technique to use during normal operation. In addition, one of the unique switch settings of the DIP switch may select an automatic control-determination procedure in which the control module may execute the procedure **300** of FIGS. **3**A and **3**B to determine the appropriate control technique to use.

(51) After a control technique is selected using the DIP switch and the control module is powered up, the control module could execute the procedure **300** of FIGS. **3**A and **3**B to confirm that the appropriate control technique is selected. If the control technique selected by the DIP switch does not match the control technique determined by the procedure **300**, the control module may override the control technique to the technique selected by the procedure **300** and/or may notify the user of an error condition (e.g., by blinking a visual indicator on the control module and/or blinking or adjusting the intensity of the lighting load).

Claims

1. A lighting controller, comprising: lighting control circuitry having: a first interface operably couplable to a controllably conductive device; and a second interface to communicatively couple to a lighting driver; wherein, the lighting control circuitry to perform a load control technique selection, responsive to an occurrence of an event, the load control technique selection including: for each of a plurality of electric load control techniques, including at least one analog electric load control technique and at least one digital electric load control technique: generate an output at the first interface to place the controllably conductive device in a conductive state; generate, at the second interface, an output signal using the respective lighting control technique; receive one or

more lighting load electrical parameters; determine whether the lighting load is responsive to the respective electric load control technique using the one or more received lighting load electrical parameters; responsive to a determination that the lighting load is responsive to one of the plurality of electric load control techniques; store data representative of the respective electric load control technique in communicatively coupled memory circuitry; and provide, at the second interface, a control signal using the respective electric load control technique to provide ON/OFF and dimming capabilities for the lighting load.

2. The lighting controller of claim 1 wherein the lighting control circuitry to further: responsive to the determination that the electric load is not responsive to any of the plurality of electric load control techniques: provide, at the first interface a controllably conductive device control signal to provide ON/OFF control of the electrical load.

3. The lighting controller of claim 1 wherein to perform the load control technique selection, responsive to the occurrence of the event, the lighting control circuitry to further: perform the load control technique selection responsive to an initial power-up of the control circuitry.

4. The lighting controller of claim 1 wherein to perform the load control technique selection, responsive to the occurrence of the event, the lighting control circuitry to further: perform the load control technique selection responsive to a placement of the control circuitry in a programming mode.

5. The lighting controller of claim 1 wherein to receive the one or more lighting load electrical parameters, the lighting control circuitry to further: receive, from a current measurement circuit, one or more signals that include data representative of a load current through at least one of: the lighting driver circuitry or the lighting load.

6. The lighting controller of claim 1 wherein to receive the one or more lighting load electrical parameters, the lighting control circuitry to further: receive, from a voltage measurement circuit, one or more signals that include data representative of a voltage across at least one of: the lighting driver circuitry or the lighting load.

7. The lighting controller of claim 6 wherein the lighting control circuitry to further: determine a power consumption of the lighting load using the measured voltage across the at least one of: the lighting driver circuitry or the lighting load.

8. A lighting load control technique selection method, comprising: receiving, by load controller control circuitry, an input indicative of an occurrence of an event, the load controller control circuitry communicatively couplable to: a controllably conductive device via a first communication interface; and lighting driver circuitry via a second communication interface; and responsive to the receipt of the input indicative of the occurrence of the event, for each of a plurality of electric load control techniques that include at least one analog electric load control technique and at least one digital electric load control technique: generating, by the load controller control circuitry, an output at the first interface to place the controllably conductive device in a conductive state; generating, by the load controller control circuitry, at the second interface, an output signal using the respective lighting control technique; receiving, by the load controller control circuitry, one or more lighting load electrical parameters; determining, by the load controller control circuitry, whether the lighting load is responsive to the respective electric load control technique using the one or more received lighting load electrical parameters; responsive to a determination that the lighting load is responsive to one of the plurality of electric load control techniques; causing, by the load controller control circuitry, a storage of data representative of the respective electric load control technique in communicatively coupled memory circuitry; and providing, by the load controller control circuitry at the second interface, a control signal using the respective electric load control technique to provide ON/OFF and dimming capabilities for the lighting load.

9. The method of claim 8, the method further comprising: responsive to the determination, by the load controller control circuitry, that the electric load is not responsive to any of the plurality of electric load control techniques: providing, by the load controller control circuitry, at the first

interface a controllably conductive device control signal to provide ON/OFF control of the electrical load.

10. The method of claim 8 wherein receiving the input indicative of the occurrence of the event, further comprises: receiving, by the load controller control circuitry, an input indicative of an initial power-up of the load controller control circuitry.

11. The method of claim 8 wherein receiving the input indicative of the occurrence of the event, further comprises: receiving, by the load controller control circuitry, an input indicative of a placement of the load controller control circuitry in a programming mode.

12. The method of claim 8 wherein receiving the one or more lighting load electrical parameters, further comprises: receiving, by the load controller control circuitry from an operatively coupled current measurement circuit, one or more signals that include data representative of a load current through at least one of: the lighting driver circuitry or the lighting load.

13. The method of claim 8 wherein receiving the one or more lighting load electrical parameters, the lighting control circuitry to further: receiving, by the load controller control circuitry from a voltage measurement circuit, one or more signals that include data representative of a voltage across at least one of: the lighting driver circuitry or the lighting load.

14. The method of claim 13, the method further comprising: determining, by the load controller control circuitry, a power consumption of the lighting load using the measured voltage across the at least one of: the lighting driver circuitry or the lighting load.

15. A non-transitory, machine-readable, storage device that includes instructions that, when executed by lighting load controller control circuitry communicatively couplable to a controllably conductive device via a first communication interface; and lighting driver circuitry via a second communication interface, cause the control circuitry to: receive an input indicative of an occurrence of an event, the load controller control circuitry; and responsive to the receipt of the input indicative of the occurrence of the event, for each of a plurality of electric load control techniques that include at least one analog electric load control technique and at least one digital electric load control technique: generate an output at the first interface to place the controllably conductive device in a conductive state; generate at the second interface, an output signal using the respective lighting control technique; receive one or more lighting load electrical parameters; determine whether the lighting load is responsive to the respective electric load control technique using the one or more received lighting load electrical parameters; responsive to a determination that the lighting load is responsive to one of the plurality of electric load control techniques; cause a storage of data representative of the respective electric load control technique in communicatively coupled memory circuitry; and provide at the second interface, a control signal using the respective electric load control technique to provide ON/OFF and dimming capabilities for the lighting load.

16. The non-transitory, machine-readable, storage device of claim 15 wherein the instructions, when executed by the lighting load controller control circuitry, cause the control circuitry to: responsive to the determination, by the load controller control circuitry, that the electric load is not responsive to any of the plurality of electric load control techniques: provide at the first interface a controllably conductive device control signal to provide ON/OFF control of the electrical load.

17. The non-transitory, machine-readable, storage device of claim 15 wherein the instructions that cause the lighting load controller control circuitry to receive the input indicative of the occurrence of the event, further cause the control circuitry to: receive an input indicative of an initial power-up of the load controller control circuitry.

18. The non-transitory, machine-readable, storage device of claim 15 wherein the instructions that cause the lighting load controller control circuitry to receive the input indicative of the occurrence of the event, further cause the control circuitry to: receive an input indicative of a placement of the load controller control circuitry in a programming mode.

19. The non-transitory, machine-readable, storage device of claim 15 wherein the instructions that cause the lighting load controller control circuitry to receive the one or more lighting load electrical

parameters, further cause the control circuitry to: receive, from an operatively coupled current measurement circuit, one or more signals that include data representative of a load current through at least one of: the lighting driver circuitry or the lighting load.

20. The non-transitory, machine-readable, storage device of claim 15 wherein the instructions that cause the lighting load controller control circuitry to receive the one or more lighting load electrical parameters, the lighting control circuitry to further: receive, from a voltage measurement circuit, one or more signals that include data representative of a voltage across at least one of: the lighting driver circuitry or the lighting load.

21. The non-transitory, machine-readable, storage device of claim 20 wherein the instructions, when executed by the lighting load controller control circuitry, cause the control circuitry to: determining, by the load controller control circuitry, a power consumption of the lighting load using the measured voltage across the at least one of: the lighting driver circuitry or the lighting load.