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Inventor(s)	LI; KE et al.

DIMMING CONTROL SYSTEMS AND METHODS COMPATIBLE WITH BOTH ANALOG VOLTAGE SIGNALS AND PULSE-WIDTH-MODULATION SIGNALS

Abstract

System and method for dimming control. For example, the system for dimming control includes: a signal converter configured to receive a dimming signal and convert the dimming signal to a converted signal associated with a first duty cycle; and a current controller configured to receive the converted signal and determine a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the signal converter is further configured to: receive an analog voltage signal as the dimming signal; and convert the analog voltage signal to the converted signal based at least in part on the analog voltage signal; wherein the signal converter is also further configured to: receive a pulse-width-modulation signal as the dimming signal; and convert the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal.

Inventors: **LI; KE (Shanghai, CN), LI; ZHUOYAN (Shanghai, CN), ZHU; LIQIANG (Shanghai, CN)**

Applicant: **ON-BRIGHT INTEGRATIONS CO., LTD.** (Shanghai, CN)

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Background/Summary

1. CROSS-REFERENCES TO RELATED APPLICATIONS
[0001] This application claims priority to Chinese Patent Application No. 202110570083.8, filed May 25, 2021, incorporated by reference herein for all purposes.
2. BACKGROUND OF THE INVENTION
[0002] Certain embodiments of the present invention are directed to circuits. More particularly, some embodiments of the invention provide dimming control systems and methods compatible with multiple types of dimming signals. Merely by way of example, some embodiments of the invention have been applied to dimming control systems and methods that are compatible with both analog voltage signals and pulse-width-modulation signals. But it would be recognized that the invention has a much broader range of applicability.
[0003] Conventional lighting systems often use different types of light sources. As an example, the light sources include an incandescent lamp and/or a light-emitting-diode (LED) lamp. The brightness of these light sources usually needs to be adjusted by dimming control systems. Some dimming control systems often receive analog voltage signals as dimming signals and use the magnitudes of the analog voltage signals to adjust the brightness of some light sources. Other dimming control systems usually receive pulse-width-modulation (PWM) signals as dimming signals and use the duty cycles of the PWM signals to adjust the brightness of other light sources.
[0004] The dimming control systems with the analog voltage signals and the dimming control systems with the PWM signals are often not compatible. For example, the dimming control systems with the analog voltage signals and the dimming control systems with the PWM signals usually require different interfaces. As an example, the dimming control systems with the analog voltage signals and the dimming control systems with the PWM signals often include different peripheral circuits.
[0005] Hence it is highly desirable to improve the techniques related to dimming control.
3. BRIEF SUMMARY OF THE INVENTION
[0006] Certain embodiments of the present invention are directed to circuits. More particularly, some embodiments of the invention provide dimming control systems and methods compatible with multiple types of dimming signals. Merely by way of example, some embodiments of the invention have been applied to dimming control systems and methods that are compatible with both analog voltage signals and pulse-width-modulation signals. But it would be recognized that the invention has a much broader range of applicability.
[0007] According to certain embodiments, a system for dimming control includes: a signal converter configured to receive a dimming signal and convert the dimming signal to a converted signal associated with a first duty cycle; and a current controller configured to receive the converted signal and determine a magnitude of a current that flows through one or more light

sources based at least in part on the converted signal; wherein the signal converter is further configured to: receive an analog voltage signal as the dimming signal; and convert the analog voltage signal to the converted signal based at least in part on the analog voltage signal; wherein the signal converter is also further configured to: receive a pulse-width-modulation signal as the dimming signal; and convert the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the current controller is further configured to use the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources.

[0008] According to some embodiments, a method for dimming control includes: receiving a dimming signal; converting the dimming signal to a converted signal associated with a first duty cycle; receiving the converted signal; and determining a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving an analog voltage signal as the dimming signal; and converting the analog voltage signal to the converted signal based at least in part on the analog voltage signal; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving a pulse-width-modulation signal as the dimming signal; and converting the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the determining a magnitude of a current that flows through one or more light sources includes: using the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources.

[0009] Depending upon embodiment, one or more benefits may be achieved. These benefits and various additional objects, features and advantages of the present invention can be fully appreciated with reference to the detailed description and accompanying drawings that follow.

Description

4. BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a simplified diagram showing a system for dimming control according to certain embodiments of the present invention.

[0011] FIG. **2** shows simplified timing diagrams for the signal converter as part of the system for dimming control as shown in FIG. **1** according to some embodiments of the present invention.

[0012] FIG. **3** shows a simplified diagram for the duty cycle of the signal as a function of the magnitude of the analog voltage signal related to the signal converter as part of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0013] FIG. **4** shows a simplified diagram for the duty cycle of the signal as a function of the magnitude of the analog voltage signal related to the signal converter as part of the system for dimming control as shown in FIG. **1** according to some embodiments of the present invention.

[0014] FIG. **5** shows simplified timing diagrams for the signal converter as part of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0015] FIG. **6** shows a simplified diagram for the duty cycle of the signal as a function of the duty cycle of the pulse-width-modulation (PWM) signal related to the signal converter as part of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0016] FIG. **7** is a simplified diagram showing the gate controller of the constant-current controller as part of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0017] FIG. **8** shows simplified timing diagrams for the voltage-level conversion circuit of the gate controller as shown in FIG. **7** as part of the constant-current controller of the system for dimming control as shown in FIG. **1** according to some embodiments of the present invention.

[0018] FIG. **9** shows a simplified diagram for the signal as a function of the magnitude of the analog voltage signal related to the gate controller as shown in FIG. **7** as part of the constant-current controller of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0019] FIG. **10** shows a simplified diagram for the filtered signal as a function of the magnitude of the analog voltage signal related to the gate controller as shown in FIG. **7** as part of the constant-current controller of the system for dimming control as shown in FIG. **1** according to some embodiments of the present invention.

[0020] FIG. **11** shows a simplified diagram for the filtered signal as a function of the duty cycle of the pulse-width-modulation (PWM) signal related to the gate controller as shown in FIG. **7** as part of the constant-current controller of the system for dimming control as shown in FIG. **1** according to certain embodiments of the present invention.

[0021] FIG. **12** is a simplified diagram showing a system for dimming control according to some embodiments of the present invention.

[0022] FIG. **13** is a simplified diagram showing a method for dimming control according to certain embodiments of the present invention.

5. DETAILED DESCRIPTION OF THE INVENTION

[0023] Certain embodiments of the present invention are directed to circuits. More particularly, some embodiments of the invention provide dimming control systems and methods compatible with multiple types of dimming signals. Merely by way of example, some embodiments of the invention have been applied to dimming control systems and methods that are compatible with both analog voltage signals and pulse-width-modulation signals. But it would be recognized that the invention has a much broader range of applicability.

[0024] FIG. **1** is a simplified diagram showing a system for dimming control according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. The system **100** for dimming control includes a signal converter **110** and a current controller **120**. For example, the signal converter **110** includes an oscillator **130** and a comparator **140**. As an example, the current controller **120** (e.g., a constant-current controller) includes a gate controller **150**, a transistor **160**, and a resistor **170**. Although the above has been shown using a selected group of components for the system **100** for dimming control, there can be many alternatives, modifications, and variations. For example, some of the components may be expanded and/or combined. Other components may be inserted to those noted above. Depending upon the embodiment, the arrangement of components may be interchanged with others replaced. Further details of these components are found throughout the present specification.

[0025] As shown in FIG. **1**, the signal converter **110** includes terminals **112**, **114**, **116** and **118**, and the current controller **120** includes terminals **122**, **124** and **126** according to some embodiments. In certain examples, the terminal **112** of the signal converter **110** receives a dimming signal **113**, the terminal **114** of the signal converter **110** receives a supply voltage **115**, the terminal **116** of the signal converter **110** receives a ground voltage, and the terminal **118** of the signal converter **110** outputs a signal **119**. For example, the dimming signal **113** is an analog voltage signal. As an example, the dimming signal **113** is a pulse-width-modulation (PWM) signal (e.g., a logic signal). In some examples, the terminal **122** of the current controller **120** receives the signal **119** from the terminal **118** of the signal converter **110**, the terminal **124** of the current controller **120** is biased to the ground voltage, and the terminal **126** of the current controller **120** receives a current **127** that flows through one or more light sources. For example, the one or more light sources include one or more incandescent lamps. As an example, the one or more light sources include one or more light-emitting-diode (LED) lamps.

[0026] In certain embodiments, the signal converter **110** converts the dimming signal **113** to the signal **119**. For example, the dimming signal **113** is the analog voltage signal and/or the pulse-width-modulation (PWM) signal. As an example, the signal converter **110** uses the dimming signal **113** to determine the duty cycle of the signal **119**. For example, the signal converter **110** includes the oscillator **130** and the comparator **140**. In some examples, the oscillator **130** generates a periodic signal **132** (e.g., a periodic signal with a constant period T.sub.1). For example, the periodic signal **132** is a triangular-wave signal. As an example, the periodic signal **132** is a sawtooth-wave signal. In certain examples, the comparator **140** includes a non-inverting input terminal **142** (e.g., the "+" terminal), an inverting input terminal **144** (e.g., the "−" terminal), and an output terminal **146**. For example, the non-inverting input terminal **142** (e.g., the "+" terminal) receives the dimming signal **113**, and the inverting input terminal **144** (e.g., the "−" terminal) receives the periodic signal **132** from the oscillator **130**.
[0027] In some embodiments, the comparator **140** compares the dimming signal **113** and the periodic signal **132**, generates the signal **119** based at least in part on the dimming signal **113** and the periodic signal **132**, and outputs the signal **119** at the output terminal **146**. For example, regardless of whether the dimming signal **113** is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal **113** is larger than the periodic signal **132**, the signal **119** is at a high voltage level. As an example, regardless of whether the dimming signal **113** is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal **113** is smaller than the periodic signal **132**, the signal **119** is at a low voltage level. In certain examples, the signal **119** changes from the high voltage level to the low voltage level and changes from the low voltage level to the high voltage level. For example, the high voltage level is equal to the supply voltage **115** (e.g., AVDD) in magnitude, and the low voltage level is equal to the ground voltage (e.g., 0 volts) in magnitude. As an example, the high voltage level corresponds to a logic high level, and the low voltage level corresponds to a logic low level.
[0028] According to certain embodiments, the terminal **122** of the current controller **120** receives the signal **119** from the terminal **118** of the signal converter **110**. In some examples, the current controller **120** uses a pulse-width-modulation mechanism, a pulse-frequency-modulation mechanism, and/or a liner control mechanism to control the magnitude of the current **127** that flows through the one or more light sources. For example, the current controller **120** uses the duty cycle of the signal **119** to control the magnitude of the current **127** that flows through the one or more light sources. As an example, by controlling the magnitude of the current **127**, the current controller **120** also controls the brightness of the one or more light sources. In some examples, the one or more light sources are one or more incandescent lamps, and the brightness of the one or more incandescent lamps corresponds to the analog voltage signal **113**. In certain examples, the one or more light sources are one or more light-emitting-diode (LED) lamps, and the brightness of the one or more light-emitting-diode (LED) lamps corresponds to the pulse-width-modulation (PWM) signal **113**. In certain examples, the current controller **120** samples the duty cycle of the signal **119** and uses the sampled duty cycle to control the magnitude of the current **127** that flows through the one or more light sources. As an example, the current controller **120** provides a one-to-one correspondence between the duty cycle of the signal **119** and the current **127** that flows through the one or more light sources.
[0029] According to some embodiments, the current controller **120** includes the gate controller **150**, the transistor **160**, and the resistor **170**. For example, the gate controller **150** includes an input terminal **152**, an input terminal **154**, and an output terminal **156**. As an example, the transistor **160** includes a drain terminal **162**, a gate terminal **164**, and a source terminal **166**. For example, the resistor **170** includes a terminal **172** and a terminal **174**. In some examples, the drain terminal **162** of the transistor **160** receives the current **127** through the terminal **126** of the current controller **120**, and the current **127** flows from the drain terminal **162** to the source terminal **166** of the transistor **160**. For example, the source terminal **166** is connected to the terminal **172** of the resistor **170**. As

an example, the current **127** flows from the terminal **172** to the terminal **174** of the resistor **170**, and the terminal **174** is biased to the ground voltage. In certain examples, the resistor **170** generates a sensing voltage **173** at the terminal **172**. For example, the sensing voltage **173** is equal to the current **127** multiplied by the resistance of the resistor **170**.

[0030] In certain embodiments, the input terminal **152** of the gate controller **150** receives the signal **119** through the terminal **122**, and the input terminal **154** of the gate controller **150** receives the sensing voltage **173** from the terminal **172** of the resistor **170**. For example, based at least in part on the signal **119** and the sensing voltage **173**, the gate controller **150** generates a gate voltage **157** and outputs the gate voltage **157** at the output terminal **156**. In some embodiments, the gate voltage **157** is received by the gate terminal **164** of the transistor **160**. For example, the gate voltage **157** is used to control the magnitude of the current **127** that flows through the transistor **160**. As an example, if the gate voltage **157** increases, the current **127** also increases, and if the gate voltage **157** decreases, the current **127** also decreases.

[0031] FIG. **2** shows simplified timing diagrams for the signal converter **110** as part of the system **100** for dimming control as shown in FIG. **1** according to some embodiments of the present invention. These diagrams are merely examples, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the waveform **213** represents the dimming signal **113** that is an analog voltage signal as a function of time, the waveform **232** represents the periodic signal **132** as a function of time, and the waveform **219** represents the signal **119** as a function of time.

[0032] In certain examples, the periodic signal **132** changes between a valley voltage level **234** (e.g., V.sub.1) and a peak voltage level **236** (e.g., V.sub.2) as shown by the waveform **232**. For example, the periodic signal **132** is a triangular-wave signal. As an example, different magnitudes of the analog voltage signal **113** correspond to different magnitudes of the current **127** respectively. In some examples, the magnitude of the analog voltage signal **113** changes between a lower voltage limit (e.g., 0 volts) and an upper voltage limit (e.g., V.sub.H). For example, the lower voltage limit (e.g., 0 volts) is smaller than or equal to the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132**. As an example, the upper voltage limit (e.g., V.sub.H) is larger than or equal to the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**.

[0033] According to certain embodiments, the signal converter **110** compares the periodic signal **132** with the analog voltage signal **113** to generate the signal **119**. In some examples, the signal **119** changes between a low voltage level **214** and a high voltage level **216** as shown by the waveform **219**. As an example, if the analog voltage signal **113** is larger than the periodic signal **132**, the signal **119** is at the high voltage level **216**. For example, if the analog voltage signal **113** is smaller than the periodic signal **132**, the signal **119** is at the low voltage level **214**.

[0034] In some embodiments, the signal converter **110** converts the analog voltage signal **113** to the signal **119**. For example, as shown in FIG. **2**, the signal **119** has a duty cycle that is equal to T.sub.on divided by T, where T represents a period of the signal **119** and T.sub.on represents a time duration during which the signal **119** is at the high voltage level **216** within the period of the signal **119**. In certain examples, if the magnitude of the analog voltage signal **113** is smaller than the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132**, the signal **119** remains at the low voltage level **214** and has a duty cycle equal to zero. In some examples, if the magnitude of the analog voltage signal **113** is larger than the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the signal **119** remains at the high voltage level **216** and has a duty cycle equal to one.

[0035] In certain embodiments, if the magnitude of the analog voltage signal **113** is larger than the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132** and is smaller than the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the signal **119** changes between the low voltage level **214** and the high voltage level **216** and has a duty cycle larger than 0 and smaller than 1. For example, if the voltage magnitude of the analog voltage signal **113** is larger than the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132** and is smaller than the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the duty cycle of the signal **119** is determined as follows:

[00001] $D_{119} = \frac{V_{DIM} - V_1}{V_2 - V_1}$ (Equation1)

where D.sub.119 represents the duty cycle of the signal **119**, and V.sub.DIM represents the magnitude of the analog voltage signal **113**. Additionally, V.sub.1 represents the valley voltage level **234** of the periodic signal **132**, and V.sub.2 represents the peak voltage level **236** of the periodic signal **132**.

[0036] In some examples, as shown in Equation 1, if the constant voltage magnitude V.sub.DIM of the analog voltage signal **113** is larger than the valley voltage level V.sub.1 of the periodic signal **132** and is smaller than the peak voltage level V.sub.2 of the periodic signal **132**, the constant voltage magnitude V.sub.DIM has a one-to-one correspondence with the duty cycle D.sub.119 of the signal **119**. In certain example, Equation 1 is valid for any magnitude of the analog voltage signal **113** that is larger than or equal to the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132** and smaller than or equal to the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**. For example, if the magnitude of the analog voltage signal **113** is equal to the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132**, the duty cycle of the signal **119** is equal to zero. As an example, if the magnitude of the analog voltage signal **113** is equal to the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the duty cycle of the signal **119** is equal to one.

[0037] In certain examples, as shown by the waveform **213**, the analog voltage signal **113** remains at a constant voltage magnitude that does not change with time. For example, the constant voltage magnitude is larger than or equal to the lower voltage limit (e.g., 0 volts) and is smaller than or equal to the upper voltage limit (e.g., V.sub.H). As an example, the constant voltage magnitude of the analog voltage signal **113** corresponds to a constant duty cycle D.sub.119 of the signal **119** as shown by the waveform **219**.

[0038] FIG. **3** shows a simplified diagram for the duty cycle of the signal **119** as a function of the magnitude of the analog voltage signal **113** related to the signal converter **110** as part of the system **100** for dimming control as shown in FIG. **1** according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** changes from the lower voltage limit 0 volts to the upper voltage limit V.sub.H. As an example, the valley voltage level V.sub.1 of the periodic signal **132** is equal to 0 volts, and the peak voltage level V.sub.2 of the periodic signal **132** is equal to V.sub.H.

[0039] As shown in FIG. **3**, the duty cycle D.sub.119 of the signal **119** increases linearly with the increasing magnitude of the analog voltage signal **113** according to some embodiments. For example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is equal to 0 volts, which is also equal to the valley voltage level V.sub.1 of the periodic signal **132**, the duty cycle D.sub.119 of the signal **119** is equal to zero according to Equation 1. As an example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is equal to V.sub.H, which is also equal to the peak voltage level V.sub.2 of the periodic signal **132**, the duty cycle D.sub.119 of the signal **119** is equal to one according to Equation 1. In certain examples, when the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** increases from 0 volts to V.sub.H, the duty cycle D.sub.119 of the signal **119** increases from 0 to 1 linearly as a function of the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** according to Equation 1.

[0040] FIG. **4** shows a simplified diagram for the duty cycle of the signal **119** as a function of the magnitude of the analog voltage signal **113** related to the signal converter **110** as part of the system **100** for dimming control as shown in FIG. **1** according to some embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** changes from the lower voltage limit 0 volts to the upper voltage limit V.sub.H. As an example, the valley voltage level V.sub.1 of the periodic signal **132** is larger than 0 volts, and the peak voltage level V.sub.2 of the periodic signal **132** is smaller than V.sub.H.

[0041] For example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is larger than or equal to 0 volts and smaller than or equal to the valley voltage level V.sub.1 of the periodic signal **132**, the duty cycle D.sub.119 of the signal **119** is equal to zero. As an example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is larger than or equal to the peak voltage level V.sub.2 of the periodic signal **132** and smaller than or equal to V.sub.H, the duty cycle D.sub.119 of the signal **119** is equal to one. As shown in FIG. **3**, when the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** increases from the valley voltage level V.sub.1 to the peak voltage level V.sub.2, the duty cycle D.sub.119 of the signal **119** increases from 0 to 1 linearly as a function of the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** according to certain embodiments.

[0042] FIG. **5** shows simplified timing diagrams for the signal converter **110** as part of the system **100** for dimming control as shown in FIG. **1** according to certain embodiments of the present invention. These diagrams are merely examples, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the waveform **513** represents the dimming signal **113** that is a pulse-width-modulation (PWM) signal as a function of time, the waveform **532** represents the periodic signal **132** as a function of time, and the waveform **519** represents the signal **119** as a function of time.

[0043] In certain examples, the periodic signal **132** changes between a valley voltage level **534** (e.g., V.sub.1) and a peak voltage level **536** (e.g., V.sub.2) as shown by the waveform **532**. For example, the periodic signal **132** is a triangular-wave signal. In some examples, the pulse-width-modulation (PWM) signal **113** changes between a low voltage level **514** (e.g., 0 volts) and a high voltage level **518** (e.g., V.sub.O). For example, the low voltage level **514** (e.g., 0 volts) is smaller than or equal to the valley voltage level **534** (e.g., V.sub.1). As an example, the high voltage level **518** (e.g., V.sub.O) is larger than or equal to the peak voltage level **536** (e.g., V.sub.2). In certain examples, the duty cycle of the pulse-width-modulation (PWM) signal **113** changes between 0 and 1. For example, different magnitudes of the duty cycle for the pulse-width-modulation (PWM) signal **113** correspond to different magnitudes of the current **127** respectively.

[0044] According to some embodiments, the signal converter **110** compares the periodic signal **132** with the pulse-width-modulation (PWM) signal **113** to generate the signal **119**. In some examples, the signal **119** changes between a low voltage level **514** and a high voltage level **516** as shown by the waveform **519**. For example, if the pulse-width-modulation (PWM) signal **113** is larger than the periodic signal **132**, the signal **119** is at the high voltage level **516**. As an example, if the pulse-width-modulation (PWM) signal **113** is smaller than the periodic signal **132**, the signal **119** is at the low voltage level **514**. In certain examples, the high voltage level **518** (e.g., V.sub.O) of the pulse-width-modulation (PWM) signal **113** is equal to or different from the high voltage level **516** of the signal **119**.

[0045] According to certain embodiments, the low voltage level **514** is the same as the low voltage level **214**, and the high voltage level **516** is the same as the high voltage level **216**. For example, both the low voltage level **214** and the same as the low voltage level **514** are equal to the ground voltage (e.g., 0 volts) in magnitude. As an example, the high voltage level **216** and the high voltage level **516** are equal to the supply voltage **115** (e.g., AVDD) in magnitude.

[0046] In some embodiments, the signal converter **110** converts the analog voltage signal **113** to the signal **119**. For example, if the pulse-width-modulation (PWM) signal **113** is at the high voltage level (e.g., V.sub.O), which is larger than the peak voltage level **536** (e.g., V.sub.2), the pulse-width-modulation (PWM) signal **113** is larger than the periodic signal **132** and the signal **119** is at the high voltage level **516**. As an example, if the pulse-width-modulation (PWM) signal **113** is at the low voltage level **514** (e.g., 0 volts), which is smaller than the valley voltage level **534** (e.g., V.sub.1), the pulse-width-modulation (PWM) signal **113** is smaller than the periodic signal **132** and the signal **119** is at the low voltage level **514**.

[0047] In certain embodiments, the duty cycle of the signal **119** is equal to the duty cycle of the pulse-width-modulation (PWM) signal **113** as shown by the waveform **519** and the waveform **513**. For example, the duty cycle of the pulse-width-modulation (PWM) signal **113** has a one-to-one correspondence with the duty cycle of the signal **119**. In some examples, as shown by the waveform **513**, the pulse-width-modulation (PWM) signal **113** has a duty cycle that is equal to T.sub.on divided by T, where T represents a period of the pulse-width-modulation (PWM) signal **113** and T.sub.on represents a time duration during which the pulse-width-modulation (PWM) signal **113** is at the high voltage level **518** (e.g., V.sub.O) within the period of the pulse-width-modulation (PWM) signal **113**. In certain examples, as shown by the waveform **519**, the signal **119** has a duty cycle that is equal to T.sub.on divided by T, where T represents a period of the signal **119** and T.sub.on represents a time duration during which the signal **119** is at the high voltage level **516** within the period of the signal **119**.

[0048] FIG. **6** shows a simplified diagram for the duty cycle of the signal **119** as a function of the duty cycle of the pulse-width-modulation (PWM) signal **113** related to the signal converter **110** as part of the system **100** for dimming control as shown in FIG. **1** according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications.

[0049] In certain examples, the periodic signal **132** changes between a valley voltage level V.sub.1 and a peak voltage level V.sub.2, and the pulse-width-modulation (PWM) signal **113** changes from a low voltage level 0 volts to a high voltage level V.sub.O. For example, the low voltage level 0 volts is smaller than the valley voltage level V.sub.1. As an example, the high voltage level V.sub.O is larger than the peak voltage level V.sub.2. In some examples, the duty cycle of the pulse-width-modulation (PWM) signal **113** changes between 0 and 1. For example, different magnitudes of the duty cycle for the pulse-width-modulation (PWM) signal **113** correspond to different magnitudes of the current **127** respectively.

[0050] As shown in FIG. **6**, when the duty cycle of the pulse-width-modulation (PWM) signal **113** increases from 0 and 1, the duty cycle of the signal **119** increases from 0 to 1 linearly as a function of the duty cycle of the pulse-width-modulation (PWM) signal **113**, according to some embodiments. For example, the duty cycle of the signal **119** is equal to the duty cycle of the pulse-width-modulation (PWM) signal **113**.

[0051] FIG. **7** is a simplified diagram showing the gate controller **150** of the current controller **120** as part of the system **100** for dimming control as shown in FIG. **1** according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. The gate controller **150** includes a voltage-level conversion circuit **710**, a filtering circuit **720**, and an operational amplifier **730**. For example, the voltage-level conversion circuit **710** includes a comparator **740**, a buffer **750**, and a switch **760**. As an example, the filtering circuit **720** includes a resistor **770** and a capacitor **780**. Although the above has been shown using a selected group of components for the gate controller **150**, there can be many alternatives, modifications, and variations. For example, some of the components may be expanded and/or combined. Other components may be inserted to those noted above. Depending upon the embodiment, the arrangement of components may be interchanged with others replaced. Further details of these components are found throughout the present specification.

[0052] In some embodiments, the voltage-level conversion circuit **710** receives the signal **119** and generates a signal **711** based at least in part on the signal **119**, wherein the signal **119** changes between a high voltage level and a low voltage level and the signal **711** changes between another high voltage level and the same low voltage level. For example, the high voltage level of the signal **119** is equal to the supply voltage **115** (e.g., AVDD), and the low voltage level of the signal **119** is equal to the ground voltage (e.g., 0 volts). As an example, the high voltage level of the signal **711** is equal to a predetermined reference voltage (e.g., V.sub.ref1), and the low voltage level of the signal **711** is equal to the ground voltage (e.g., 0 volts), wherein the predetermined reference voltage (e.g., V.sub.ref1) is different from (e.g., smaller than) the supply voltage **115** (e.g., AVDD). In certain examples, if the signal **119** is at the supply voltage **115** (e.g., AVDD), the signal **711** is at the predetermined reference voltage (e.g., V.sub.ref1), wherein the supply voltage **115** (e.g., AVDD) and the predetermined reference voltage (e.g., V.sub.ref1) are not equal. In some examples, if the signal **119** is at the ground voltage (e.g., 0 volts), the signal **711** is also at the ground voltage (e.g., 0 volts). For example, the signal **119** and the signal **711** have the same frequency and the same phase. As an example, the signal **119** and the signal **711** have the same duty cycle.

[0053] In certain embodiments, the predetermined reference voltage (e.g., V.sub.ref1) of the signal **711** is smaller than the supply voltage **115** (e.g., AVDD) of the signal **119**. For example, if the signal **119** is smaller than the predetermined reference voltage (e.g., V.sub.ref1), the voltage-level conversion circuit **710** generates the signal **711** at the ground voltage (e.g., 0 volts). As an example, if the signal **119** is larger than the predetermined reference voltage (e.g., V.sub.ref1), the voltage-level conversion circuit **710** generates the signal **711** at the predetermined reference voltage (e.g., V.sub.ref1).

[0054] As shown in FIG. **7**, the voltage-level conversion circuit **710** includes the comparator **740**, the buffer **750**, and the switch **760** according to some embodiments. For example, the comparator **740** includes a non-inverting input terminal **742** (e.g., the "+" terminal), an inverting input terminal **744** (e.g., the "−" terminal), and an output terminal **746**. As an example, the buffer **750** includes a non-inverting input terminal **752** (e.g., the "+" terminal), an inverting input terminal **754** (e.g., the "−" terminal), and an output terminal **756**. In certain examples, the non-inverting input terminal **742** (e.g., the "+" terminal) of the comparator **740** receives the predetermined reference voltage (e.g., V.sub.ref1), and the inverting input terminal **744** (e.g., the "−" terminal) of the comparator **740** receives the signal **119**. For example, the comparator **740** compares the predetermined reference voltage (e.g., V.sub.ref1) and the signal **119** and generates a comparison signal **747** at the output terminal **756**. As an example, the comparison signal **747** is used to control the switch **760**. In some examples, the non-inverting input terminal **752** (e.g., the "+" terminal) of the buffer **750** receives the predetermined reference voltage (e.g., V.sub.ref1), and the inverting input terminal **754** (e.g., the "−" terminal) of the buffer **750** is connected to the output terminal **756** of the buffer **750**. For example, the output terminal **756** of the buffer **750** is biased at the predetermined reference voltage (e.g., V.sub.ref1).

[0055] According to certain embodiments, the switch **760** includes terminals **766** and **768**. For example, the terminal **768** is connected to a terminal **772** of the resistor **770**. As an example, the terminal **768** is connected to a terminal **762** or a terminal **764**. For example, if the comparison signal **747** is at a logic high level, the terminal **768** is connected to the terminal **762**, and the signal **711** is equal to the signal **119**. As an example, if the comparison signal **747** is at a logic low level, the terminal **768** is connected to the terminal **764**, which is connected to the inverting input terminal **754** (e.g., the "−" terminal) and the output terminal **756** of the buffer **750**, and the signal **711** is equal to the predetermined reference voltage (e.g., V.sub.ref1). In some examples, if the signal **119** is at the ground voltage (e.g., 0 volts), the comparison signal **747** is at the logic high level, so that the terminal **768** is connected to the terminal **762** and the signal **711** is also at the ground voltage (e.g., 0 volts). In certain examples, if the signal **119** is at the supply voltage **115** (e.g., AVDD), the comparison signal **747** is at the logic low level, so that the terminal **768** is connected to the terminal **764** and the signal **711** is equal to the predetermined reference voltage

(e.g., V.sub.ref1).
[0056] In some embodiments, the filtering circuit **720** receives the signal **711** and generates a filtered signal **721** based at least in part on the signal **711**. For example, the filtering circuit **720** performs filtering on the signal **711** to generate the filtered signal **721**. As an example, the filtering circuit **720** outputs the filtered signal **721** to the operational amplifier **730**. In certain examples, the filtering circuit **720** is an RC filtering circuit that includes the resistor **770** and the capacitor **780**. For example, the resistor **770** includes terminals **772** and **774**. As an example, the capacitor **780** includes terminals **782** and **784**. In some examples, the terminal **774** of the resistor **770** is connected to the terminal **782** of the capacitor **780**, and the terminal **784** of the capacitor **780** is biased to the ground voltage (e.g., 0 volts). For example, the terminal **772** of the resistor **770** receives the signal **711**. As an example, the terminal **774** of the resistor **770** and the terminal **782** of the capacitor **780** are biased to the filtered signal **721**.
[0057] In certain embodiments, the filtered signal **721** is determined by the duty cycle of the signal **711** and the high voltage level of the signal **711**. For example, the duty cycle of the signal **711** is equal to the duty cycle of the signal **119**, and the high voltage level of the signal **711** is equal to the predetermined reference voltage (e.g., V.sub.ref1). In some examples, the filtered signal **721** is determined as follows:
[00002] $V_{721}=V_{\mathrm{ref1}}\times D_{119}$ (Equation2)
where V.sub.721 represents the filtered signal **721**, and D.sub.119 represents the duty cycle of the signal **119**. Additionally, V.sub.ref1 represents the predetermined reference voltage, which is received by the non-inverting input terminal **742** (e.g., the "+" terminal) of the comparator **740** and the non-inverting input terminal **752** (e.g., the "+" terminal) of the buffer **750**. For example, as shown by Equation 2, if the duty cycle of the signal **119** is equal to one, the filtered signal **721** is equal to the predetermined reference voltage V.sub.ref1.
[0058] In some examples, according to Equation 2, the filtered signal **721** depends on the duty cycle of the signal **119**. For example, if the dimming signal **113** is an analog voltage signal, the duty cycle of the signal **119** depends on the magnitude of the analog voltage signal **113**, and if the dimming signal **113** is a pulse-width-modulation (PWM) signal, the duty cycle of the signal **119** depends on the duty cycle of the pulse-width-modulation (PWM) signal **113**. As an example, if the dimming signal **113** is an analog voltage signal, the filtered signal **721** depends on the magnitude of the analog voltage signal **113**, and if the dimming signal **113** is a pulse-width-modulation (PWM) signal, the filtered signal **721** depends on the duty cycle of the pulse-width-modulation (PWM) signal **113**.
[0059] According to some embodiments, if the dimming signal **113** is an analog voltage signal, the filtered signal **721** depends on the magnitude of the analog voltage signal **113**. For example, if the magnitude of the analog voltage signal **113** is smaller than the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132**, the signal **119** has a duty cycle equal to zero and the filtered signal **721** is equal to zero according to Equation 2. As an example, if the magnitude of the analog voltage signal **113** is larger than the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the signal **119** has a duty cycle equal to one and the filtered signal **721** is equal to the predetermined reference voltage V.sub.ref1 according to Equation 2. For example, if the magnitude of the analog voltage signal **113** is larger than the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132** and is smaller than the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the filtered signal **721** is determined as follows:
[00003] $V_{721}=V_{\mathrm{ref1}}\times\frac{V_{\mathrm{DIM}}-V_1}{V_2-V_1}$ (Equation3)
Where V.sub.721 represents the filtered signal **721**, and V.sub.ref1 represents the predetermined reference voltage, which is received by the non-inverting input terminal **742** (e.g., the "+" terminal) of the comparator **740** and the non-inverting input terminal **752** (e.g., the "+" terminal) of the buffer **750**. Additionally, V.sub.DIM represents the magnitude of the analog voltage signal **113**.

Also, V.sub.1 represents the valley voltage level **234** of the periodic signal **132**, and V.sub.2 represents the peak voltage level **236** of the periodic signal **132**.

[0060] In some examples, as shown in Equation 3, if the voltage magnitude V.sub.DIM of the analog voltage signal **113** is larger than the valley voltage level V.sub.1 of the periodic signal **132** and is smaller than the peak voltage level V.sub.2 of the periodic signal **132**, the voltage magnitude V.sub.DIM has a one-to-one correspondence with the filtered signal **721**. In certain example, Equation 3 is valid for any magnitude of the analog voltage signal **113** that is larger than or equal to the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132** and smaller than or equal to the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**. For example, if the magnitude of the analog voltage signal **113** is equal to the valley voltage level **234** (e.g., V.sub.1) of the periodic signal **132**, the filtered signal **721** is equal to zero. As an example, if the magnitude of the analog voltage signal **113** is equal to the peak voltage level **236** (e.g., V.sub.2) of the periodic signal **132**, the filtered signal **721** is equal to the predetermined reference voltage V.sub.ref1.

[0061] According to certain embodiments, if the dimming signal **113** is a pulse-width-modulation (PWM) signal, the filtered signal **721** depends on the duty cycle of the pulse-width-modulation (PWM) signal **113**. For example, the filtered signal **721** is determined as follows:

[00004] $V_{721} = V_{\mathrm{ref1}} \times D_{113}$ (Equation4)

where V.sub.721 represents the filtered signal **721**, and D.sub.113 represents the duty cycle of the pulse-width-modulation (PWM) signal **113**. Additionally, V.sub.ref1 represents the predetermined reference voltage, which is received by the non-inverting input terminal **742** (e.g., the "+" terminal) of the comparator **740** and the non-inverting input terminal **752** (e.g., the "+" terminal) of the buffer **750**.

[0062] In some embodiments, the operational amplifier **730** includes a non-inverting input terminal **732** (e.g., the "+" terminal), an inverting input terminal **734** (e.g., the "−" terminal), and an output terminal **736**. For example, the non-inverting input terminal **732** (e.g., the "+" terminal) receives the filtered signal **721**. As an example, the inverting input terminal **734** (e.g., the "−" terminal) receives the sensing voltage **173**, which indicates the magnitude of the current **127**. In some examples, the operational amplifier **730** generates the gate voltage **157** and outputs the gate voltage **157** at the output terminal **736**. For example, the gate voltage **157** is received by the gate terminal **164** of the transistor **160** and used to control the magnitude of the current **127** that flows through the transistor **160**. As an example, if the gate voltage **157** increases, the current **127** also increases, and if the gate voltage **157** decreases, the current **127** also decreases. In certain embodiments, the current controller **120** that includes the gate controller **150** as shown in FIG. **7** uses the liner control mechanism to control the magnitude of the current **127** that flows through the one or more light sources.

[0063] FIG. **8** shows simplified timing diagrams for the voltage-level conversion circuit **710** of the gate controller **150** as shown in FIG. **7** as part of the current controller **120** of the system **100** for dimming control as shown in FIG. **1** according to some embodiments of the present invention. These diagrams are merely examples, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the waveform **819** represents the signal **119** as a function of time, and the waveform **811** represents the signal **711** as a function of time.

[0064] According to certain embodiments, the signal **119** changes between the supply voltage **115** (e.g., AVDD) and the ground voltage (e.g., 0 volts) as shown by the waveform **819**, and the signal **711** changes between the predetermined reference voltage (e.g., V.sub.ref1) and the ground voltage (e.g., 0 volts) as shown by the waveform **811**. In some examples, the supply voltage **115** (e.g., AVDD) is larger than the predetermined reference voltage (e.g., V.sub.ref1). In certain examples, the signal **119** and the signal **711** have the same frequency and the same phase. As an example, the signal **119** and the signal **711** have the same duty cycle.

[0065] In some embodiments, as shown by the waveform **819**, the signal **119** has a duty cycle that is equal to T.sub.on divided by T, where T represents a period of the signal **119** and T.sub.on represents a time duration during which the signal **119** is at the supply voltage **115** (e.g., AVDD) within the period of the signal **119**. In certain embodiments, as shown by the waveform **811**, the signal **711** has a duty cycle that is equal to T.sub.on divided by T, where T represents a period of the signal **711** and T.sub.on represents a time duration during which the signal **711** is at the predetermined reference voltage (e.g., V.sub.ref1) within the period of the signal **711**.

[0066] FIG. **9** shows a simplified diagram for the filtered signal **721** as a function of the magnitude of the analog voltage signal **113** related to the gate controller **150** as shown in FIG. **7** as part of the current controller **120** of the system **100** for dimming control as shown in FIG. **1** according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** changes from the lower voltage limit 0 volts to the upper voltage limit V.sub.H. As an example, the valley voltage level V.sub.1 of the periodic signal **132** is equal to 0 volts, and the peak voltage level V.sub.2 of the periodic signal **132** is equal to V.sub.H.

[0067] As shown in FIG. **9**, the filtered signal **721** (e.g., Vs) increases linearly with the increasing magnitude of the analog voltage signal **113** according to some embodiments. For example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is equal to 0 volts, which is also equal to the valley voltage level V.sub.1 of the periodic signal **132**, the filtered signal **721** (e.g., Vs) is equal to 0 volts to Equation 3. As an example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is equal to V.sub.H, which is also equal to the peak voltage level V.sub.2 of the periodic signal **132**, the filtered signal **721** (e.g., Vs) is equal to the predetermined reference voltage V.sub.ren according to Equation 3. In certain examples, when the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** increases from 0 volts to V.sub.H, the filtered signal **721** (e.g., Vs) increases from 0 volts to the predetermined reference voltage V.sub.ref1 linearly as a function of the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** according to Equation 3.

[0068] FIG. **10** shows a simplified diagram for the filtered signal **721** as a function of the magnitude of the analog voltage signal **113** related to the gate controller **150** as shown in FIG. **7** as part of the current controller **120** of the system **100** for dimming control as shown in FIG. **1** according to some embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. For example, the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** changes from the lower voltage limit 0 volts to the upper voltage limit V.sub.H. As an example, the valley voltage level V.sub.1 of the periodic signal **132** is larger than 0 volts, and the peak voltage level V.sub.2 of the periodic signal **132** is smaller than V.sub.H.

[0069] For example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is larger than or equal to 0 volts and smaller than or equal to the valley voltage level V.sub.1 of the periodic signal **132**, the filtered signal **721** (e.g., Vs) is equal to 0 volts. As an example, if the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** is larger than or equal to the peak voltage level V.sub.2 of the periodic signal **132** and smaller than or equal to V.sub.H, the filtered signal **721** (e.g., Vs) is equal to the predetermined reference voltage V.sub.refi. As shown in FIG. **10**, when the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** increases from the valley voltage level V.sub.1 to the peak voltage level V.sub.2, the filtered signal **721** (e.g., Vs) increases from 0 volts to the predetermined reference voltage V.sub.ref1 linearly as a function of the magnitude (e.g., V.sub.DIM) of the analog voltage signal **113** according to certain embodiments.

[0070] FIG. **11** shows a simplified diagram for the filtered signal **721** as a function of the duty cycle of the pulse-width-modulation (PWM) signal **113** related to the gate controller **150** as shown in FIG. **7** as part of the current controller **120** of the system **100** for dimming control as shown in

FIG. **1** according to certain embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications.

[0071] In certain examples, the periodic signal **132** changes between a valley voltage level V.sub.1 and a peak voltage level V.sub.2, and the pulse-width-modulation (PWM) signal **113** changes from a low voltage level 0 volts to a high voltage level V.sub.O. For example, the low voltage level 0 volts is smaller than the valley voltage level V.sub.1. As an example, the high voltage level V.sub.O is larger than the peak voltage level V.sub.2. In some examples, the duty cycle of the pulse-width-modulation (PWM) signal **113** changes between 0 and 1. For example, different magnitudes of the duty cycle for the pulse-width-modulation (PWM) signal **113** correspond to different magnitudes of the current **127** respectively.

[0072] As shown in FIG. **11**, when the duty cycle of the pulse-width-modulation (PWM) signal **113** increases from 0 and 1, the filtered signal **721** (e.g., Vs) increases from 0 volts to the predetermined reference voltage V.sub.ref1 linearly as a function of the duty cycle of the pulse-width-modulation (PWM) signal **113**, according to some embodiments.

[0073] FIG. **12** is a simplified diagram showing a system for dimming control according to some embodiments of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. The system **1200** for dimming control includes a signal converter **1210** and a current controller **1220**. For example, the signal converter **1210** includes an oscillator **1230** and a comparator **1240**. As an example, the current controller **1220** (e.g., a constant-current controller) includes an operational amplifier **1250**, a resistor **1270**, transistors **1260** and **1280**, and a NOT gate **1290**. Although the above has been shown using a selected group of components for the system **1200** for dimming control, there can be many alternatives, modifications, and variations. For example, some of the components may be expanded and/or combined. Other components may be inserted to those noted above. Depending upon the embodiment, the arrangement of components may be interchanged with others replaced. Further details of these components are found throughout the present specification.

[0074] As shown in FIG. **12**, the signal converter **1210** includes terminals **1212**, **1214**, **1216** and **1218**, and the current controller **1220** includes terminals **1222**, **1224**, **1226** and **1228** according to some embodiments. In certain examples, the terminal **1212** of the signal converter **1210** receives a dimming signal **1213**, the terminal **1214** of the signal converter **1210** receives a supply voltage **1215**, the terminal **1216** of the signal converter **1210** receives a ground voltage, and the terminal **1218** of the signal converter **1210** outputs a signal **1219**. For example, the dimming signal **1213** is an analog voltage signal. As an example, the dimming signal **1213** is a pulse-width-modulation (PWM) signal (e.g., a logic signal). In some examples, the terminal **1228** of the current controller **1220** receives the signal **1219** from the terminal **1218** of the signal converter **1210**, the terminal **1222** of the current controller **1220** receives a predetermined reference voltage **1223** (e.g., V.sub.ref2), the terminal **1224** of the current controller **1220** is biased to the ground voltage, and the terminal **1226** of the current controller **1220** receives a current **1227** that flows through one or more light sources. For example, the one or more light sources include one or more incandescent lamps. As an example, the one or more light sources include one or more light-emitting-diode (LED) lamps.

[0075] In certain embodiments, the signal converter **1210** converts the dimming signal **1213** to the signal **1219**. For example, the dimming signal **1213** is the analog voltage signal and/or the pulse-width-modulation (PWM) signal. As an example, the signal converter **1210** uses the dimming signal **1213** to determine the duty cycle of the signal **1219**. For example, the signal converter **1210** includes the oscillator **1230** and the comparator **1240**. In some examples, the oscillator **1230** generates a periodic signal **1232** (e.g., a periodic signal with a constant period T.sub.2). For example, the periodic signal **1232** is a triangular-wave signal. As an example, the periodic signal

1232 is a sawtooth-wave signal. In certain examples, the comparator **1240** includes a non-inverting input terminal **1242** (e.g., the "+" terminal), an inverting input terminal **1244** (e.g., the "−" terminal), and an output terminal **1246**. For example, the non-inverting input terminal **1242** (e.g., the "+" terminal) receives the dimming signal **1213**, and the inverting input terminal **1244** (e.g., the "−" terminal) receives the periodic signal **1232** from the oscillator **1230**.

[0076] In some embodiments, the comparator **1240** compares the dimming signal **1213** and the periodic signal **1232**, generates the signal **1219** based at least in part on the dimming signal **1213** and the periodic signal **1232**, and outputs the signal **1219** at the output terminal **1246**. For example, regardless of whether the dimming signal **1213** is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal **1213** is larger than the periodic signal **1232**, the signal **1219** is at a high voltage level. As an example, regardless of whether the dimming signal **1213** is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal **1213** is smaller than the periodic signal **1232**, the signal **1219** is at a low voltage level. In certain examples, the signal **1219** changes from the high voltage level to the low voltage level and changes from the low voltage level to the high voltage level. For example, the high voltage level is equal to the supply voltage **1215** (e.g., AVDD) in magnitude, and the low voltage level is equal to the ground voltage (e.g., 0 volts) in magnitude. As an example, the high voltage level corresponds to a logic high level, and the low voltage level corresponds to a logic low level.

[0077] According to certain embodiments, the terminal **1228** of the current controller **1220** receives the signal **1219** from the terminal **1218** of the signal converter **1210**. In some examples, the current controller **1220** uses a pulse-width-modulation mechanism, a pulse-frequency-modulation mechanism, and/or a liner control mechanism to control the magnitude of the current **1227** that flows through the one or more light sources. In certain examples, by controlling the magnitude of the current **1227**, the current controller **1220** also controls the brightness of the one or more light sources. For example, the one or more light sources are one or more incandescent lamps, and the brightness of the one or more incandescent lamps corresponds to the analog voltage signal **1213**. In certain examples, the one or more light sources are one or more light-emitting-diode (LED) lamps, and the brightness of the one or more light-emitting-diode (LED) lamps corresponds to the pulse-width-modulation (PWM) signal **1213**.

[0078] According to some embodiments, the current controller **1220** includes the operational amplifier **1250**, the resistor **1270**, the transistors **1260** and **1280**, and the NOT gate **1290**. For example, the operational amplifier **1250** includes a non-inverting input terminal **1252** (e.g., the "+" terminal), an inverting input terminal **1254** (e.g., the "−" terminal), and an output terminal **1256**. As an example, the transistor **1260** includes a drain terminal **1262**, a gate terminal **1264**, and a source terminal **1266**, and the transistor **1280** includes a drain terminal **1282**, a gate terminal **1284**, and a source terminal **1286**. For example, the NOT gate **1290** includes an input terminal **1292** and an output terminal **1294**, and the resistor **1270** includes a terminal **1272** and a terminal **1274**.

[0079] In some examples, the non-inverting input terminal **1252** (e.g., the "+" terminal) of the operational amplifier **1250** receives the predetermined reference voltage **1223** (e.g., V.sub.ref2) through the terminal **1222** of the current controller **1220**, the inverting input terminal **1254** (e.g., the "−" terminal) of the operational amplifier **1250** is connected to the source terminal **1266** of the transistor **1260** and the terminal **1272** of the resistor **1270**, and the output terminal **1256** of the operational amplifier **1250** is connected to the gate terminal **1264** of the transistor **1260** and the drain terminal **1282** of the transistor **1280**. For example, the drain terminal **1262** of the transistor **1260** receives the current **1227** through the terminal **1226** of the current controller **1220**. As an example, the source terminal **1286** of the transistor **1280** and the terminal **1274** of the resistor **1270** are connected and biased to the ground voltage through the terminal **1224** of the current controller **1220**. In certain examples, the NOT gate **1290** includes an input terminal **1292** and an output terminal **1294**. For example, the input terminal **1292** of the NOT gate **1290** receives the signal **1219** through the terminal **1228** of the current controller **1220**. As an example, the output terminal **1294**

of the NOT gate **1290** is connected to the gate terminal **1284** of the transistor **1280**.
[0080] In certain embodiments, the NOT gate **1290** generates a signal **1295** based at least in part on the signal **1219** and outputs the signal **1295** at the output terminal **1294**. For example, if the signal **1219** is at the high voltage level, the signal **1295** is at a low voltage level corresponding to a logic low level. As an example, if the signal **1219** is at the low voltage level, the signal **1295** is at a high voltage level corresponding to a logic high level. In some examples, the signal **1295** is received by the gate terminal **1284** of the transistor **1280**. For example, if the signal **1295** is at the low voltage level corresponding to the logic low level, the transistor **1280** is turned off. As an example, if the signal **1295** is at the high voltage level corresponding to the logic high level, the transistor **1280** is turned on.
[0081] In some embodiments, the gate terminal **1264** of the transistor **1260** is connected to the output terminal **1256** of the operational amplifier **1250** and the drain terminal **1282** of the transistor **1280**. For example, if the transistor **1280** is turned on, with the source terminal **1286** of the transistor **1280** being biased to the ground voltage, the gate terminal **1264** of the transistor **1260** is at a low voltage level, causing the transistor **1260** to be turned off and the current **1227** to be equal to zero in magnitude. As an example, if the transistor **1280** is turned off, the gate terminal **1264** of the transistor **1260** receives a voltage signal **1257** that is generated by the operational amplifier **1250**, and the voltage signal **1257** is used to control the current **1227** that flows through the one or more light sources.
[0082] According to certain embodiments, if the transistor **1280** is turned off, the voltage signal **1257** is used to control the current **1227** that flows through the one or more light sources. For example, when the transistor **1280** is turned on, if the voltage signal **1257** increases, the current **1227** also increases, and if the voltage signal **1257** decreases, the current **1227** also decreases. As an example, the resistor **1270** generates a sensing voltage **1273** that represents the magnitude of the current **1227**, and the sensing voltage **1273** is received by the inverting input terminal **1254** (e.g., the "−" terminal) of the operational amplifier **1250**.
[0083] According to some embodiments, the non-inverting input terminal **1252** (e.g., the "−" terminal) of the operational amplifier **1250** receives the predetermined reference voltage **1223** (e.g., V.sub.ref2) through the terminal **1222** of the current controller **1220**. For example, the voltage signal **1257** is generated by the operational amplifier **1250** based at least in part on the predetermined reference voltage **1223** (e.g., V.sub.ref2) and the sensing voltage **1273**. As example, if the transistor **1280** is turned on, the current **1227** that flows through the one or more light sources is equal to the predetermined reference voltage **1223** (e.g., V.sub.ref2) divided by the resistance of the resistor **1270**.
[0084] As shown in FIG. **12**, when the signal **1219** is at the high voltage level, the current **1227** that flows through the one or more light sources is equal to the predetermined reference voltage **1223** (e.g., V.sub.ref2) divided by the resistance of the resistor **1270**, and when the signal **1219** is at the low voltage level, the current **1227** that flows through the one or more light sources is equal to zero according to certain embodiments. According to some embodiments, the average magnitude of the current **1227** is determined as follows:

$$I\text{.sub.ave\_1227}=V\text{.sub.ref2}/R\text{.sub.1270}\times D\text{.sub.1219} \qquad \text{(Equation 5)}$$

where I.sub.ave_1227 represents the average magnitude of the current **1227**. Additionally, V.sub.ref2 represents the predetermined reference voltage **1223**, and R.sub.1270 represents the resistance of the resistor **1270**. Also, D.sub.1219 represents the duty cycle of the signal **1219**. As an example, the current controller **1220** provides a one-to-one correspondence between the duty cycle of the signal **1219** and the average magnitude of the current **1227** that flows through the one or more light sources.
[0085] FIG. **13** is a simplified diagram showing a method for dimming control according to certain embodiments of the present invention. This diagram is merely an example, which should not

unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. The method **1300** for dimming control includes a process **1310** for powering up a system for dimming control, a process **1320** for obtaining a dimming signal, a process **1330** for converting the dimming signal to a converted signal, and a process **1340** for using a duty cycle of the converted signal to control a current that flows through one or more light sources. Although the above has been shown using a selected group of processes for the method **1300** for dimming control, there can be many alternatives, modifications, and variations. For example, some of the processes may be expanded and/or combined. Other processes may be inserted to those noted above. Depending upon the embodiment, the sequence of processes may be interchanged with others replaced. Further details of these processes are found throughout the present specification.

[0086] At the process **1310**, a system for dimming control is powered up according to some embodiments. For example, the system for dimming control is the system **100** for dimming control, which is powered up by at least receiving the supply voltage **115** at the terminal **114** of the signal converter **110** as part of the system **100** for dimming control. As an example, the system for dimming control is the system **1200** for dimming control, which is powered up by at least receiving the supply voltage **1215** at the terminal **1214** of the signal converter **1210** as part of the system **1200** for dimming control.

[0087] At the process **1320**, a dimming signal is obtained according to certain embodiments. For example, the dimming signal is an analog voltage signal. As an example, the dimming signal is a pulse-width-modulation (PWM) signal. In some examples, the dimming signal **113** is received at the terminal **112** of the signal converter **110** as part of the system **100** for dimming control. In certain examples, the dimming signal **1213** is received at the terminal **1212** of the signal converter **1210** as part of the system **1200** for dimming control.

[0088] At the process **1330**, the dimming signal is converted to a converted signal according to some embodiments. For example, the converted signal (e.g., the signal **119** and/or the signal **1219**) changes between a high voltage level and a low voltage level. As an example, the duty cycle of the converted signal (e.g., the signal **119** and/or the signal **1219**) is determined based at least in part on the dimming signal. In certain examples, if the dimming signal is an analog voltage signal, the duty cycle of the converted signal is determined by the magnitude of the analog voltage signal. In some examples, if the dimming signal is a pulse-width-modulation (PWM) signal, the duty cycle of the converted signal is determined by the duty cycle of the pulse-width-modulation (PWM) signal. For example, the dimming signal **113** is converted to the converted signal **119** by the signal converter **110** as part of the system **100** for dimming control. As an example, the dimming signal **1213** is converted to the converted signal **1219** by the signal converter **1210** as part of the system **1200** for dimming control.

[0089] At the process **1340**, a duty cycle of the converted signal is used to control a current that flows through one or more light sources according to certain embodiments. For example, the duty cycle of the converted signal **119** is used by the current controller **120** as part of the system **100** for dimming control to control the magnitude of the current **127** that flows through the one or more light sources. As an example, the duty cycle of the converted signal **1219** is used by the current controller **1220** as part of the system **1200** for dimming control to control the magnitude of the current **1227** that flows through the one or more light sources.

[0090] Some embodiments of the present invention provide a system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) that support multi-modes of a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**). For example, the multi-modes of the dimming signal include one mode in which the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal and another mode in which the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is a pulse-width-modulation (PWM) signal. As an example, regardless of whether the dimming signal is an analog voltage signal or a pulse-width-modulation (PWM) signal, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) generates a converted signal (e.g., the signal **119** and/or the signal **1219**) based on at least information associated with the dimming signal.

[0091] Certain embodiments of the present invention provide a system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) that converts a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) to a converted signal (e.g., the signal **119** and/or the signal **1219**). For example, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) determines the duty cycle of the converted signal (e.g., the signal **119** and/or the signal **1219**) based at least in part on the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**), regardless of whether the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal. As an example, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) uses the duty cycle of the converted signal (e.g., the signal **119** and/or the signal **1219**) to control a current (e.g., the current **127** and/or the current **1227**) that flows through the one or more light sources and also control the brightness of the one or more light sources.

[0092] Some embodiments of the present invention provide a system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) that controls the brightness of one or more light sources regardless of whether a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal. For example, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) can handle both an analog voltage signal as the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) and a pulse-width-modulation (PWM) signal as the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**). As an example, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) reduces design complexity and/or system costs by supporting multi-modes of a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**).

[0093] Certain embodiments of the present invention provide a system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) that, regardless of whether a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal, uses the same mechanism to convert the dimming signal to a converted signal (e.g., the signal **119** and/or the signal **1219**). For example, regardless of whether the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is larger than a periodic signal (e.g., the periodic signal **132** and/or the periodic signal **1232**), the converted signal (e.g., the signal **119** and/or the signal **1219**) is at a high voltage level. As an example, regardless of whether the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal, if the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is smaller than a periodic signal (e.g., the periodic signal **132** and/or the periodic signal **1232**), the converted signal (e.g., the signal **119** and/or the signal **1219**) is at a low voltage level.

[0094] Some embodiments of the present invention provide a system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) that does not need to determine whether a dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal before converting the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) to a converted signal (e.g., the signal **119** and/or the signal **1219**), because regardless of whether the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) is an analog voltage signal or a pulse-width-modulation (PWM) signal, the system for dimming control (e.g., the system **100** for dimming control and/or the system **1200** for dimming control) uses the same mechanism to convert the dimming signal (e.g., the dimming signal **113** and/or the dimming signal **1213**) to the converted signal (e.g., the signal **119** and/or the signal **1219**).

[0095] According to certain embodiments, a system for dimming control includes: a signal converter configured to receive a dimming signal and convert the dimming signal to a converted signal associated with a first duty cycle; and a current controller configured to receive the converted signal and determine a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the signal converter is further configured to: receive an analog voltage signal as the dimming signal; and convert the analog voltage signal to the converted signal based at least in part on the analog voltage signal; wherein the signal converter is also further configured to: receive a pulse-width-modulation signal as the dimming signal; and convert the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the current controller is further configured to use the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources. For example, the system for dimming control is implemented according to at least FIG. **1** and/or FIG. **12**.

[0096] As an example, the current controller is further configured to determine the magnitude of the current that flows through the one or more light sources to control a brightness of the one or more light sources. For example, the one or more light sources are one or more incandescent lamps; and the brightness of the one or more incandescent lamps corresponds to the analog voltage signal received by the signal converter as the dimming signal. As an example, the one or more light sources are one or more light-emitting-diode lamps; and the brightness of the one or more light-emitting-diode lamps corresponds to the pulse-width-modulation signal received by the signal converter as the dimming signal.

[0097] For example, the signal converter is further configured to: compare a reference signal and the dimming signal; and generate the converted signal based at least in part on the reference signal and the dimming signal. As an example, the signal converter is further configured to: compare the reference signal and the analog voltage signal as the dimming signal; generate the converted signal at a first voltage level if the analog voltage signal is larger than the reference signal in magnitude; and generate the converted signal at a second voltage level if the analog voltage signal is smaller than the reference signal in magnitude; wherein the first voltage level and the second voltage level are different. For example, the signal converter is further configured to: compare the reference signal and the pulse-width-modulation signal as the dimming signal; generate the converted signal at the first voltage level if the pulse-width-modulation signal is larger than the reference signal in magnitude; and generate the converted signal at the second voltage level if the pulse-width-modulation signal is smaller than the reference signal in magnitude. As an example, the first voltage level is larger than the second voltage level.

[0098] For example, the first voltage level is equal to a supply voltage in magnitude; and the second voltage level is equal to a ground voltage in magnitude. As an example, the current controller is further configured to: receive the converted signal changing between the supply voltage and the ground voltage in magnitude; and generate a first signal changing between a predetermined voltage and the ground voltage in magnitude based at least in part on the converted signal. For example, the predetermined voltage and the supply voltage are not equal in magnitude. As an example, the current controller is further configured to: if the converted signal is equal to the supply voltage in magnitude, generate the first signal equal to the predetermined voltage in magnitude; and if the converted signal is equal to the ground voltage in magnitude, generate the first signal equal to the ground voltage in magnitude.

[0099] For example, the reference signal is a periodic signal associated with a peak signal level and a valley signal level, the peak signal level being larger than the valley signal level. As an example, the signal converter is further configured to: receive the analog voltage signal as the dimming signal; if the analog voltage signal is equal to or smaller than the valley signal level in magnitude, set the first duty cycle of the converted signal equal to zero; and if the analog voltage signal is equal to or larger than the peak signal level in magnitude, set the first duty cycle of the converted signal equal to one. For example, the signal converter is further configured to, if the analog voltage signal is larger than the valley signal level and smaller than the peak signal level in magnitude, increase the first duty cycle of the converted signal if the analog voltage signal increases in magnitude. As an example, the signal converter is further configured to: receive the pulse-width-modulation signal as the dimming signal, the pulse-width-modulation signal being associated with a second duty cycle and changing between a third voltage level and a fourth voltage level, the third voltage level being larger than the fourth voltage level; and if the third voltage level of the pulse-width-modulation signal is larger than the peak signal level of the periodic signal and the fourth voltage level of the pulse-width-modulation signal is smaller than the valley signal level of the periodic signal, set the first duty cycle of the converted signal equal to the second duty cycle of the pulse-width-modulation signal.

[0100] According to some embodiments, a method for dimming control includes: receiving a dimming signal; converting the dimming signal to a converted signal associated with a first duty cycle; receiving the converted signal; and determining a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving an analog voltage signal as the dimming signal; and converting the analog voltage signal to the converted signal based at least in part on the analog voltage signal; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving a pulse-width-modulation signal as the dimming signal; and converting the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the determining a magnitude of a current that flows through one or more light sources includes: using the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources. For example, the method for dimming control is implemented according to at least FIG. **1**, FIG. **12**, and/or FIG. **13**.

[0101] As an example, the determining a magnitude of a current that flows through one or more light sources includes: controlling a brightness of the one or more light sources by at least determining the magnitude of the current that flows through the one or more light sources. For example, the one or more light sources are one or more incandescent lamps; and the brightness of the one or more incandescent lamps corresponds to the analog voltage signal received as the dimming signal. As an example, the one or more light sources are one or more light-emitting-diode lamps; and the brightness of the one or more light-emitting-diode lamps corresponds to the pulse-width-modulation signal received as the dimming signal. For example, the converting the dimming signal to a converted signal associated with a first duty cycle includes: comparing a reference signal and the dimming signal; and generating the converted signal based at least in part on the reference signal and the dimming signal. As an example, the converting the dimming signal to a converted signal associated with a first duty cycle includes: comparing the reference signal and the analog voltage signal as the dimming signal; generating the converted signal at a first voltage level if the analog voltage signal is larger than the reference signal in magnitude; and generating the converted signal at a second voltage level if the analog voltage signal is smaller than the reference signal in magnitude; wherein the first voltage level and the second voltage level are different. For example, the converting the dimming signal to a converted signal associated with a first duty cycle includes: comparing the reference signal and the pulse-width-modulation signal as the dimming signal; generating the converted signal at the first voltage level if the pulse-width-modulation signal is larger than the reference signal in magnitude; and generating the converted signal at the

second voltage level if the pulse-width-modulation signal is smaller than the reference signal in magnitude. As an example, the first voltage level is larger than the second voltage level.
[0102] For example, the first voltage level is equal to a supply voltage in magnitude; and the second voltage level is equal to a ground voltage in magnitude. As an example, the receiving the converted signal includes: receiving the converted signal changing between the supply voltage and the ground voltage in magnitude; the determining a magnitude of a current that flows through one or more light sources includes: generating a first signal changing between a predetermined voltage and the ground voltage in magnitude based at least in part on the converted signal. For example, the predetermined voltage and the supply voltage are not equal in magnitude. As an example, the generating a first signal changing between a predetermined voltage and the ground voltage in magnitude includes: if the converted signal is equal to the supply voltage in magnitude, generating the first signal equal to the predetermined voltage in magnitude; and if the converted signal is equal to the ground voltage in magnitude, generating the first signal equal to the ground voltage in magnitude.
[0103] For example, the reference signal is a periodic signal associated with a peak signal level and a valley signal level, the peak signal level being larger than the valley signal level. As an example, the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving the analog voltage signal as the dimming signal; if the analog voltage signal is equal to or smaller than the valley signal level in magnitude, setting the first duty cycle of the converted signal equal to zero; and if the analog voltage signal is equal to or larger than the peak signal level in magnitude, setting the first duty cycle of the converted signal equal to one. For example, the converting the dimming signal to a converted signal includes: if the analog voltage signal is larger than the valley signal level and smaller than the peak signal level in magnitude, increasing the first duty cycle of the converted signal if the analog voltage signal increases in magnitude. As an example, the receiving a dimming signal and the converting the dimming signal to a converted signal include: receiving the pulse-width-modulation signal as the dimming signal, the pulse-width-modulation signal being associated with a second duty cycle and changing between a third voltage level and a fourth voltage level, the third voltage level being larger than the fourth voltage level; and if the third voltage level of the pulse-width-modulation signal is larger than the peak signal level of the periodic signal and the fourth voltage level of the pulse-width-modulation signal is smaller than the valley signal level of the periodic signal, setting the first duty cycle of the converted signal equal to the second duty cycle of the pulse-width-modulation signal.
[0104] For example, some or all components of various embodiments of the present invention each are, individually and/or in combination with at least another component, implemented using one or more software components, one or more hardware components, and/or one or more combinations of software and hardware components. As an example, some or all components of various embodiments of the present invention each are, individually and/or in combination with at least another component, implemented in one or more circuits, such as one or more analog circuits and/or one or more digital circuits. For example, various embodiments and/or examples of the present invention can be combined.
[0105] Although specific embodiments of the present invention have been described, it will be understood by those of skill in the art that there are other embodiments that are equivalent to the described embodiments. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrated embodiments.

Claims

1.-**32**. (canceled)
33. A system for dimming control, the system comprising: a signal converter configured to receive a dimming signal and convert the dimming signal to a converted signal associated with a first duty

cycle; and a current controller configured to receive the converted signal and determine a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the signal converter is further configured to: in response to the dimming signal being a pulse-width-modulation signal associated with a second duty cycle, convert the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the current controller is further configured to use the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources.

34. The system of claim 33 wherein the current controller is further configured to determine the magnitude of the current that flows through the one or more light sources to control a brightness of the one or more light sources.

35. The system of claim 34 wherein: the one or more light sources are one or more light-emitting-diode lamps; and the brightness of the one or more light-emitting-diode lamps corresponds to the pulse-width-modulation signal received by the signal converter as the dimming signal.

36. The system of claim 33 wherein the signal converter is further configured to: compare a reference signal and the dimming signal; and generate the converted signal based at least in part on the reference signal and the dimming signal.

37. The system of claim 36 wherein the signal converter is further configured to: compare the reference signal and the pulse-width-modulation signal as the dimming signal; generate the converted signal at a first voltage level if the pulse-width-modulation signal is larger than the reference signal in magnitude; and generate the converted signal at a second voltage level if the pulse-width-modulation signal is smaller than the reference signal in magnitude.

38. The system of claim 37 wherein the first voltage level is larger than the second voltage level.

39. The system of claim 38 wherein: the first voltage level is equal to a supply voltage in magnitude; and the second voltage level is equal to a ground voltage in magnitude.

40. The system of claim 39 wherein the current controller is further configured to: receive the converted signal changing between the supply voltage and the ground voltage in magnitude; and generate a first signal changing between a predetermined voltage and the ground voltage in magnitude based at least in part on the converted signal.

41. The system of claim 40 wherein the predetermined voltage and the supply voltage are not equal in magnitude.

42. The system of claim 41 wherein the current controller is further configured to: if the converted signal is equal to the supply voltage in magnitude, generate the first signal equal to the predetermined voltage in magnitude; and if the converted signal is equal to the ground voltage in magnitude, generate the first signal equal to the ground voltage in magnitude.

43. The system of claim 37 wherein the reference signal is a periodic signal associated with a peak signal level and a valley signal level, the peak signal level being larger than the valley signal level.

44. The system of claim 41 wherein the pulse-width-modulation signal changes between a third voltage level and a fourth voltage level, and the third voltage level is larger than the fourth voltage level; wherein the signal converter is further configured to: if the third voltage level of the pulse-width-modulation signal is larger than the peak signal level of the periodic signal and the fourth voltage level of the pulse-width-modulation signal is smaller than the valley signal level of the periodic signal, set the first duty cycle of the converted signal equal to the second duty cycle of the pulse-width-modulation signal.

45. A method for dimming control, the method comprising: receiving a dimming signal; converting the dimming signal to a converted signal associated with a first duty cycle; receiving the converted signal; and determining a magnitude of a current that flows through one or more light sources based at least in part on the converted signal; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal include: in response to the dimming signal being a pulse-width-modulation signal associated with a second duty cycle, converting the pulse-width-modulation signal to the converted signal based at least in part on the pulse-width-modulation signal; wherein the determining a magnitude of a current that flows through one or more light sources includes: using the first duty cycle of the converted signal to determine the magnitude of the current that flows through the one or more light sources.

46. The method of claim 45 wherein the determining a magnitude of a current that flows through one or more light sources includes: controlling a brightness of the one or more light sources by at least determining the magnitude of the current that flows through the one or more light sources.

47. The method of claim 46 wherein: the one or more light sources are one or more light-emitting-diode lamps; and the brightness of the one or more light-emitting-diode lamps corresponds to the pulse-width-modulation signal received as the dimming signal.

48. The method of claim 45 wherein the converting the dimming signal to the converted signal associated with the first duty cycle includes: comparing a reference signal and the dimming signal; and generating the converted signal based at least in part on the reference signal and the dimming signal.

49. The method of claim 48 wherein the converting the dimming signal to the converted signal associated with the first duty cycle includes: comparing the reference signal and the pulse-width-modulation signal as the dimming signal; generating the converted signal at a first voltage level if the pulse-width-modulation signal is larger than the reference signal in magnitude; and generating the converted signal at a second voltage level if the pulse-width-modulation signal is smaller than the reference signal in magnitude.

50. The method of claim 49 wherein the first voltage level is larger than the second voltage level.

51. The method of claim 50 wherein: the first voltage level is equal to a supply voltage in magnitude; and the second voltage level is equal to a ground voltage in magnitude.

52. The method of claim 51 wherein: the receiving the converted signal includes: receiving the converted signal changing between the supply voltage and the ground voltage in magnitude; the determining a magnitude of a current that flows through one or more light sources includes: generating a first signal changing between a predetermined voltage and the ground voltage in magnitude based at least in part on the converted signal.

53. The method of claim 52 wherein the predetermined voltage and the supply voltage are not equal in magnitude.

54. The method of claim 52 wherein the generating a first signal changing between a predetermined voltage and the ground voltage in magnitude includes: if the converted signal is equal to the supply voltage in magnitude, generating the first signal equal to the predetermined voltage in magnitude; and if the converted signal is equal to the ground voltage in magnitude, generating the first signal equal to the ground voltage in magnitude.

55. The method of claim 54 wherein the reference signal is a periodic signal associated with a peak signal level and a valley signal level, the peak signal level being larger than the valley signal level.

56. The method of claim 54 wherein the pulse-width-modulation signal changes between a third voltage level and a fourth voltage level, the third voltage level is larger than the fourth voltage level; wherein the receiving a dimming signal and the converting the dimming signal to a converted signal further include: if the third voltage level of the pulse-width-modulation signal is larger than the peak signal level of the periodic signal and the fourth voltage level of the pulse-width-modulation signal is smaller than the valley signal level of the periodic signal, setting the first duty cycle of the converted signal equal to the second duty cycle of the pulse-width-modulation signal.