PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DATE: **May 17, 2013**

UTILITY PATENT APPLICATION TRANSMITTAL LETTER AND FEE TRANSMITTAL FORM (37 CFR § 1.53(b)) FOR ELECTRONIC FILING

Attorney Docket No.: **5308-706TSCT3**

Inventor(s): **John K. Roberts; Keith J. Vadas**

Applicant: **Cree, Inc.**

Entitled: **SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES**

Correspondence Address: **Customer No. 65106**

Transmitted herewith for filing under 37 CFR § 1.53(b) is:

1. ☒ **26** pages of Specification
2. ☒ **6** sheets of Formal Drawings (35 USC 113)
3. ☒ Application Data Sheet. See 37 CFR 1.76
4. ☐ Oath or Declaration
   a. ☐ newly executed *(copy)*
   b. ☐ copy from prior application
5. ☐ Power of Attorney ☐ 37 CFR 3.73(c) Statement
6. ☐ Sequence Listing
   a. ☐ computer readable copy
   b. ☐ paper copy (___ pages)
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7. ☐ Information Disclosure Statement
8. ☐ Preliminary Amendment ***(Please enter all claim amendments prior to calculating the filing fee.)***
9. ☐ Non-publication Request under 35 U.S.C. 122(b)(2)(B)(i).
10. ☐ Other:

11. ☐ Applicant claims small entity status. See 37 CFR § 1.27.

The fee has been calculated as shown below:

	Column 1 No. Filed	Column 2 No. Extra	Small Entity Rate Fee	Large Entity Rate Fee
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FILING FEE			$ 70.00	$280.00
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☒ Please charge my Deposit Account No. 50-0220 in the amount of $1600.00.
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Respectfully submitted,

Timothy J. Wall
Registration No. 50,743

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Kirsten S. Carlos

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
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Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

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Inventor 2 Remove

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Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

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All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

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☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	65106		
Email Address	uspto@myersbigel.com	Add Email	Remove Email

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Title of the Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES		
Attorney Docket Number	5308-706TSCT3	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	13/469188	2012-05-11
Prior Application Status			Remove

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Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/977422	2010-12-23
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	11/601504	2006-11-17
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	60/738305	2005-11-18

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This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

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In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

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If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Cree, Inc.

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	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

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Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

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Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

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Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature				Date (YYYY-MM-DD)	2013-05-17
First Name	Timothy J.	Last Name	Wall	Registration Number	50743

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This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Application 13/469,188, filed May 11, 2012, entitled "SOLID STATE LIGHTING PANELS WITH VARIABLE BOOST CURRENT SOURCES" which is a continuation of U.S. Application 12/977,422, filed December 23, 2010, entitled "SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES" which is a continuation of U.S. Application 11/601,504, filed November 17, 2006, entitled "SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES" which claims priority to U. S. Provisional Patent Application No. 60/738,305 entitled "SYSTEM AND METHOD FOR INTERCONNECTION AND INTEGRATION OF LED BACKLIGHTING MODULES" filed November 18, 2005, the disclosures of which are hereby incorporated herein by reference as if set forth in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to solid state lighting, and more particularly to adjustable solid state lighting panels and to systems and methods for generating high voltages for illuminating solid state lighting panels.

BACKGROUND

[0003] Solid state lighting arrays are used for a number of lighting applications. For example, solid state lighting panels including arrays of solid state lighting devices have been used as direct illumination sources, for example, in architectural and/or accent lighting. A solid state lighting device may include, for example, a packaged light emitting device including one or more light emitting diodes (LEDs). Inorganic LEDs typically include semiconductor layers forming p-n junctions. Organic LEDs (OLEDs), which include organic light emission layers, are another type of solid state light emitting device. Typically, a solid state light emitting device generates light through the recombination of electronic carriers, i.e. electrons and holes, in a light emitting layer or region.

[0004] Solid state lighting panels are commonly used as backlights for small liquid crystal display (LCD) display screens, such as LCD display screens used in portable

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electronic devices. In addition, there has been increased interest in the use of solid state lighting panels as backlights for larger displays, such as LCD television displays.

[0005] For smaller LCD screens, backlight assemblies typically employ white LED lighting devices that include a blue-emitting LED coated with a wavelength conversion phosphor that converts some of the blue light emitted by the LED into yellow light. The resulting light, which is a combination of blue light and yellow light, may appear white to an observer. However, while light generated by such an arrangement may appear white, objects illuminated by such light may not appear to have a natural coloring, because of the limited spectrum of the light. For example, because the light may have little energy in the red portion of the visible spectrum, red colors in an object may not be illuminated well by such light. As a result, the object may appear to have an unnatural coloring when viewed under such a light source.

[0006] The color rendering index of a light source is an objective measure of the ability of the light generated by the source to accurately illuminate a broad range of colors. The color rendering index ranges from essentially zero for monochromatic sources to nearly 100 for incandescent sources. Light generated from a phosphor-based solid state light source may have a relatively low color rendering index.

[0007] For large-scale illumination applications, it is often desirable to provide a lighting source that generates a white light having a high color rendering index, so that objects illuminated by the lighting panel may appear more natural. Similarly, for display backlight applications, it may be desirable to provide a backlight source that permits the display to have a large range of displayable colors (color gamut). Accordingly, such lighting sources may typically include an array of solid state lighting devices including red, green and blue light emitting devices. When red, green and blue light emitting devices are energized simultaneously, the resulting combined light may appear white, or nearly white, depending on the relative intensities of the red, green and blue sources, which may provide a high color rendering index. There are many different hues of light that may be considered "white." For example, some "white" light, such as light generated by sodium vapor lighting devices, may appear yellowish in color, while other "white" light, such as light generated by some fluorescent lighting devices, may appear more bluish in color. Similarly, a display may generate a large range of colors by altering the relative intensities of the red, green and blue light sources of a backlight unit.

[0008] For larger display and/or illumination applications, multiple solid state lighting tiles may be connected together, for example, in a two dimensional array, to form a larger

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lighting panel. Such lighting panels may generate a significant amount of heat, however, due to the large number of light emitting devices included therein and/or due to the operation of electronic driver circuitry included in the lighting panel. Heat generated by the lighting panel must be dissipated or else the lighting panel may overheat, potentially damaging the lighting panel and/or components thereof. In order to dissipate a large amount of heat, a lighting panel may be provided with heat sinks and/or other surfaces from which excess heat may be radiated. Such features may be undesirable for a lighting panel, however, since they may be bulky, heavy and/or expensive.

SUMMARY

[0009] A lighting system according to some embodiments of the invention includes a lighting panel having a string of solid state lighting devices and a current supply circuit having a voltage input terminal, a control input terminal, and first and second output terminals coupled to the string of solid state lighting devices. The current supply circuit may be configured to supply an on-state drive current to the string of solid state lighting devices in response to a control signal. The current supply circuit may include a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal. The current supply circuit may be configured to operate in continuous conduction mode in which a varying or constant current continuously flows through the charging inductor while the on-state drive current is supplied to the string of solid state light emitting devices.

[0010] The current supply circuit may include a rectifier having an anode coupled to the charging inductor and a cathode coupled to the storage capacitor, a controller having a control input and first and second control outputs, and a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller. The first control transistor may be configured to cause the charging inductor to be energized in response to a first control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first control signal.

[0011] The lighting system may further include a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller. The second control transistor may be configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to a second control signal from the controller.

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[0012] The current supply circuit may further include a low pass filter between the second control output and the second control transistor.

[0013] The current supply circuit may further include a sense resistor coupled to the second output terminal of the current supply circuit, and the controller may further include a feedback input coupled to the sense resistor. The controller may be configured to activate the second control signal in response to a feedback signal received on the feedback input.

[0014] The current supply circuit may further include a low pass filter coupled between the sense resistor and the feedback input of the controller.

[0015] The charging inductor may have an inductance of about 50 μH to about 1.3mH. In particular embodiments, the charging inductor may have an inductance of about 680 μH. The current supply circuit may be a variable voltage boost current supply circuit.

[0016] The lighting system may further include a plurality of strings of solid state light emitting devices and a plurality of current supply circuits connected to respective ones of the strings of solid state light emitting devices and configured to operate in continuous conduction mode.

[0017] The current supply circuit may be configured to convert at least about 85% of input power into output power. In some embodiments, the current supply circuit may be configured to convert at least about 90% of input power into output power.

[0018] Some embodiments of the invention provide methods of generating an on-state drive current for driving a string of solid state light emitting devices in a lighting system. The methods include energizing a charging inductor with an input voltage, discharging energy stored in the charging inductor into an output capacitor, and applying a voltage on the output capacitor to the string of solid state lighting devices, wherein current continuously flows through the charging inductor while the on-state drive current is supplied to the string of solid state light emitting devices.

[0019] Discharging energy stored in the charging inductor into an output capacitor may include discharging energy stored in the charging inductor through a rectifier. Energizing the charging inductor with an input voltage may include activating a first control transistor coupled to the charging inductor with a first control signal.

[0020] The methods may further include detecting an output current and activating the first control transistor in response to the detected output current. Applying a voltage on the output capacitor to the string of solid state lighting devices may include activating a second control transistor coupled to the string with a second control signal.

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[0021] The methods may further include filtering the second control signal and applying the filtered second control signal to the second control transistor. The methods may further include filtering the detected output current using a low pass filter.

[0022] A lighting system according to some embodiments of the invention includes a lighting panel including a first string of solid state lighting devices configured to emit red light, a second string of solid state lighting devices configured to emit green light, and a third string of solid state lighting devices configured to emit blue light, and at least three current supply circuits coupled to the first, second and third strings, respectively. Each of the current supply circuits may include a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

[0023] The lighting system may further include a digital control system coupled to the current supply circuits and configured to generate a plurality of pulse width modulation (PWM) control signals. Each of the current supply circuits is configured to supply an on-state drive current to the respective string of solid state lighting devices in response to one of the plurality of PWM control signals generated by the digital control system.

[0024] The digital control system may include a closed loop digital control system that is configured to generate the PWM control signals in response to sensor output signals generated by at least one light sensor in response to light output by the lighting panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate certain embodiment(s) of the invention. In the drawings:

[0026] **Figure 1** is a front view of a solid state lighting tile in accordance with some embodiments of the invention;

[0027] **Figure 2** is a top view of a packaged solid state lighting device including a plurality of LEDs in accordance with some embodiments of the invention;

[0028] **Figure 3** is a schematic circuit diagram illustrating the electrical interconnection of LEDs in a solid state lighting tile in accordance with some embodiments of the invention;

[0029] **Figure 4A** is a front view of a bar assembly including multiple solid state lighting tiles in accordance with some embodiments of the invention;

[0030] **Figure 4B** is a front view of a lighting panel in accordance with some embodiments of the invention including multiple bar assemblies;

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[0031] **Figure 5** is a schematic block diagram illustrating a lighting system in accordance with some embodiments of the invention;

[0032] **Figures 6A-6D** are a schematic diagrams illustrating possible configurations of photosensors on a lighting panel in accordance with some embodiments of the invention;

[0033] **Figures 7-8** are schematic diagrams illustrating elements of a lighting system according to some embodiments of the invention;

[0034] **Figure 9** is a schematic circuit diagram of a current supply circuit according to some embodiments of the invention; and

[0035] **Figure 10** is a graph of inductor current versus time for a current supply circuit according to some embodiments of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0036] Embodiments of the present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

[0037] It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of the present invention. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0038] It will be understood that when an element such as a layer, region or substrate is referred to as being "on" or extending "onto" another element, it can be directly on or extend directly onto the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" or extending "directly onto" another element, there are no intervening elements present. It will also be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present.

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In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0039] Relative terms such as "below" or "above" or "upper" or "lower" or "horizontal" or "vertical" may be used herein to describe a relationship of one element, layer or region to another element, layer or region as illustrated in the figures. It will be understood that these terms are intended to encompass different orientations of the device in addition to the orientation depicted in the figures.

[0040] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including" when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0041] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms used herein should be interpreted as having a meaning that is consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0042] The present invention is described below with reference to flowchart illustrations and/or block diagrams of methods, systems and computer program products according to embodiments of the invention. It will be understood that some blocks of the flowchart illustrations and/or block diagrams, and combinations of some blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be stored or implemented in a microcontroller, microprocessor, digital signal processor (DSP), field programmable gate array (FPGA), a state machine, programmable logic controller (PLC) or other processing circuit, general purpose computer, special purpose computer, or other programmable data processing apparatus such as to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

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[0043] These computer program instructions may also be stored in a computer readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer readable memory produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0044] The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. It is to be understood that the functions/acts noted in the blocks may occur out of the order noted in the operational illustrations. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved. Although some of the diagrams include arrows on communication paths to show a primary direction of communication, it is to be understood that communication may occur in the opposite direction to the depicted arrows.

[0045] Referring now to **Figure 1**, a solid state lighting tile **10** may include thereon a number of solid state lighting elements **12** arranged in a regular and/or irregular two dimensional array. The tile **10** may include, for example, a printed circuit board (PCB) on which one or more circuit elements may be mounted. In particular, a tile **10** may include a metal core PCB (MCPCB) including a metal core having thereon a polymer coating on which patterned metal traces (not shown) may be formed. MCPCB material, and material similar thereto, is commercially available from, for example, The Bergquist Company. The PCB may further include heavy clad (4 oz. copper or more) and/or conventional FR-4 PCB material with thermal vias. MCPCB material may provide improved thermal performance compared to conventional PCB material. However, MCPCB material may also be heavier than conventional PCB material, which may not include a metal core.

[0046] In the embodiments illustrated in **Figure 1**, the lighting elements **12** are multi-chip clusters of four solid state emitting devices per cluster. In the tile **10**, four lighting elements **12** are serially arranged in a first path **20**, while four lighting elements **12** are serially arranged in a second path **21**. The lighting elements **12** of the first path **20** are connected, for example via printed circuits, to a set of four anode contacts **22** arranged at a first end of the tile **10**, and a set of four cathode contacts **24** arranged at a second end of the

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tile **10**. The lighting elements **12** of the second path **21** are connected to a set of four anode contacts **26** arranged at the second end of the tile **10**, and a set of four cathode contacts **28** arranged at the first end of the tile **10**.

[0047] The solid state lighting elements **12** may include, for example, organic and/or inorganic light emitting devices. An example of a solid state lighting element **12** for high power illumination applications is illustrated in **Figure 2**. A solid state lighting element **12** may comprise a packaged discrete electronic component including a carrier substrate **13** on which a plurality of LED chips **16A-16D** are mounted. In other embodiments, one or more solid state lighting elements **12** may comprise LED chips **16A-16D** mounted directly onto electrical traces on the surface of the tile **10,** forming a multi-chip module or chip on board assembly**.** Suitable tiles are disclosed in commonly assigned US Patent Application Serial No. 11/368,976 entitled "ADAPTIVE ADJUSTMENT OF LIGHT OUTPUT OF SOLID STATE LIGHTING PANELS" filed March 6, 2006 (Attorney Docket 5308-632), the disclosure of which is incorporated herein by reference.

[0048] The LED chips **16A-16D** may include at least a red LED **16A**, a green LED **16B** and a blue LED **16C**. The blue and/or green LEDs may be InGaN-based blue and/or green LED chips available from Cree, Inc., the assignee of the present invention. The red LEDs may be, for example, AlInGaP LED chips available from Epistar, Osram Opto Semiconductors and others. The lighting element **12** may include an additional green LED **16D** in order to make more green light available.

[0049] In some embodiments, the LEDs **16** may have a square or rectangular periphery with an edge length of about 900 μm or greater (i.e. so-called "power chips." However, in other embodiments, the LED chips **16** may have an edge length of 500 μm or less (i.e. so-called "small chips"). In particular, small LED chips may operate with better electrical conversion efficiency than power chips. For example, green LED chips with a maximum edge dimension less than 500 microns and as small as 260 μm, may commonly have a higher electrical conversion efficiency than 900 μm chips, and are known to typically produce 55 lumens of luminous flux per Watt of dissipated electrical power and as much as 90 lumens or more of luminous flux per Watt of dissipated electrical power.

[0050] As further illustrated in **Figure 2**, the LEDs **16A-16D** may be covered by an encapsulant **14,** which may be clear and/or may include light scattering particles, phosphors, and/or other elements to achieve a desired emission pattern, color and/or intensity. While not illustrated in **Figure 2**, the lighting device **12** may further include a reflector cup surrounding the LEDs **16A-16D**, a lens mounted above the LEDs **16A-16D**, one or more heat sinks for

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removing heat from the lighting device, an electrostatic discharge protection chip, and/or other elements.

[0051] LED chips **16A-16D** of the lighting elements **12** in the tile **10** may be electrically interconnected as shown in the schematic circuit diagram in **Figure 3**. As shown therein, the LEDs may be interconnected such that the blue LEDs **16A** in the first path **20** are connected in series to form a string **20A**. Likewise, the first green LEDs **16B** in the first path **20** may be arranged in series to form a string **20B**, while the second green LEDs **16D** may be arranged in series to form a separate string **20D**. The red LEDs **16C** may be arranged in series to form a string **20C**. Each string **20A-20D** may be connected to an anode contact **22A-22D** arranged at a first end of the tile **10** and a cathode contact **24A-24D** arranged at the second end of the tile **10**, respectively.

[0052] A string **20A-20D** may include all, or less than all, of the corresponding LEDs in the first path **20** or the second path **21**. For example, the string **20A** may include all of the blue LEDs from all of the lighting elements **12** in the first path **20**. Alternatively, a string **20A** may include only a subset of the corresponding LEDs in the first path **20**. Accordingly the first path **20** may include four serial strings **20A-20D** arranged in parallel on the tile **10**.

[0053] The second path **21** on the tile **10** may include four serial strings **21A**, **21B**, **21C**, **21D** arranged in parallel. The strings **21A** to **21D** are connected to anode contacts **26A** to **26D**, which are arranged at the second end of the tile **10** and to cathode contacts **28A** to **28D**, which are arranged at the first end of the tile **10**, respectively.

[0054] It will be appreciated that, while the embodiments illustrated in **Figures 1-3** include four LED chips **16** per lighting device **12** which are electrically connected to form at least four strings of LEDs **16** per path **20**, **21**, more and/or fewer than four LED chips **16** may be provided per lighting device **12**, and more and/or fewer than four LED strings may be provided per path **20**, **21** on the tile **10**. For example, a lighting device **12** may include only one green LED chip **16B**, in which case the LEDs may be connected to form three strings per path **20**, **21**. Likewise, in some embodiments, the two green LED chips in a lighting device **12** may be connected in serial to one another, in which case there may only be a single string of green LED chips per path **20**, **22**. Further, a tile **10** may include only a single path **20** instead of plural paths **20**, **21** and/or more than two paths **20**, **21** may be provided on a single tile **10**.

[0055] Multiple tiles **10** may be assembled to form a larger lighting bar assembly **30** as illustrated in **Figure 4A**. As shown therein, a bar assembly **30** may include two or

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more tiles **10**, **10'**, **10''** connected end-to-end. Accordingly, referring to **Figures 3** and **4**, the cathode contacts **24** of the first path **20** of the leftmost tile **10** may be electrically connected to the anode contacts **22** of the first path **20** of the central tile **10'**, and the cathode contacts **24** of the first path **20** of the central tile **10'** may be electrically connected to the anode contacts **22** of the first path **20** of the rightmost tile **10''**, respectively. Similarly, the anode contacts **26** of the second path **21** of the leftmost tile **10** may be electrically connected to the cathode contacts **28** of the second path **21** of the central tile **10'**, and the anode contacts **26** of the second path **21** of the central tile **10'** may be electrically connected to the cathode contacts **28** of the second path **21** of the rightmost tile **10''**, respectively.

[0056] Furthermore, the cathode contacts **24** of the first path **20** of the rightmost tile **10''** may be electrically connected to the anode contacts **26** of the second path **21** of the rightmost tile **10''** by a loopback connector **35**. For example, the loopback connector **35** may electrically connect the cathode **24A** of the string **20A** of blue LED chips **16A** of the first path **20** of the rightmost tile **10''** with the anode **26A** of the string **21A** of blue LED chips of the second path **21** of the rightmost tile **10''**. In this manner, the string **20A** of the first path **20** may be connected in serial with the string **21A** of the second path **21** by a conductor **35A** of the loopback connector **35** to form a single string **23A** of blue LED chips **16**. The other strings of the paths **20**, **21** of the tiles **10**, **10'**, **10''** may be connected in a similar manner.

[0057] The loopback connector **35** may include an edge connector, a flexible wiring board, or any other suitable connector. In addition, the loop connector may include printed traces formed on/in the tile **10**.

[0058] While the bar assembly **30** shown in **Figure 4A** is a one dimensional array of tiles **10**, other configurations are possible. For example, the tiles **10** could be connected in a two-dimensional array in which the tiles **10** are all located in the same plane, or in a three dimensional configuration in which the tiles **10** are not all arranged in the same plane. Furthermore the tiles **10** need not be rectangular or square, but could, for example, be hexagonal, triangular, or the like.

[0059] Referring to **Figure 4B**, in some embodiments, a plurality of bar assemblies **30** may be combined to form a lighting panel **40**, which may be used, for example, as a backlighting unit (BLU) for an LCD display. As shown in **Figure 4B**, a lighting panel **40** may include four bar assemblies **30**, each of which includes six tiles **10**. The rightmost tile **10** of each bar assembly **30** includes a loopback connector **35**. Accordingly, each bar assembly **30** may include four strings **23** of LEDs (i.e. one red, two green and one blue).

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Alternatively, each bar assembly **30** may include three strings **23** of LEDs (i.e. one red, one green and one blue).

[0060] In embodiments including four LED strings **23** (one red, two green and one blue) per bar assembly **30**, a lighting panel **40** including nine bar assemblies may have 36 separate strings of LEDs. In embodiments including three LED strings **23** (one red, one green and one blue) per bar assembly **30**, a lighting panel **40** including nine bar assemblies may have 27 separate strings of LEDs. Moreover, in a bar assembly **30** including six tiles **10** with eight solid state lighting elements 12 each, an LED string **23** may include 48 LEDs connected in serial.

[0061] For some types of LEDs, in particular blue and/or green LEDs, the forward voltage (Vf) may vary by as much as +/- 0.75V from a nominal value from chip to chip at a standard drive current of 20 mA. A typical blue or green LED may have a Vf of 3.2 Volts. Thus, the forward voltage of such chips may vary by as much as 25%. For a string of LEDs containing 48 LEDs, the total Vf required to operate the string at 20mA may vary by as much as +/- 36V.

[0062] Accordingly, depending on the particular characteristics of the LEDs in a bar assembly, a string of one light bar assembly (e.g. the blue string) may require significantly different operating voltage compared to a corresponding string of another bar assembly. If the power supply is not designed accordingly, these variations may significantly affect the color and/or brightness uniformity of a lighting panel that includes multiple tiles **10** and/or bar assemblies **30**, as such Vf variations may lead to variations in brightness and/or hue from tile to tile and/or from bar to bar. For example, current differences from string to string, which may result from large LED string voltage variations, may lead to large differences in the flux, peak wavelength, and/or dominant wavelength output by a string. Variations in LED drive current on the order of 5% or more may result in unacceptable variations in light output from string to string and/or from tile to tile. Such variations may significantly affect the overall color gamut, or range of displayable colors, of a lighting panel and/or may affect the uniformity of color and/or luminance, of a lighting panel.

[0063] In addition, the light output characteristics of LED chips may change during their operational lifetime. For example, the light output by an LED may change over time and/or with ambient temperature.

[0064] In order to provide consistent, controllable light output characteristics for a lighting panel, some embodiments of the invention provide a lighting panel having two or more serial strings of LED chips. An independent current control circuit is provided for each

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of the strings of LED chips. Furthermore, current to each of the strings may be individually controlled, for example, by means of pulse width modulation (PWM) and/or pulse frequency modulation (PFM). The width of pulses applied to a particular string in a PWM scheme (or the frequency of pulses in a PFM scheme) may be based on a pre-stored pulse width (frequency) value that may be modified during operation based, for example, on a user input and/or a sensor input.

[0065] Accordingly, referring to **Figure 5**, a lighting system **200** is shown. The lighting system **200**, which may be a backlight for an LCD display panel, includes a lighting panel **40**. The lighting panel **40** may include, for example, a plurality of bar assemblies **30**, which, as described above, may include a plurality of tiles **10**. However, it will be appreciated that embodiments of the invention may be employed in conjunction with lighting panels formed in other configurations. For example, some embodiments of the invention may be employed with solid state backlight panels that include a single, large area tile.

[0066] In particular embodiments, however, a lighting panel **40** may include a plurality of bar assemblies **30**, each of which may have four cathode connectors and four anode connectors corresponding to the anodes and cathodes of four independent strings **23** of LEDs each having the same dominant wavelength. For example, each bar assembly **23** may have a red string **23A**, two green strings **23B**, **23D**, and a blue string **23C**, each with a corresponding pair of anode/cathode contacts on one side of the bar assembly **30**. In particular embodiments, a lighting panel **40** may include nine bar assemblies **30**. Thus, a lighting panel **40** may include 36 separate LED strings (or 27 strings if only one green string is included per bar assembly).

[0067] A current driver **220** provides independent current control for each of the LED strings **23** of the lighting panel **40**. For example, the current driver **220** may provide independent current control for 36 (or 27) separate LED strings in the lighting panel **40**. The current driver **220** may provide a constant current source for each of the 36 (or 27) separate LED strings of the lighting panel **40** under the control of a controller **230**. In some embodiments, the controller **230** may be implemented using an 8-bit microcontroller such as a PIC18F8722 from Microchip Technology Inc., which may be programmed to provide pulse width modulation (PWM) control of 36 separate current supply blocks within the driver **220** for the 36 (or 27) LED strings **23**.

[0068] Pulse width information for each of the 36 (or 27) LED strings may be obtained by the controller **230** from a color management unit **260**, which may in some

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embodiments include a color management controller such as the Avago HDJD-J822-SCR00 color management controller.

[0069] The color management unit **260** may be connected to the controller **230** through an I2C (Inter-Integrated Circuit) communication link **235**. The color management unit **260** may be configured as a slave device on an I2C communication link **235**, while the controller **230** may be configured as a master device on the link **235**. I2C communication links provide a low-speed signaling protocol for communication between integrated circuit devices. The controller **230**, the color management unit **260** and the communication link **235** may together form a feedback control system configured to control the light output from the lighting panel **40**. The registers R1-R9, etc., may correspond to internal registers in the controller **230** and/or may correspond to memory locations in a memory device (not shown) accessible by the controller **230**.

[0070] The controller **230** may include a register, e.g. registers R1-R9, G1A-G9A, B1-B9, G1B-G9B, for each LED string **23**, i.e. for a lighting unit with 36 LED strings **23**, the color management unit **260** may include at least 36 registers. Each of the registers is configured to store pulse width information for one of the LED strings **23**. The initial values in the registers may be determined by an initialization/calibration process. However, the register values may be adaptively changed over time based on user input **250** and/or input from one or more sensors **240** coupled to the lighting panel **40**.

[0071] The sensors **240** may include, for example, a temperature sensor **240A**, one or more photosensors **240B**, and/or one or more other sensors **240C**. In particular embodiments, a lighting panel **40** may include one photosensor **240B** for each bar assembly **30** in the lighting panel. However, in other embodiments, one photosensor **240B** could be provided for each LED string **30** in the lighting panel. In other embodiments, each tile **10** in the lighting panel **40** may include one or more photosensors **240B**.

[0072] In some embodiments, the photosensor **240B** may include photo-sensitive regions that are configured to be preferentially responsive to light having different dominant wavelengths. Thus, wavelengths of light generated by different LED strings **23**, for example a red LED string **23A** and a blue LED string **23C**, may generate separate outputs from the photosensor **240B**. In some embodiments, the photosensor **240B** may be configured to independently sense light having dominant wavelengths in the red, green and blue portions of the visible spectrum. The photosensor **240B** may include one or more photosensitive devices, such as photodiodes. The photosensor **240B** may include, for example, an Avago HDJD-S831-QT333 tricolor photo sensor.

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[0073] Sensor outputs from the photosensors **240B** may be provided to the color management unit **260**, which may be configured to sample such outputs and to provide the sampled values to the controller **230** in order to adjust the register values for corresponding LED strings **23** in order to correct variations in light output on a string-by-string basis. In some embodiments, an application specific integrated circuit (ASIC) may be provided on each tile **10** along with one or more photosensors **240B** in order to pre-process sensor data before it is provided to the color management unit **260**. Furthermore, in some embodiments, the sensor output and/or ASIC output may be sampled directly by the controller **230**.

[0074] The photosensors **240B** may be arranged at various locations within the lighting panel **40** in order to obtain representative sample data. Alternatively and/or additionally, light guides such as optical fibers may be provided in the lighting panel **40** to collect light from desired locations. In that case, the photosensors **240B** need not be arranged within an optical display region of the lighting panel **40**, but could be provided, for example, on the back side of the lighting panel **40**. Further, an optical switch may be provided to switch light from different light guides which collect light from different areas of the lighting panel **40** to a photosensor **240B**. Thus, a single photosensor **240B** may be used to sequentially collect light from various locations on the lighting panel **40**.

[0075] The user input **250** may be configured to permit a user to selectively adjust attributes of the lighting panel **40**, such as color temperature, brightness, hue, etc., by means of user controls such as manual input controls on an LCD panel and/or software-based input controls if, for example, the LCD panel is a computer monitor.

[0076] The temperature sensor **240A** may provide temperature information to the color management unit **260** and/or the controller **230**, which may adjust the light output from the lighting panel on a string-to-string and/or color-to-color basis based on known/predicted brightness vs. temperature operating characteristics of the LED chips **16** in the strings **23**.

[0077] Various configurations of photosensors **240B** are shown in **Figures 6A-6D**. For example, in the embodiments of **Figure 6A**, a single photosensor **240B** is provided in the lighting panel **40**. The photosensor **240B** may be provided at a location where it may receive an average amount of light from more than one tile/string in the lighting panel.

[0078] In order to provide more extensive data regarding light output characteristics of the lighting panel **40**, more than one photosensor **240B** may be used. For example, as shown in **Figure 6B**, there may be one photosensor **240B** per bar assembly **30**. In that case, the photosensors **240B** may be located at ends of the bar assemblies **30** and may be arranged

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to receive an average/combined amount of light emitted from the bar assembly **30** with which they are associated.

[0079] As shown in **Figure 6C**, photosensors **240B** may be arranged at one or more locations within a periphery of the light emitting region of the lighting panel **40**. However in some embodiments, the photosensors **240B** may be located away from the light emitting region of the lighting panel **40**, and light from various locations within the light emitting region of the lighting panel **40** may be transmitted to the sensors **240B** through one or more light guides. For example, as shown in **Figure 6D**, light from one or more locations **249** within the light emitting region of the lighting panel **40** is transmitted away from the light emitting region via light guides **247**, which may be optical fibers that may extend through and/or across the tiles **10**.

[0080] In the embodiments illustrated in **Figure 6D**, the light guides **247** terminate at an optical switch **245**, which selects a particular guide **247** to connect to the photosensor **240B** based on control signals from the controller **230** and/or from the color management unit **260**. It will be appreciated, however, that the optical switch **245** is optional, and that each of the light guides **245** may terminate at a respective photosensor **240B**. In further embodiments, instead of an optical switch **245**, the light guides **247** may terminate at a light combiner, which combines the light received over the light guides **247** and provides the combined light to a photosensor **240B**. The light guides **247** may extend across partially across, and/or through the tiles **10**. For example, in some embodiments, the light guides **247** may run behind the panel **40** to various light collection locations and then run through the panel at such locations. Furthermore, the photosensor **240B** may be mounted on a front side of the panel (i.e. on the side of the panel **40** on which the lighting devices **16** are mounted) or on a reverse side of the panel **40** and/or a tile **10** and/or bar assembly **30**.

[0081] Referring now to **Figure 7**, a current driver **220** may include a plurality of bar driver circuits **320A - 320D**. One bar driver circuit **320A-320D** may be provided for each bar assembly **30** in a lighting panel **40**. In the embodiments shown in **Figure 7**, the lighting panel **40** includes four bar assemblies **30**. However, in some embodiments the lighting panel **40** may include nine bar assemblies **30**, in which case the current driver **220** may include nine bar driver circuits **320**. As shown in **Figure 8**, in some embodiments, each bar driver circuit **320** may include four current supply circuits **400A-400D**, i.e., one current supply circuit **400A-400D** for each LED string **23A-23D** of the corresponding bar assembly **30**. Operation of the current supply circuits **400A-400B** may be controlled by control signals **342** from the controller **230**.

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[0082] A current supply circuit **400** according to some embodiments of the invention is illustrated in more detail in **Figure 9**. As shown therein, a current supply circuit **400** may have a variable voltage boost converter configuration including a PWM controller **410**, a charging inductor **420**, a diode **430**, an output capacitor **440**, first and second control transistors **450**, **460**, and a sense resistor **470**. The current supply circuit **400** receives an input voltage VIN, which may be 34V in some embodiments. The current supply circuit **400** also receives a pulse width modulation signal PWM from the controller **230**. The current supply circuit **400** is configured to provide a substantially constant current to a corresponding LED string **23** via output terminals DIODE+ and DIODE-, which are connected to the anode and cathode of the corresponding LED string, respectively. The current supply circuit may act as a voltage boost converter to provide the high voltage that may be required to drive an LED string **23**. For example, an LED string **23** may require a forward voltage of about 170 V or more. Furthermore, the constant current may be supplied with a variable voltage boost to account for differences in average forward voltage from string to string. The PWM controller **410** may include, for example, an HV9911NG current mode PWM controller from Supertex.

[0083] The current supply circuit **400** is configured to supply current to the corresponding LED string **23** while the PWM input is a logic HIGH. Accordingly, for each timing loop, the PWM input of each current supply circuit **400** in the driver **220** is set to logic HIGH at the first clock cycle of the timing loop. The PWM input of a particular current supply circuit **400** is set to logic LOW, thereby turning off current to the corresponding LED string **23**, when a counter in the controller **230** reaches the value stored in a register of the controller **230** corresponding to the LED string **23**. Thus, while each LED string **23** in the lighting panel **40** may be turned on simultaneously, the strings may be turned off at different times during a given timing loop, which would give the LED strings different pulse widths within the timing loop. The apparent brightness of an LED string **23** may be approximately proportional to the duty cycle of the LED string **23**, i.e., the fraction of the timing loop in which the LED string **23** is being supplied with current.

[0084] An LED string **23** may be supplied with a substantially constant current during the period in which it is turned on. By manipulating the pulse width of the current signal, the average current passing through the LED string **23** may be altered even while maintaining the on-state current at a substantially constant value. Thus, the dominant wavelength of the LEDs **16** in the LED string **23**, which may vary with applied current, may remain substantially stable even though the average current passing through the LEDs **16** is being altered. Similarly, the luminous flux per unit power dissipated by the LED string **23**

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may remain more constant at various average current levels than, for example, if the average current of the LED string **23** was being manipulated using a variable current source.

[0085] The value stored in a register of the controller **230** corresponding to a particular LED string may be based on a value received from the color management unit **260** over the communication link **235**. Alternatively and/or additionally, the register value may be based on a value and/or voltage level directly sampled by the controller **230** from a sensor **240**.

[0086] In some embodiments, the color management unit 260 may provide a value corresponding to a duty cycle (i.e. a value from 0 to 100), which may be translated by the controller **230** into a register value based on the number of cycles in a timing loop. For example, the color management unit **260** indicates to the controller **230** via the communication link **235** that a particular LED string **23** should have a duty cycle of 50%. If a timing loop includes 10,000 clock cycles, then assuming the controller increments the counter with each clock cycle, the controller **230** may store a value of 5000 in the register corresponding to the LED string in question. Thus, in a particular timing loop, the counter is reset to zero at the beginning of the loop and the LED string **23** is turned on by sending an appropriate PWM signal to the current supply circuit **400** serving the LED string **23**. When the counter has counted to a value of 5000, the PWM signal for the current supply circuit **400** is reset, turning the LED string off.

[0087] In some embodiments, the pulse repetition frequency (i.e. pulse repetition rate) of the PWM signal may be in excess of 60 Hz. In particular embodiments, the PWM period may be 5 ms or less, for an overall PWM pulse repetition frequency of 200 Hz or greater. A delay may be included in the loop, such that the counter may be incremented only 100 times in a single timing loop. Thus, the register value for a given LED string **23** may correspond directly to the duty cycle for the LED string **23**. However, any suitable counting process may be used provided that the brightness of the LED string **23** is appropriately controlled.

[0088] The register values of the controller **230** may be updated from time to time to take into account changing sensor values. In some embodiments, updated register values may be obtained from the color management unit **260** multiple times per second.

[0089] Furthermore, the data read from the color management unit **260** by the controller **230** may be filtered to limit the amount of change that occurs in a given cycle. For example, when a changed value is read from the color management unit **260**, an error value may be calculated and scaled to provide proportional control ("P"), as in a conventional PID

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(Proportional-Integral-Derivative) feedback controller. Further, the error signal may be scaled in an integral and/or derivative manner as in a PID feedback loop. Filtering and/or scaling of the changed values may be performed in the color management unit **260** and/or in the controller **230**.

[0090] The configuration and operation of a variable voltage boost current supply circuit **400** according to some embodiments of the invention will now be described in greater detail. As noted above, a current supply circuit **400** may include a PWM controller **410** that is configured to control the operation of a first transistor **450** and a second transistor **460** to provide a constant current to the output terminals DIODE+ and DIODE-. When the first transistor **450** is turned on by the control signal CTRL1 from the PWM controller **410**, the charging inductor **420** is energized by the input voltage VIN. In some embodiments, the input voltage VIN may be about 34 VDC (compared to 24 VDC for a typical voltage converter operating in discontinuous conduction mode, as explained in more detail below).

[0091] When the first transistor **450** is turned off, magnetic energy stored in the charging inductor **420** is discharged as a current through the rectifier diode **430** and is stored in the output capacitor **440**. By repeatedly charging and discharging the magnetic field of the charging inductor **420**, a high voltage can be built up in the output capacitor **440**. When the second transistor **460** is activated by the control signal CTRL2 from the PWM controller **410**, the voltage stored in the output capacitor **440** is applied to the output terminal DIODE+. The control signal CTRL2 may be filtered by a low pass filter **480** to remove sharp edges from the control signal CTRL2 that may cause ringing or oscillation of the transistor **460**.

[0092] The current through the output terminals is monitored by the PWM controller **410** as a feedback signal FDBK which corresponds to a voltage on the sense resistor **470**. The feedback signal FDBK may be filtered by a low pass filter **490**, which may be, for example an RC filter including a series resistor **485** and a shunt capacitor **475**, in order to suppress transient currents that may arise when the LED string **23** is turned on.

[0093] The voltage stored on the output capacitor **440** is adjusted by the PWM controller **410** in response to the feedback signal FDBK to provide a constant current through the output terminals.

[0094] A conventional current driver may operate in discontinuous conduction mode (DCM) , in which current does not flow continuously through the charging inductor **420**. In some embodiments of the present invention, the current supply circuits **400** in the driver circuits **320** are configured to operate in continuous conduction mode (CCM), in which current flows continuously through the charging inductor **420**.

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[0095] Representative inductor current waveforms for continuous conduction mode and discontinuous conduction mode are shown in **Figure 10**. The waveforms shown in **Figure 10** are illustrative only and do not represent actual or simulated waveforms. In particular, the inductor current of a current supply circuit operating in discontinuous conduction mode (DCM) has a series of peaks followed by periods of zero current. In the continuous conduction mode (CCM), the inductor current has peaks. However, the peak currents may be lower than in DCM, and the inductor current may not return to zero between the peaks.

[0096] Since the power dissipated by the current supply circuit **400** is dependent on the square of the inductor current ($P = I^2R$), DCM operation may consume more electric power than CCM operation, even though there are periods of no current conduction between the peaks of the DCM output current, because the peaks of the DCM output current may result in significant average power dissipation.

[0097] A circuit configured for CCM operation may have a similar topology as a circuit configured for DCM operation. However, in a circuit configured for CCM operation according to some embodiments of the invention, the charging inductor **420** may have a larger inductance value than an inductor used for DCM operation. For example, in a current supply circuit **400** configured according to some embodiments of the invention, the charging inductor **420** may have an inductance of about 50 μH to about 1.3mH. In particular embodiments, the charging inductor **420** may have an inductance of about 680 μH.

[0098] The value of the charging inductor **420** that results in CCM operation may depend on a number of factors, including the type of PWM controller IC used, the boost ratio (i.e. the ratio of output voltage to input voltage), and/or the number of LEDs in the string being driven. In some cases, if the boost ratio is too high, an inductance that would otherwise result in CCM operation may instead result in DCM operation.

[0099] In some embodiments according to the invention, a current supply circuit **400** operating in CCM may achieve greater than 85% conversion efficiency, and in some cases may achieve greater than 90% conversion efficiency, compared to a typical DCM converter, which may be capable of only about 80% conversion efficiency (defined as power out/power in x 100). The difference between 80% efficiency and 90% efficiency may represent a reduction in the amount of energy wasted (and hence heat produced) of 50% (i.e., 20% to 10%). A fifty percent reduction in heat dissipation may allow the lighting panel to run cooler and/or for the LEDs thereon to operate more efficiently, and/or may enable the

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production of lighting panel systems having smaller heat sinks and/or that require less cooling. Accordingly, a lighting system including a current supply circuit **400** according to embodiments of the invention may be made smaller, thinner, lighter, and/or less expensively.

[00100] In the drawings and specification, there have been disclosed typical embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

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That which is claimed is:

1. A lighting system, comprising:

at least three strings of solid state lighting devices that are respectively configured to emit at least a first light, a second light and a third light, respectively; and

a digital control system that is configured to generate a first pulse width modulation (PWM) control signal and a second PWM control signal and that includes a closed loop control system that is configured to generate the first and second PWM control signals in response to sensor output signals generated by at least one sensor, the first and second PWM control signals operative to cause an on-state drive current to be supplied to ones of the at least three strings of solid state lighting devices.

2. The lighting system according to Claim 1, further comprising at least three current supply circuits coupled to the first, second and third strings, respectively, wherein each of the current supply circuits is configured to supply the on-state drive current to a respective string of the at least three solid state lighting devices in response to the first and second PWM control signals.

3. The lighting system according to Claim 2, wherein ones of the at least three current supply circuits comprise a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

4. The lighting system according to Claim 2, wherein ones of the at least three current supply circuits comprise a voltage input terminal, a control input terminal, and first and second output terminals coupled to the string of solid state lighting devices.

5. The lighting system according to Claim 2, wherein the at least three current supply circuits are configured to supply the on-state drive current to the at least three first strings of solid state lighting devices, respectively.

6. The lighting system according to Claim 2, wherein ones of the at least three current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal.

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7. The lighting system according to Claim 6, wherein the current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first, second and third strings, respectively.

8. The lighting system according to Claim 6, wherein each of the current supply circuits comprises:

a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor;

a controller having a control input and first and second control outputs; and

a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller,

wherein the first control transistor is configured to cause the charging inductor to be energized in response to a first control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first control signal.

9. The lighting system according to Claim 8, further comprising a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller;

wherein the second control transistor is configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to a second control signal from the controller.

10. The lighting system according to Claim 9, wherein the current supply circuit further comprises:

a low pass filter between the second control output and the second control transistor.

11. The lighting system according to Claim 9, wherein the current supply circuit further comprises a sense resistor coupled to the second output terminal of the current supply circuit, and wherein the controller further comprises a feedback input coupled to the sense resistor; and

wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input.

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12. The lighting system according to Claim 11, wherein the current supply circuit further comprises a low pass filter coupled between the sense resistor and the feedback input of the controller.

13. The lighting system according to Claim 8, wherein the charging inductor has an inductance of about 50 μH to about 1.3 mH.

14. The lighting system according to Claim 8, wherein the charging inductor has an inductance of about 680 μH.

15. The lighting system according to Claim 1, wherein the at least one sensor comprises a temperature sensor that generates a sensor output signal corresponding to temperature information.

16. The lighting system according to Claim 1, wherein the at least one sensor comprises a light sensor that generates sensor output signal responsive to light output by the lighting system.

17. The lighting system according to Claim 1, wherein the current supply circuit is configured to convert at least about 85% of input power into output power.

18. The lighting system according to Claim 1, wherein the current supply circuit is configured to convert at least about 90% of input power into output power.

19. A lighting system, comprising:

a lighting panel including at least three strings of solid state lighting devices that are each configured to emit light;

at least three current supply circuits coupled to the at least three strings, respectively, wherein each of the current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and

a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the current supply circuits, a first PWM

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control signal and a second PWM control signal that are supplied to the at least three strings, respectively,

wherein each of the current supply circuits comprises:

a first control transistor including a control terminal coupled to a first control output of the PWM controller, and

a second control transistor coupled to an output terminal of the current supply circuit and having an input coupled to a second control output of the PWM controller.

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SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

ABSTRACT OF THE DISCLOSURE

A lighting system includes a lighting panel having a string of solid state lighting devices and a current supply circuit having a voltage input terminal, a control input terminal, and first and second output terminals coupled to the string of solid state lighting devices. The current supply circuit is configured to supply an on-state drive current to the string of solid state lighting devices in response to a control signal. The current supply circuit includes a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal. The current supply circuit is configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the string of solid state light emitting devices.

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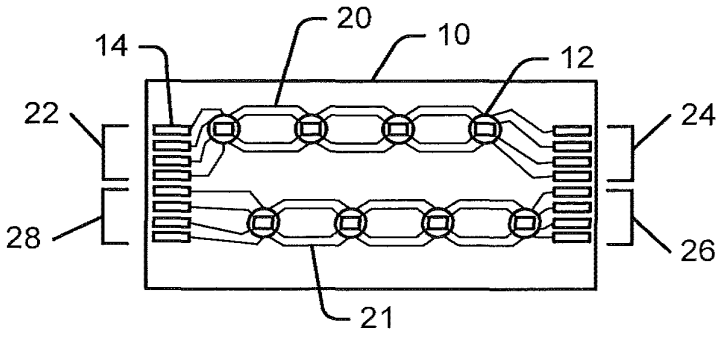


FIGURE 1

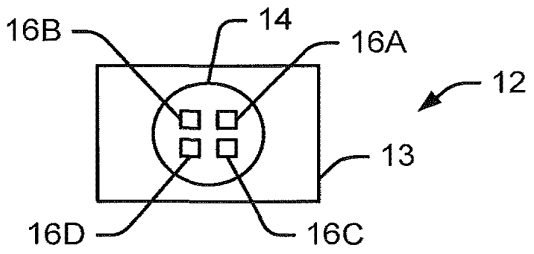


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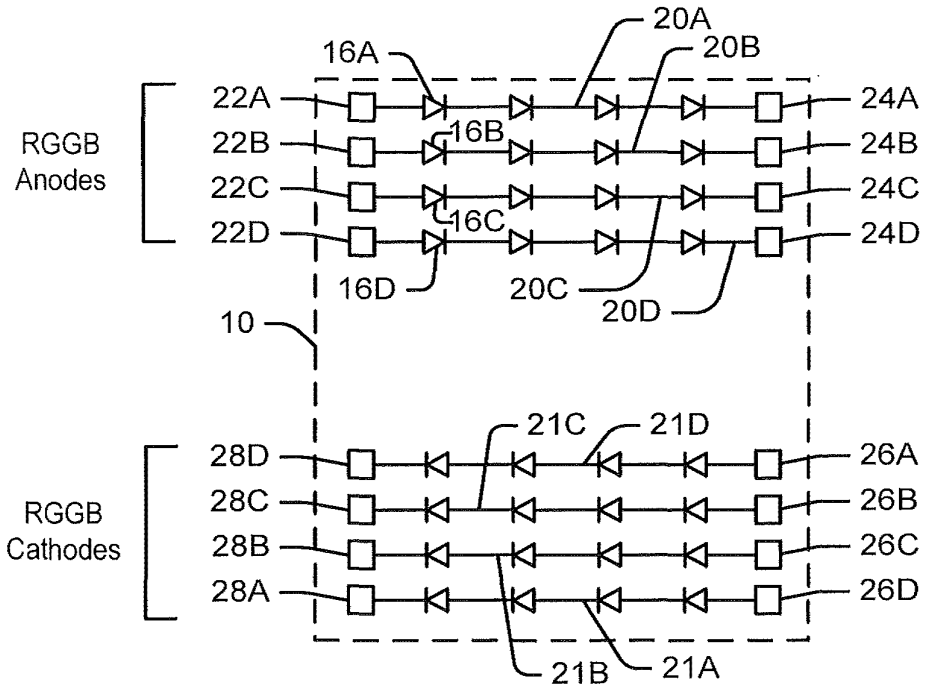


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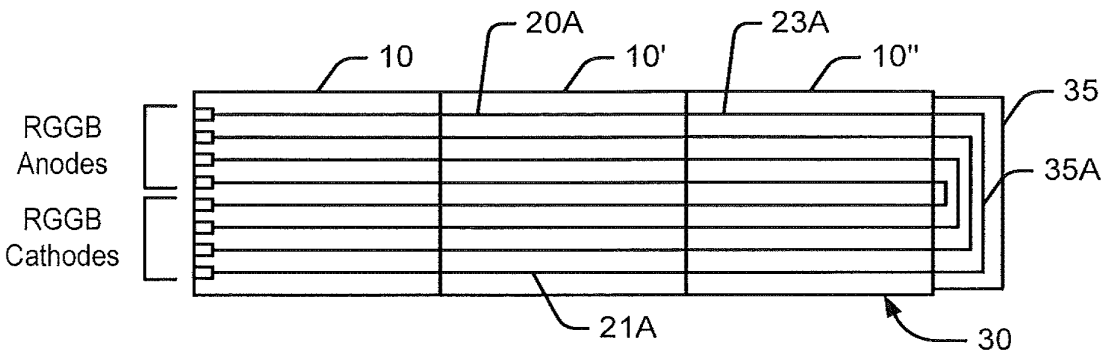


FIGURE 4A

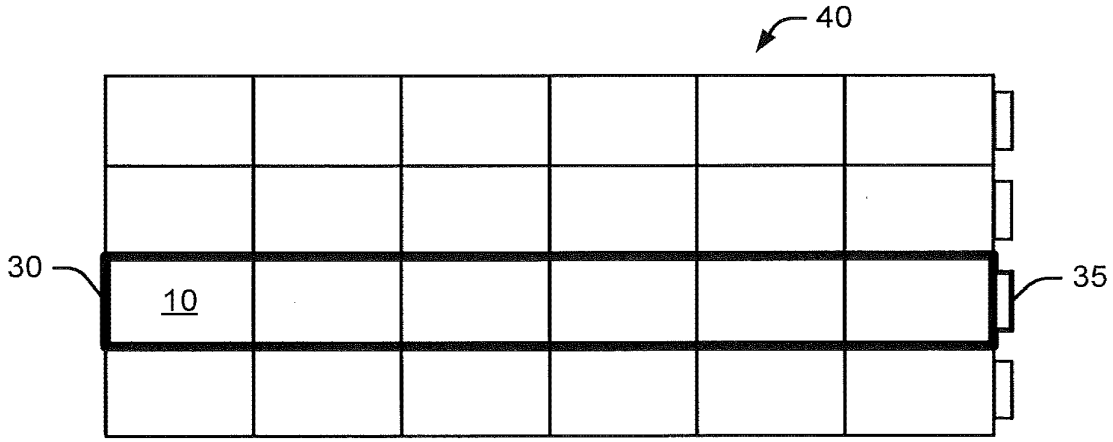


FIGURE 4B

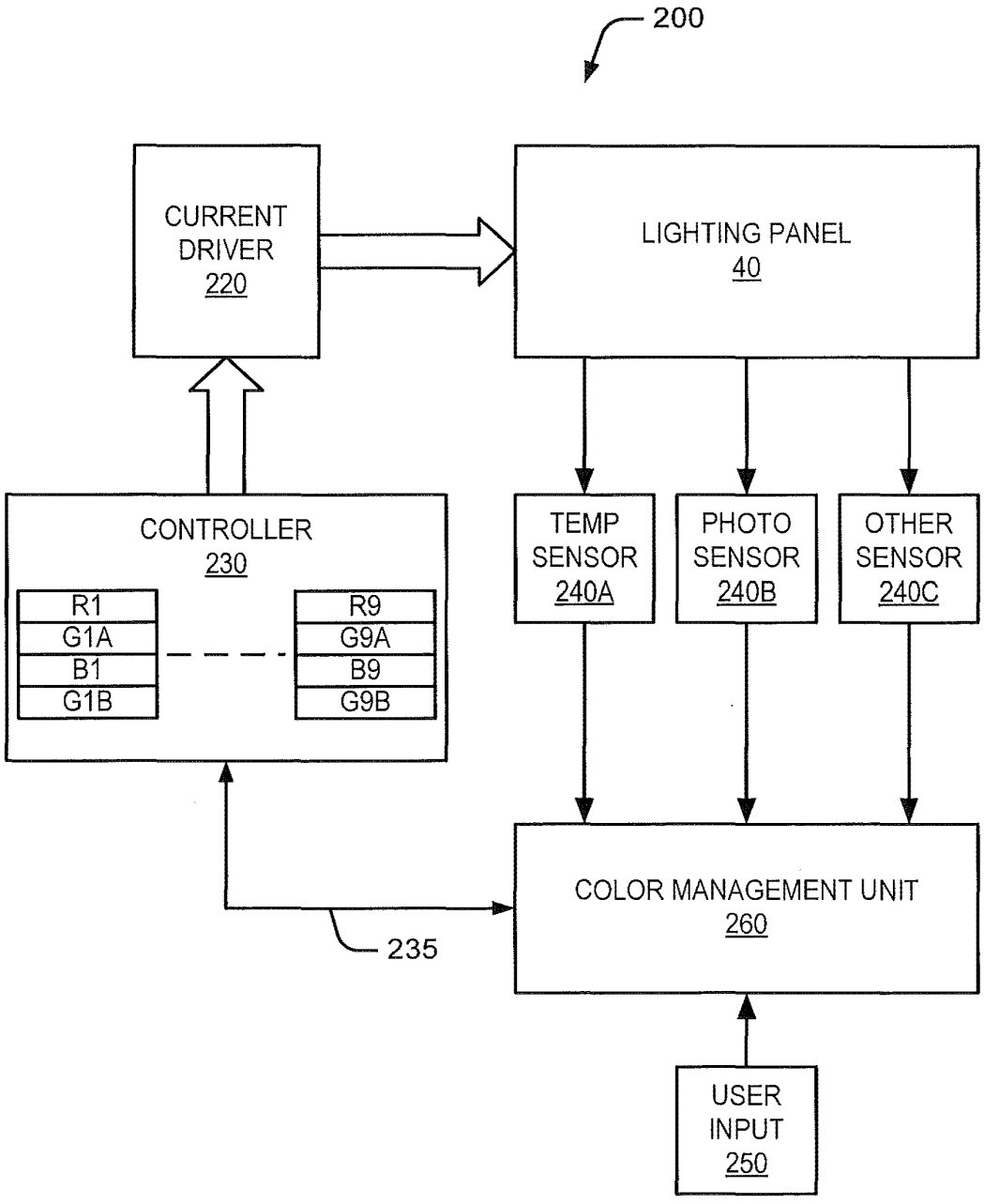

200
CURRENT DRIVER 220
LIGHTING PANEL 40
CONTROLLER 230
R1
G1A
B1
G1B
R9
G9A
B9
G9B
TEMP SENSOR 240A
PHOTO SENSOR 240B
OTHER SENSOR 240C
COLOR MANAGEMENT UNIT 260
235
USER INPUT 250

FIGURE 5

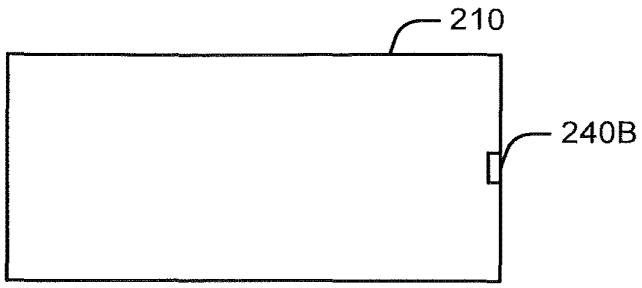


FIGURE 6A

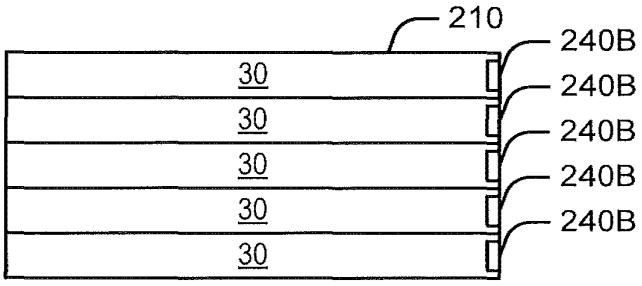


FIGURE 6B

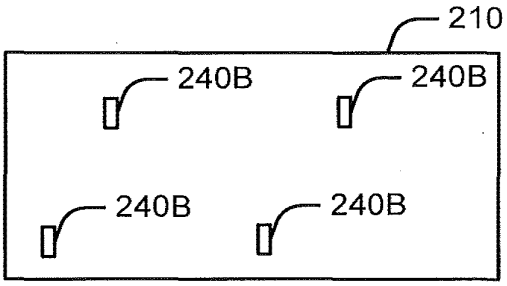


FIGURE 6C

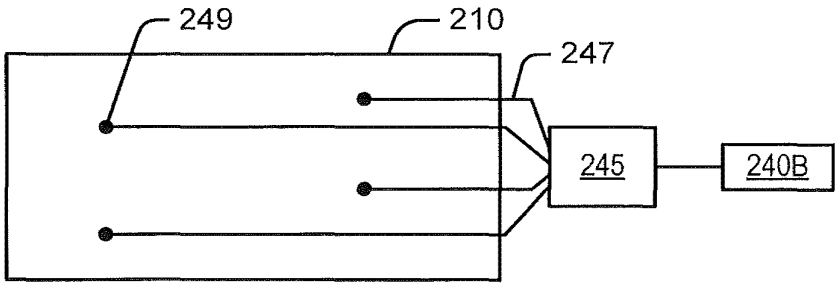


FIGURE 6D

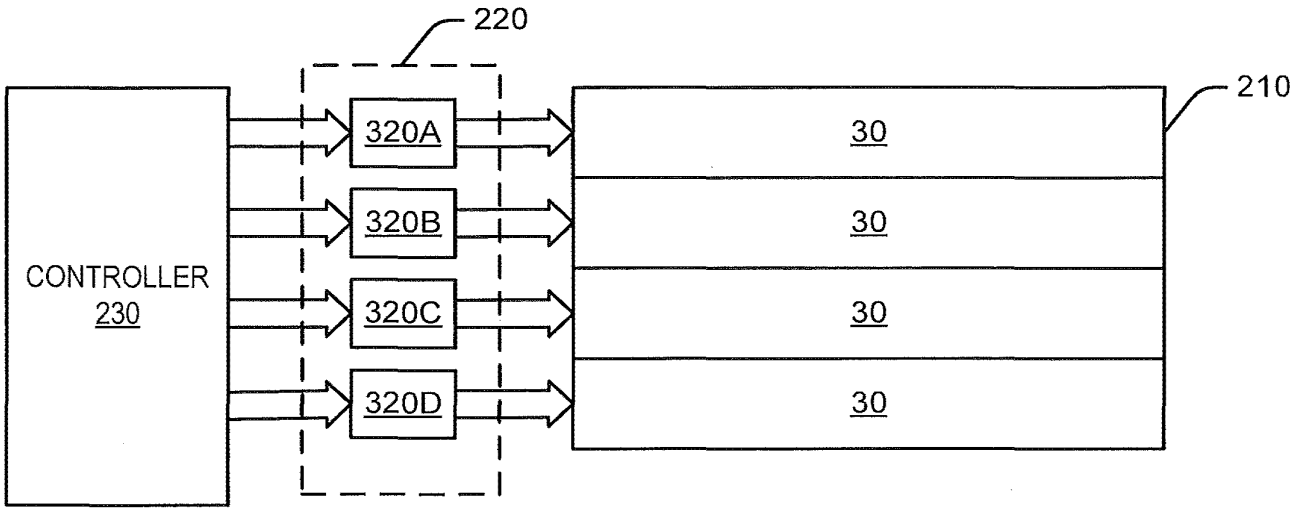


FIGURE 7

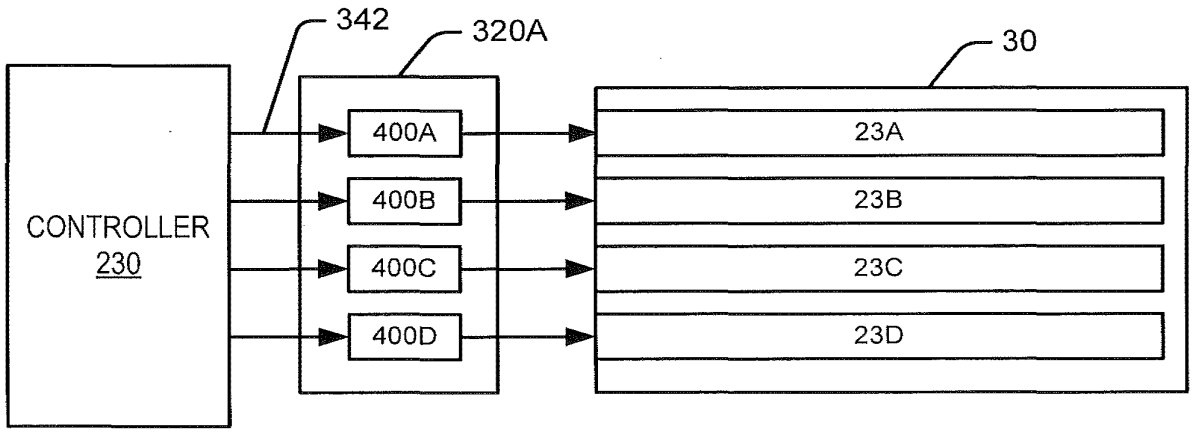


FIGURE 8

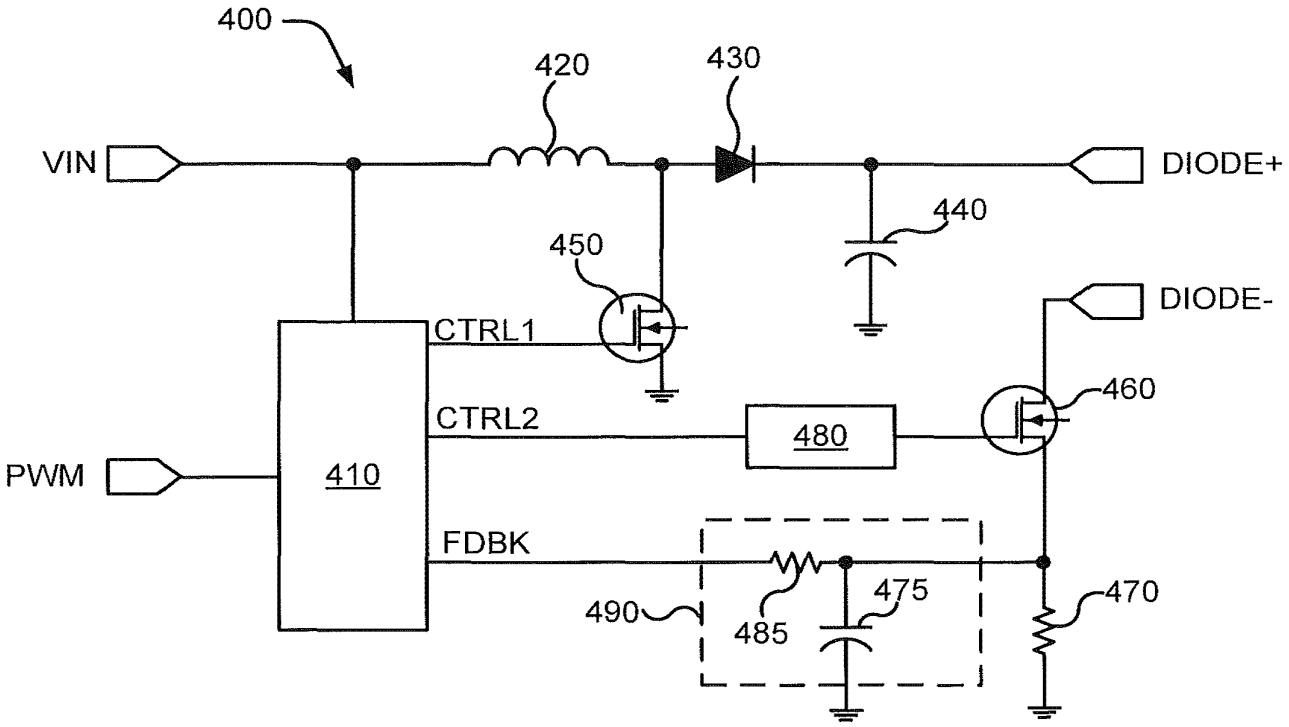


FIGURE 9

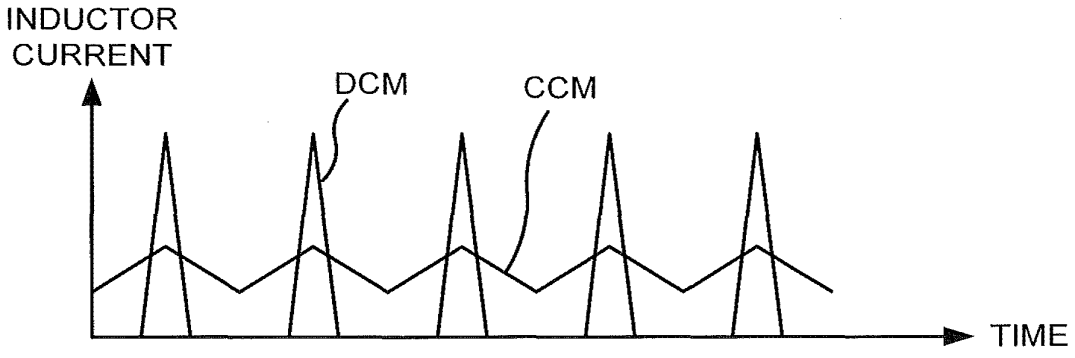


FIGURE 10

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Filer:	Timothy Jennings Wall/Kirsten Carlos
Attorney Docket Number:	5308-706TSCT3

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	280	280
Utility Search Fee	1111	1	600	600
Utility Examination Fee	1311	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1600**

Electronic Acknowledgement Receipt

EFS ID:	15809162
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Kirsten Carlos
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	17-MAY-2013
Filing Date:	
Time Stamp:	16:44:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1600
RAM confirmation Number	3879
Deposit Account	500220
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	5308_706TSCT3Transmittal.pdf	171561 c3fc45ab0f97f8a171a74e17b5cb26af153091fd	no	2
Warnings:					
Information:					
2	Application Data Sheet	5308_706TSCT3ADS.pdf	662396 598abfd3c02997c821b2767eb9025a129485d36e	no	6
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3		5308_706TSCT3Application.pdf	3036152 4f24877d28544fc2048ad2f7f44529ddb1e05f36	yes	26

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	21
Claims	22	25
Abstract	26	26

Warnings:					
Information:					
4	Drawings-only black and white line drawings	5308_706TSCT3Figures.pdf	299316 b5be3c2845ae3a0b3a855ce6702dcda28cef1462	no	6
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	33174 5a6c5a2f471abde7b96dd958d4565c073a65be36	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4202599		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DATE: **May 17, 2013**

UTILITY PATENT APPLICATION TRANSMITTAL LETTER AND FEE TRANSMITTAL FORM (37 CFR § 1.53(b)) FOR ELECTRONIC FILING

Attorney Docket No.: **5308-706TSCT3**

Inventor(s): **John K. Roberts; Keith J. Vadas**

Applicant: **Cree, Inc.**

Entitled: **SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES**

Correspondence Address: **Customer No. 65106**

Transmitted herewith for filing under 37 CFR § 1.53(b) is:

1. ☒ **26** pages of Specification
2. ☒ **6** sheets of Formal Drawings (35 USC 113)
3. ☒ Application Data Sheet. See 37 CFR 1.76
4. ☐ Oath or Declaration
   a. ☐ newly executed *(copy)*
   b. ☐ copy from prior application
5. ☐ Power of Attorney ☐ 37 CFR 3.73(c) Statement
6. ☐ Sequence Listing
   a. ☐ computer readable copy
   b. ☐ paper copy (___ pages)
   c. ☐ statement regarding sequence listing (___ page)
7. ☐ Information Disclosure Statement
8. ☐ Preliminary Amendment ***(Please enter all claim amendments prior to calculating the filing fee.)***
9. ☐ Non-publication Request under 35 U.S.C. 122(b)(2)(B)(i).
10. ☐ Other:

11. ☐ Applicant claims small entity status. See 37 CFR § 1.27.

The fee has been calculated as shown below:

	Column 1 No. Filed	Column 2 No. Extra	Small Entity Rate Fee	Large Entity Rate Fee
TOTAL CLAIMS	**19** - 20 =	**0**	* 40 = $	*80 = $0.00
INDEP CLAIMS	**2** - 3 =	**0**	*210 = $	*420 = $
FILING FEE			$ 70.00	$280.00
SEARCH FEE			$300.00	$600.00
EXAMINATION FEE			$360.00	$720.00
☐ MULTIPLE Dependent Claims Presented			+ 390 = $	+ 780 = $
☐ NON-ENGLISH SPECIFICATION			+ 70 = $	+ 140 = $
☐ SURCHARGE (for late submission of basic filing fee, examination fee or inventor's oath or declaration)			+ 70 = $	+ 140 = $
If the difference in Col. 1 is less than zero, Enter "0" in Col. 2			Total $	Total $1600.00

	Total number of pages @ .75 rate	Extra page units (rounded up, per 50)	Small Entity Rate Fee	Large Entity Rate Fee
EFS APPLICATION SIZE FEE	____ * .75 = ____ - 100 = ____	**0**	* 200 = $	* 400 = $.00

☒ Please charge my Deposit Account No. 50-0220 in the amount of $1600.00.
☒ The Commissioner is hereby authorized to credit overpayments or charge the appropriate fees associated with this communication to Deposit Account No. 50-0220.

Respectfully submitted,

Timothy J. Wall
Registration No. 50,743

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4) to the U.S. Patent and Trademark Office on May 17, 2013.

Kirsten S. Carlos

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Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 06/12/2013

ASAHLE SALE #00000038 Mailroom Dt: 05/17/2013 500220 13896977
01 FC : 1051 140.00 DA

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/896,977	Filing Date 05/17/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
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	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

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LDRC
/WANDA NELSON/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: John K .Roberts et al. Confirmation No.: 9407
Serial No.: 13/896,977
Filing Date: May 17, 2013
For: **SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES**

Date: May 22, 2013

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL APPLICATION DATA SHEET TRANSMITTAL SHEET

Dear Sir:

Applicants submit herewith a Supplemental Application Data Sheet. The Application Data Sheet filed with the application on May 17, 2013 failed to include Inventor 3. This Supplemental Application Data Sheet contains Inventor 3 and should replace the previously filed Application Data Sheet.

Respectfully submitted,

Timothy J. Wall
Registration No. 50,743
Attorney for Applicants

Customer Number 65106
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
919-854-1400
919-854-1401 (Fax)

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on May 22, 2013.

Michele P. McMahan

PTO/AIA/14 (03-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	John	K.	Roberts	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Grand Rapids	State/Province	MI	Country of Residence	US

Mailing Address of Inventor:

Address 1	1061 Plymouth Avenue SE		
Address 2			
City	Grand Rapids	State/Province	MI
Postal Code	49506-6525	Country i	US

Inventor 2 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Keith	J.	Vadas	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Lake Worth	State/Province	FL	Country of Residence	US

Mailing Address of Inventor:

Address 1	7202 Michigan Isle Road		
Address 2			
City	Lake Worth	State/Province	FL
Postal Code	33467	Country i	US

Inventor 3 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Muhinthan		Murugesu	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

City	Morrisville	State/Province	NC	Country of Residence	US

Mailing Address of Inventor:

Address 1	528 Writers Way		
Address 2			
City	Morrisville	State/Province	NC
Postal Code	27560	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	65106		
Email Address	uspto@myersbigel.com	Add Email	Remove Email

Application Information:

Title of the Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES		
Attorney Docket Number	5308-706TSCT3	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	Suggested Figure for Publication (if any)	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

Customer Number	65106

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	13/469188	2012-05-11
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/977422	2010-12-23
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	11/601504	2006-11-17
Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	60/738305	2005-11-18

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[1] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country[1]	Filing Date (YYYY-MM-DD)	Access Code[1] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Cree, Inc.

Mailing Address Information For Applicant:

Address 1	4600 Silicon Drive		
Address 2			
City	Durham	**State/Province**	NC
Country	US	Postal Code	27703
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	5308-706TSCT3
	Application Number	
Title of Invention	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES	

Mailing Address Information For Non-Applicant Assignee:			
Address 1			
Address 2			
City		State/Province	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature				Date (YYYY-MM-DD)	2013-05-22
First Name	Timothy J.	Last Name	Wall	Registration Number	50743

Additional Signature may be generated within this form by selecting the Add button.

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Electronic Acknowledgement Receipt

EFS ID:	15842895
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	22-MAY-2013
Filing Date:	
Time Stamp:	14:25:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		5308-706TSCT3-Supplemental-ADS.pdf	2887867 e6a14fadc3a5ede52dee01310b77d6f3a0ac1c44	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Miscellaneous Incoming Letter	1	1
	Application Data Sheet	2	7
Warnings:			
Information:			
	Total Files Size (in bytes):	2887867	

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
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Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re: John K. Roberts et al. Confirmation No. 9407
U.S. Serial No. 13/896,977
Filing Date: May 17, 2013
For: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Date: May 24, 2013

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Sir:

Prior to the examination of the above-referenced application, please enter the following amendments and consider the remarks below.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 9 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-19. Canceled

20. (New) A lighting system, comprising:

at least three strings of solid state lighting devices that are respectively configured to emit at least a first light, a second light and a third light, respectively;

at least three current supply circuits coupled to first, second and third strings of the at least three strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least three strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor, each of the current supply circuits comprising:

a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and

first and second output terminals coupled to the respective string of the at least three strings of solid state lighting devices.

21. (New) The lighting system according to Claim 20, further comprising a sense resistor coupled to the second output terminal of ones of the current supply circuits.

22. (New) The lighting system according to Claim 21,

wherein the controller further comprises a feedback input coupled to the sense resistor, and

wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input.

23. (New) The lighting system according to Claim 20, wherein the controller comprises a closed loop control system that is configured to generate the first and second

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Exhibit 1002 - Page 60 of 321

PWM control signals in response to the sensor output signals generated by the at least one temperature sensor.

24. (New) The lighting system according to Claim 20, wherein ones of the at least three current supply circuits comprise a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

25. (New) The lighting system according to Claim 20, wherein ones of the at least three current supply circuits comprise a voltage input terminal, and a control input terminal.

26. (New) The lighting system according to Claim 20, wherein ones of the at least three current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal.

27. (New) The lighting system according to Claim 26, wherein the ones of the current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first, second and third strings, respectively.

28. (New) The lighting system according to Claim 26, wherein each of the current supply circuits comprises:

a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor; and

a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller,

wherein the first control transistor is configured to cause the charging inductor to be energized in response to the first PWM control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first PWM control signal.

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Exhibit 1002 - Page 61 of 321

29. (New) The lighting system according to Claim 28, further comprising a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller;

wherein the second control transistor is configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to the second PWM control signal from the controller.

30. (New) The lighting system according to Claim 29, wherein ones of the current supply circuits further comprise:

a low pass filter between the second control output and the second control transistor.

31. (New) The lighting system according to Claim 26, wherein the charging inductor has an inductance of about 50 μH to about 1.3 mH.

32. (New) The lighting system according to Claim 26, wherein the charging inductor has an inductance of about 680 μH.

33. (New) The lighting system according to Claim 20, wherein the sensor output signal comprises a first sensor output signal, further comprising a light sensor that generates a second sensor output signal responsive to light output by the lighting system,

wherein the at least one control signal comprises the first sensor output signal and the second output sensor signal.

34. (New) The lighting system according to Claim 20, wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power.

35. (New) The lighting system according to Claim 20, wherein ones of the current supply circuit is configured to convert at least about 90% of input power into output power.

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Exhibit 1002 - Page 62 of 321

36. (New) A lighting system, comprising:

a lighting panel including at least three strings of solid state lighting devices that are each configured to emit light;

at least three current supply circuits coupled to the at least three strings, respectively, wherein each of the current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and

a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least three strings, respectively,

wherein each of the current supply circuits comprises:

a temperature sensor that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and

a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller.

37. (New) A lighting system, comprising:

a plurality of strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

a digital control system that is configured to generate a first pulse width modulation (PWM) control signal and a second PWM control signal and that includes a closed loop control system that is configured to generate the first and second PWM control signals in response to sensor output signals generated by a temperature sensor, the first and second PWM control signals operative to cause an on-state drive current to be supplied to ones of the plurality of strings of solid state lighting devices; and

a plurality of current supply circuits coupled to the plurality of strings of solid state lighting devices, respectively,

wherein each of the current supply circuits is configured to supply the on-state drive current to a respective string of the plurality of strings of solid state lighting devices in response to the first and second PWM control signals, and

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wherein each of the current supply circuits includes a controller having a control input, a first control output configured to provide the first PWM control signal, and a second control output configured to provide the second PWM control signal.

38. (New) The lighting system according to Claim 37, wherein each of the current supply circuits comprises a sense resistor that is coupled to an output terminal of the respective one of the current supply circuits and that is coupled to a feedback input of the digital control system to provide the closed loop control.

39. (New) The lighting system according to Claim 38, further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input to the digital control system.

40. (New) The lighting system according to Claim 37,

wherein the plurality of strings of solid state lighting devices comprises a first string of solid state lighting devices that are coated with a wavelength conversion phosphor and that are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and

wherein the plurality of strings of solid state lighting devices further comprises a second string of solid state lighting devices that are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

41. (New) The lighting system according to Claim 40, wherein the plurality of current supply circuits include a first current supply circuit coupled to the first string of solid state lighting devices and a second current supply circuit coupled to the second string of solid state lighting devices, and

wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

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42. (New) The lighting system according to Claim 37, wherein the plurality of strings of solid state lighting devices are further configured to emit a third light,

wherein the plurality of strings of solid state lighting devices comprises a first string of solid state lighting devices that are coated with a wavelength conversion phosphor and that are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color,

wherein the plurality of strings of solid state lighting devices comprises a second string of solid state lighting devices that are coated with a wavelength conversion phosphor and that are configured to emit the second light that includes a combined light including a dominant wavelength corresponding to the blue color and a dominant wavelength corresponding to the yellow color, and

wherein the plurality of strings of solid state lighting devices further comprises a third string of solid state lighting devices that are configured to emit the third light that includes a dominant wavelength corresponding to a red color.

43. (New) The lighting system according to Claim 42, wherein the plurality of current supply circuits include a first current supply circuit coupled to the first string of solid state lighting devices, a second current supply circuit coupled to the second string of solid state lighting devices and a third current supply circuit coupled to the third string of solid state lighting devices, and

wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

44. (New) The lighting system according to Claim 43, wherein the second supply circuit provides current control of the second string of solid state lighting devices that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

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45. (New) The lighting system according to Claim 44, wherein the first current supply circuit provides current control of the first string of solid state lighting devices at a first duty cycle and the second current supply circuit provides current control of the second string of solid state lighting devices at a second duty cycle that is different from the first duty cycle.

46. (New) The lighting system according to Claim 45, wherein the first duty cycle is substantially fixed and the second duty cycle is substantially variable.

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Exhibit 1002 - Page 66 of 321

REMARKS

This Preliminary Amendment is being filed to cancel Claims 1-19 and add Claims 20-46.

Entry of this Preliminary Amendment, examination of the application, and allowance of the application is respectfully requested. If, in the opinion of the Examiner, a telephonic conference would expedite the examination of this matter, the Examiner is invited to call the undersigned attorney at (919) 854-1400

Respectfully submitted,

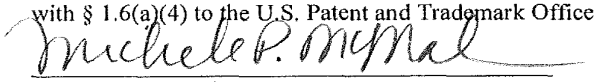


Timothy J. Wall
Registration No. 50,743

Customer Number 65106
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
919-854-1400
919-854-1401 (Fax)

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on May 24, 2013.



Michele P. McMahan

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 67 of 321

Electronic Patent Application Fee Transmittal

Application Number:	13896977
Filing Date:	
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Filer:	Timothy Jennings Wall/Michele McMahan
Attorney Docket Number:	5308-706TSCT3

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in Excess of 20	1202	7	80	560
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**560**

Electronic Acknowledgement Receipt

EFS ID:	15864265
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	24-MAY-2013
Filing Date:	
Time Stamp:	12:18:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$560
RAM confirmation Number	9779
Deposit Account	500220
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 70 of 321

1		5308-706TSCT3-Preliminary-Amendment.pdf	752548 0189b70ebc659ac8c4f7313fc9d1c9b271d1658d	yes	9

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Preliminary Amendment	1	1
Claims	2	8
Applicant Arguments/Remarks Made in an Amendment	9	9

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30480 4c87756b1c39857776a6b4cb65e3ee6211afc270	no	2

Warnings:

Information:

Total Files Size (in bytes):	783028

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/896,977	05/17/2013	2821	2300	5308-706TSCT3	27	3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

FILING RECEIPT

OC000000061909980

Date Mailed: 06/19/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

John K. Roberts, Grand Rapids, MI;
Keith J. Vadas, Lake Worth, FL;

Applicant(s)

Cree, Inc., Durham, NC

Assignment For Published Patent Application

Cree, Inc., Durham, NC

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/469,188 05/11/2012 PAT 8461776
which is a CON of 12/977,422 12/23/2010 PAT 8203286
which is a CON of 11/601,504 11/17/2006 PAT 7872430
which claims benefit of 60/738,305 11/18/2005

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 06/12/2013

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 72 of 321

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/896,977**

Projected Publication Date: 09/26/2013

Non-Publication Request: No

Early Publication Request: No

Title

SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Preliminary Class

315

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Exhibit 1002 - Page 73 of 321

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

NOTICE



Date Mailed: 06/19/2013

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  John K. Roberts
  Keith J. Vadas

  Applicant may submit the inventor's oath or declaration at any time before the Notice of Allowance and Fee(s) Due, PTOL-85, is mailed.

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Exhibit 1002 - Page 75 of 321

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/896,977

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	27 minus 20 =	* 7			OR	x 80 =	560
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2160

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re: John K. Roberts et al. Confirmation No. 9407
U.S. Serial No. 13/896,977
Filing Date: May 17, 2013
For: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Date: June 20, 2013

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL PRELIMINARY AMENDMENT

Sir:

Prior to the examination of the above-referenced application, please enter the following amendments and consider the remarks below.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 7 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-46. (Canceled)

47. (New) A lighting system, comprising:

at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least two current supply circuits coupled to first and second strings of the at least two strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least two strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor, each of the current supply circuits comprising:

a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and

first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices.

48. (New) The lighting system according to Claim 47, further comprising a sense resistor coupled to the second output terminal of ones of the current supply circuits.

49. (New) The lighting system according to Claim 48,

wherein the controller further comprises a feedback input coupled to the sense resistor, and

wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input.

50. (New) The lighting system according to Claim 47, wherein the controller comprises a closed loop control system that is configured to generate the first and second

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Exhibit 1002 - Page 78 of 321

PWM control signals in response to the sensor output signals generated by the at least one temperature sensor.

51. (New) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

52. (New) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a voltage input terminal, and a control input terminal.

53. (New) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal.

54. (New) The lighting system according to Claim 53, wherein the ones of the at least two current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first and second strings, respectively.

55. (New) The lighting system according to Claim 53, wherein each of the current supply circuits comprises:

a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor; and

a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller,

wherein the first control transistor is configured to cause the charging inductor to be energized in response to the first PWM control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first PWM control signal.

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Exhibit 1002 - Page 79 of 321

56. (New) The lighting system according to Claim 55, further comprising a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller;

wherein the second control transistor is configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to the second PWM control signal from the controller.

57. (New) The lighting system according to Claim 56, wherein ones of the current supply circuits further comprise:

a low pass filter between the second control output and the second control transistor.

58. (New) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 50 μH to about 1.3 mH.

59. (New) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 680 μH.

60. (New) The lighting system according to Claim 47, wherein the sensor output signal comprises a first sensor output signal, further comprising a light sensor that generates a second sensor output signal responsive to light output by the lighting system,

wherein the at least one control signal comprises the first sensor output signal and the second output sensor signal.

61. (New) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power.

62. (New) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 90% of input power into output power.

63. (New) A lighting system, comprising:

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a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices, respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices, wherein the first current supply circuit is responsive to at least one control signal generated in response to a feedback signal generated from the second string of solid state devices.

64. (New) The lighting system according to Claim 63,

wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and

a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively,

65. (New) The lighting system according to Claim 64, wherein each of the first and second current supply circuits comprises:

a temperature sensor that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and

a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller.

66. (New) The lighting system according to Claim 63, wherein each of the first and second current supply circuits comprises a sense resistor that is coupled to an output terminal of the respective one of the first and second current supply circuits and that is coupled to a feedback input to provide the feedback signal to provide closed loop control.

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67. (New) The lighting system according to Claim 66, further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input.

68. (New) The lighting system according to Claim 63,

wherein the first string of solid state lighting devices are coated with a wavelength conversion phosphor and are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and

wherein the second string of solid state lighting devices are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

69. (New) The lighting system according to Claim 68, wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

70. (New) The lighting system according to Claim 68, further comprising a third string of solid state lighting devices that are configured to emit a third light that includes a dominant wavelength corresponding to a red color.

71. (New) The lighting system according to Claim 70, further comprising a third current supply circuit that is configured to supply an on-state drive current to the third string of solid state lighting devices, and

wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 82 of 321

REMARKS

This Preliminary Amendment is being filed to cancel Claims 20-46 and add Claims 47-71.

Entry of this Preliminary Amendment, examination of the application, and allowance of the application is respectfully requested. If, in the opinion of the Examiner, a telephonic conference would expedite the examination of this matter, the Examiner is invited to call the undersigned attorney at (919) 854-1400

Respectfully submitted,

Timothy J. Wall
Registration No. 50,743

Customer Number 65106
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
919-854-1400
919-854-1401 (Fax)

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on June 20, 2013.

Michele P. McMahan

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 83 of 321

Electronic Acknowledgement Receipt

EFS ID:	16091182
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	20-JUN-2013
Filing Date:	17-MAY-2013
Time Stamp:	07:39:07
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		5308-706CT3-Supp-Preliminary-Amendment.pdf	592104 1fbf37d525cb7c43a6180086ef950683e9277886	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Supplemental Response or Supplemental Amendment	1	1
	Claims	2	6
	Applicant Arguments/Remarks Made in an Amendment	7	7
Warnings:			
Information:			
	Total Files Size (in bytes):	592104	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

65106 7590 08/08/2013

MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

EXAMINER
A, MINH D

ART UNIT	PAPER NUMBER
2821	

NOTIFICATION DATE	DELIVERY MODE
08/08/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

uspto@myersbigel.com

Office Action Summary	Application No. 13/896,977	Applicant(s) ROBERTS ET AL.	
	Examiner MINH D. A	Art Unit 2821	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *20 June 2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *47-71* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *47-54, 58-71* is/are rejected.

8)☒ Claim(s) *55-57* is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some * c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

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DETAILED ACTION

This is a response to the Applicants' filing on 5/17/13. In virtue of this filing, claims 1-24 are currently presented in the instant application.

This Office Action is a response to Applicant's Preliminary amendment filed on 5/17/13. By virtue of this amendment, claims 1-46 are cancelled and thus, claims 47-71 are currently presented in the instant application.

Double Patenting

1. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to

be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO internet Web site contains terminal disclaimer forms which may be used. Please visit http://www.uspto.gov/forms/. The filing date of the application will determine what form should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

2. Claims 63-71 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-17 of U.S. Patent No. 7,872,430. Although the claims at issue are not identical, they are not patentably distinct from each other because of the below reasons:

All limitations of claim 63 of instant application are similar all limitations of claim 1 of Patent application above. The limitations of claim 63 of the instant application are broader or similar to compare with the limitation of claim 1 of the Patent application above.

Claims 64-71 are also rejected on the ground of nonstatutory double patenting since they are dependent to claim 63.

3. Claims 63-71 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-15 of U.S. Patent No.8,203,286. Although the claims

at issue are not identical, they are not patentably distinct from each other because the below reasons:

All limitations of claim 63 of instant application are similar all limitations of claim 1 of Patent application above. The limitations of claim 63 of the instant application are broader or similar to compare with the limitation of claim 1 of the Patent application above.

Claims 64-71 are also rejected on the ground of nonstatutory double patenting since they are dependent to claim 63.

4. Claims 63-71 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-27 of U.S. Patent No. 8,461,776. Although the claims at issue are not identical, they are not patentably distinct from each other because the below reasons:

All limitations of claim 63 of instant application are similar all limitations of claim 18 of Patent application above. The limitations of claim 63 of the instant application are broader or similar to compare with the limitation of claim 18 of the Patent application above.

Claims 64-71 are also rejected on the ground of nonstatutory double patenting since they are dependent to claim 63.

Claim Rejections - 35 USC § 103

5. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been

obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claims 47-54, 60-71 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over by Bruning et al (US Patent no: 6,888, 529) in view of Morgan et al (US Pub. No: 2004/0160199).

Regarding claim 47, Bruning et al disclose in figures 3-4, a lighting system, comprising: at least two of solid state lighting devices that are respectively configured to emit at least a first light (Red) and a second light(green), respectively; at least two current supply circuits(210R, 210G) coupled to first and second of solid state lighting devices, respectively, each of the current supply circuits(210R, 210G) configured to supply an on-state drive current to a respective string of the at least two of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor(228), each of the current supply circuits(210R, 210G) comprising: a controller(232R, 232G) having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices. Col.3, lines 19-29 for independent pulse modulation to the current supplied to the red, green and blue.

Bruning et al do not clearly disclose that, at least **two strings** of solid state lighting devices that are respectively configured to emit at least a first light and a second light.

Morgan et al disclose in figure 19 that, at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light. Paragraph [0291 to 0292].

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the at least two lighting devices of Bruning et al by employing at least two strings of solid state lighting devices as taught by Morgan et al for the purpose of setting a different colors for each string, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Morgan et al.

Regarding claim 48, combination Bruning et al and Morgan et al disclose further comprising a sense resistor coupled to the second output terminal of ones of the current supply circuits. See figure 4 of Bruning et al.

Regarding claim 49, combination Bruning et al and Morgan et al disclose wherein the controller further comprises a feedback input coupled to the sense resistor, and wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input. See figure 4 of Bruning et al.

Regarding claim 50, combination Bruning et al and Morgan et al disclose wherein the controller comprises a closed loop control system that is configured to generate the first and second PWM control signals in response to the sensor output signals generated by the at least one temperature sensor. See figure 4 of Bruning et al.

Regarding claim 51, combination Bruning et al and Morgan et al disclose wherein ones of the at least two current supply circuits comprise a variable voltage boost,

constant current power supply circuit configured to operate in continuous current mode. See figures 4A-4D of Bruning et al.

Regarding claim 52, combination Bruning et al and Morgan et al disclose wherein ones of the at least two current supply circuits comprise a voltage input terminal, and a control input terminal. Figure 4 of Bruning et al.

Regarding claim 53, combination Bruning et al and Morgan et al disclose wherein ones of the at least two current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal. See figure 4 of Bruning et al.

Regarding claim 54, combination Bruning et al and Morgan et al disclose wherein the ones of the at least two current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first and second strings, respectively.

Regarding claim 60, combination Bruning et al and Morgan et al disclose wherein the sensor output signal comprises a first sensor output signal, further comprising a light sensor that generates a second sensor output signal responsive to light output by the lighting system, wherein the at least one control signal comprises the first sensor output signal and the second output sensor signal. Figure 4 of Bruning et al.

Regarding claim 61, combination Bruning et al and Morgan et al disclose wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power.

Regarding claim 62-62, combination Bruning et al and Morgan et al disclose wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power and wherein ones of the current supply circuits are configured to convert at least about 90% of input power into output power.

Regarding claim 63 is interpreted and rejected using the (similar/same) reasoning as claim 47 above that, combination Bruning et al and Morgan et al disclose a lighting system, comprising: a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively; at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices, respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices, wherein the first current supply circuit is responsive to at least one control signal generated in response to a feedback signal generated from the second string of solid state devices.

Regarding claim 64, combination Bruning et al and Morgan et al disclose wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively.

Regarding claim 65, combination Bruning et al and Morgan et al disclose wherein each of the first and second current supply circuits comprises: a temperature sensor that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller.

Regarding claim 66, combination Bruning et al and Morgan et al disclose wherein each of the first and second current supply circuits comprises a sense resistor that is coupled to an output terminal of the respective one of the first and second current supply circuits and that is coupled to a feedback input to provide the feedback signal to provide closed loop control.

Regarding claim 67, combination Bruning et al and Morgan et al disclose further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input.

Regarding claim 68, combination Bruning et al and Morgan et al disclose, wherein the first string of solid state lighting devices are coated with a wavelength conversion phosphor and are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and wherein the second string of solid state lighting devices are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

Regarding claim 69, combination Bruning et al and Morgan et al disclose wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

Regarding claim 70, combination Bruning et al and Morgan et al disclose further comprising a third string of solid state lighting devices that are configured to emit a third light that includes a dominant wavelength corresponding to a red color.

Regarding claim 71, combination Bruning et al and Morgan et al disclose further comprising a third current supply circuit that is configured to supply an on-state drive current to the third string of solid state lighting devices, and wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

7. Claims 58-59 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over by Bruning et al (US Patent no: 6,888, 529) in view of Morgan et al (US Pub. No: 2004/0160199) as applied to claim 53 above, and further in view of Pecukonis (US Patent No: 6,471,716).

Regarding claim 58-59, combination Bruning et al and Morgan et al do not disclose wherein the charging inductor has an inductance of about 50 µH to about 1.3 mH and wherein the charging inductor has an inductance of about 680 µH.

Pecukonis disclose in figure 2A that, a transistor is coupled between an inductor (38) and a rectifier (53) for supply current for an array of LEDs. See figure 2A-2B.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the inductor of combination Bruning et al and Morgan et al by employing an inductor as taught by Pecukonis for the purpose of supplying enough current flow to an array of LEDs, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Pecukonis.

Combination Bruning et al and Morgan et al and Pecukonis do not disclose exactly value of inductor.

The limitations are not of patentable merits since it is directed to a manner of operating the control device which does not differentiate apparatus claim from the prior art. A claim containing a recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus if the prior art apparatus teaches all the structural limitations of the claim. See MPEP § 2114.

Allowable Subject Matter

8. Claims 55-57 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

9. The following is a statement of reasons for the indication of allowable subject matter:

Prior art of record fails to disclose or fairly suggest, alone or in combination, wherein each of the current supply circuits comprises: a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor; and a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller, wherein the first control transistor is configured to cause the charging inductor to be energized in response to the first PWM control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first PWM control signal as recited in claim 55(claims 56-57 would 6-57 would be allowable since they are dependent on claim 55).

Citation of pertinent prior art

The prior art made of record and not relied upon is considered pertinent to applicants' disclosure. See prior arts/references listed on the PTO-892 form attached.

Inquiry

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh Dieu A whose telephone number is (571) 272-1817. The examiner can normally be reached on M-F (8:00AM to 5:00PM).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W Owens can be reached on (571) 272-1662. The fax phone

number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Minh D A/

Primary Examiner

Art Unit 2821

Date 8/4/13

Notice of References Cited	Application/Control No. 13/896,977	Applicant(s)/Patent Under Reexamination ROBERTS ET AL.	
	Examiner MINH D. A	Art Unit 2821	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2004/0135524	07-2004	Gunter et al.	315/291
*	B	US-6,888,529	05-2005	Bruning et al.	345/102
*	C	US-7,872,430	01-2011	Roberts et al.	315/307
*	D	US-8,203,266	06-2012	Egawa et al.	313/544
*	E	US-8,461,776	06-2013	Roberts et al.	315/291
*	F	US-6,471,716	10-2002	Pecukonis, Joseph P.	607/89
*	G	US-6,717,559	04-2004	Weindorf, Paul F. L.	345/82
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	Art Unit
	MINH D A	2821

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
315	291, 307, 224, 246, 185R, 200R, 312	8/2/13	MA

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor's name search "East", see serch print out	8/4/13	MA
Test search "East", see search print out	8/2/13	MA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	Art Unit
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013								
	1	-								
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013								
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	71	✓								

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
L2	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and L1	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
L3	32	L2 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
L4	4	L3 and string	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
L5	235	(string$1) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
L6	65	L5 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
L7	325	switch$3 near4 regulator same (string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:06
L8	67	switch$3 near4 regulator same (string$1 or	US-	OR	ON	2013/08/04

		array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting) same inductor	PGPUB; USPAT; USOCR; FPRS; EPO; JPO			19:07
L9	5	L8 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:07
S1	10	"7872430"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S2	15	"8203286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S3	1	"8461776"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S4	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:50
S5	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S6	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S7	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2013/08/02 19:51

			JPO			
S8	859	315/185R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S9	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S10	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:52
S11	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:42
S12	2386	S11 and (constant near4 (current or voltage) or variable with (boost or buck or bulk))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:44
S13	602	S12 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:44
S14	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S15	49	S13 and S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S16	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR;	OR	ON	2013/08/04 07:45

			FPRS; EPO; JPO			
S17	34	S13 and S16	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S18	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S19	22	S13 and S18	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S20	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S21	1	S13 and S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S22	859	315/185R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S23	1	S13 and S22	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S24	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S25	1	S13 and S24	US-PGPUB;	OR	ON	2013/08/04 07:46

			USPAT; USOCR; FPRS; EPO; JPO			
S26	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S27	19	S13 and S26	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S28	105675	"315"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S29	165442	"345"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S30	113	S13 and S28	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S31	40	S13 and S29	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S32	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S33	0	S32 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48

S34	26	S32 and S12	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S35	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S36	2386	S35 and (constant near4 (current or voltage) or variable with (boost or buck or bulk))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S37	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S38	26	S37 and S36	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S39	21	S38 and temperature near4 sensor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S40	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:28
S41	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and S40	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:29
S42	32	S41 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS;	OR	ON	2013/08/04 11:29

			EPO; JPO			

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

PUBLICATION NOTICE

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Title:SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Publication No.US-2013-0249408-A1
Publication Date:09/26/2013

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re: John K. Roberts et al.
U.S. Serial No. 13/896,977
Filing Date: May 17, 2013
For: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Confirmation No. 9407
Examiner: Minh Dieu A
Group Art Unit: 2821

Date: November 8, 2013

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO AUGUST 8, 2013 OFFICE ACTION

Sir:

This paper is responsive to the Office Action mailed August 8, 2013 regarding the above-referenced patent application. Please amend this application as follows and reconsider the rejections of the claims for at least the reasons presented in the following remarks.

If any extension of time for the accompanying response or submission is required, Applicants request that this be considered a petition therefor. The Commissioner is hereby authorized to charge any additional fee, which may be required, or credit any refund, to our Deposit Account No. 50-0220.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 8 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-46. (Canceled)

47. (Previously Presented) A lighting system, comprising:

at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least two current supply circuits coupled to first and second strings of the at least two strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least two strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor, each of the current supply circuits comprising:

a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and

first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices.

48. (Previously Presented) The lighting system according to Claim 47, further comprising a sense resistor coupled to the second output terminal of ones of the current supply circuits.

49. (Previously Presented) The lighting system according to Claim 48,

wherein the controller further comprises a feedback input coupled to the sense resistor, and

wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input.

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50. (Previously Presented) The lighting system according to Claim 47, wherein the controller comprises a closed loop control system that is configured to generate the first and second PWM control signals in response to the sensor output signals generated by the at least one temperature sensor.

51. (Previously Presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

52. (Previously Presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a voltage input terminal, and a control input terminal.

53. (Previously Presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal.

54. (Previously Presented) The lighting system according to Claim 53, wherein the ones of the at least two current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first and second strings, respectively.

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55. (Previously Presented) The lighting system according to Claim 53, wherein each of the current supply circuits comprises:

a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor; and

a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller,

wherein the first control transistor is configured to cause the charging inductor to be energized in response to the first PWM control signal from the controller and to cause energy stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first PWM control signal.

56. (Previously Presented) The lighting system according to Claim 55, further comprising a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller;

wherein the second control transistor is configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to the second PWM control signal from the controller.

57. (Previously Presented) The lighting system according to Claim 56, wherein ones of the current supply circuits further comprise:

a low pass filter between the second control output and the second control transistor.

58. (Previously Presented) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 50 μH to about 1.3 mH.

59. (Previously Presented) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 680 μH.

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60. (Previously Presented) The lighting system according to Claim 47, wherein the sensor output signal comprises a first sensor output signal, further comprising a light sensor that generates a second sensor output signal responsive to light output by the lighting system,

wherein the at least one control signal comprises the first sensor output signal and the second output sensor signal.

61. (Previously Presented) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power.

62. (Previously Presented) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 90% of input power into output power.

63. (Currently Amended) A lighting system, comprising:

a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices, respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices[[,]]; and ~~wherein the first current supply circuit is responsive to at least one control signal generated in response to a feedback signal generated from the second string of solid state devices.~~

a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings.

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64. (Currently Amended) The lighting system according to Claim 63,

wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.~~; and~~

~~a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively,~~

65. (Previously Presented) The lighting system according to Claim 64, wherein each of the first and second current supply circuits comprises:

a temperature sensor that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and

a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller.

66. (Previously Presented) The lighting system according to Claim 63, wherein each of the first and second current supply circuits comprises a sense resistor that is coupled to an output terminal of the respective one of the first and second current supply circuits and that is coupled to a feedback input to provide the feedback signal to provide closed loop control.

67. (Previously Presented) The lighting system according to Claim 66, further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input.

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68. (Previously Presented) The lighting system according to Claim 63,

wherein the first string of solid state lighting devices are coated with a wavelength conversion phosphor and are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and

wherein the second string of solid state lighting devices are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

69. (Previously Presented) The lighting system according to Claim 68, wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

70. (Previously Presented) The lighting system according to Claim 68, further comprising a third string of solid state lighting devices that are configured to emit a third light that includes a dominant wavelength corresponding to a red color.

71. (Previously Presented) The lighting system according to Claim 70, further comprising a third current supply circuit that is configured to supply an on-state drive current to the third string of solid state lighting devices, and

wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

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REMARKS

Applicants appreciate the detailed examination evidenced by the Office Action mailed August 8, 2013 (hereinafter "Office Action"). Applicants appreciate the indication that Claims 55-57 include allowable subject matter. However, Claims 55-57 have not been rewritten in independent form as Applicants believe that all claims are patentable over the cited references for the reasons that will be discussed in detail below.

Claim 63 has been amended to include a portion of the recitations of Claim 64, which has been amended herein. Additionally, Applicants are filing a terminal disclaimer concurrently with this Amendment to overcome the double patenting rejections. Applicants respectfully submit that the pending claims are patentable for at least the reasons provided herein, the allowance of which is respectfully requested.

Status of the Claims

Claims 47-54 and 60-71 stand rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,888,529 to Bruning et al. (hereinafter "Bruning") in view of U.S. Patent Publication No. 2004/0160199 to Morgan et al. (hereinafter "Morgan"). (Office Action, p. 5).

Claims 58-59 stand rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Bruning, in view of Morgan, and further in view of U.S. Patent No. 6,471,716 to Pecukonis (hereinafter "Pecukonis"). (Office Action, p. 10).

Double Patenting Rejections

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-17 of U.S. Patent No. 7,872,430. (*See* Office Action, page 3.) In response, Applicants submit herewith a Terminal Disclaimer disclaiming additional term over United States Patent No. 7,872,430. Applicants' agreement to provide a Terminal Disclaimer is to expedite issuance of the present case and does not admit that the present invention is not patentably distinct from United States Patent No. 7,872,430. Withdrawal of the double patenting rejection is respectfully requested.

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-15 of U.S. Patent No. 8,203,286. (*See* Office Action, page 3.) In

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response, Applicants submit herewith a Terminal Disclaimer disclaiming additional term over United States Patent No. 8,203,286. Applicants' agreement to provide a Terminal Disclaimer is to expedite issuance of the present case and does not admit that the present invention is not patentably distinct from United States Patent No. 8,203,286. Withdrawal of the double patenting rejection is respectfully requested.

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-27 of U.S. Patent No. 8,461,776. (*See* Office Action, page 4.) In response, Applicants submit herewith a Terminal Disclaimer disclaiming additional term over United States Patent No. 8,461,776. Applicants' agreement to provide a Terminal Disclaimer is to expedite issuance of the present case and does not admit that the present invention is not patentably distinct from United States Patent No. 8,461,776. Withdrawal of the double patenting rejection is respectfully requested.

Independent Claim 47 is Patentable Over the Cited References

Independent Claim 47 stands rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over Bruning in view of Morgan. (Office Action, p. 5). Claim 47 recites:

> A lighting system, comprising:
> at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;
> **at least two current supply circuits** coupled to first and second strings of the at least two strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least two strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor, **each of the current supply circuits comprising:**
> **a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal;** and
> first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices. (*Emphasis added.*)

Regarding Claim 47, the Office Action alleges:

> Regarding claim 47, Bruning et al disclose in figures 3-4, a lighting system, comprising: at least two of solid state lighting devices that are respectively configured to emit at least a first light (Red) and a second light(green), respectively; at least two current supply circuits (210R, 210G) coupled to first and second of solid state lighting devices, respectively, each of the

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current supply circuits (210R, 210G) configured to supply an on-state drive current to a respective string of the at least two of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor (228), each of the current supply circuits (210R, 210G) comprising: a controller (232R, 232G) having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices. Col.3, lines 19-29 for independent pulse modulation to the current supplied to the red, green and blue. (Office Action, page 5, *emphasis added.*)

Applicants respectfully disagree. For example, Figure 4 of Bruning is reproduced below for the Examiner's convenience:

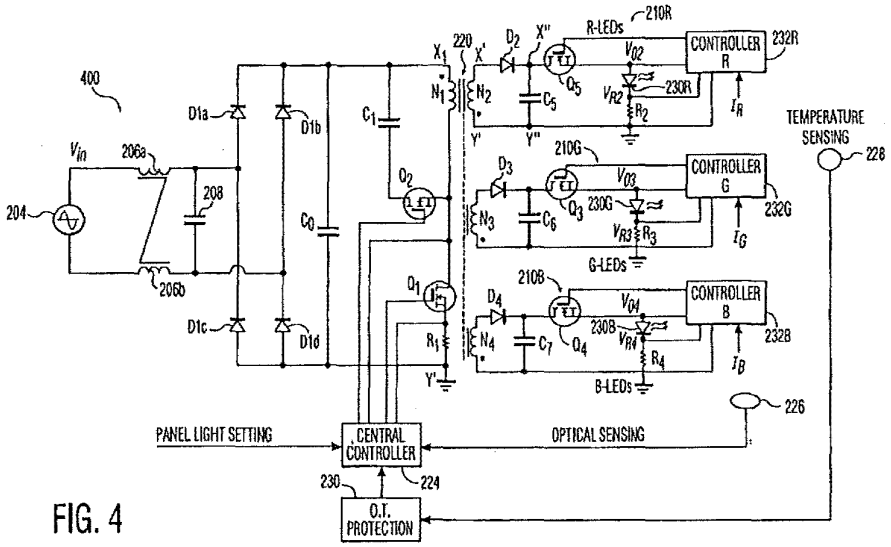


FIG. 4

Figure 4 of Bruning illustrates a circuit diagram of an LED backlight. (Bruning, col. 6, lines 63-64.) The Office Action alleges that sub-arrays 210R and 210G are current supply circuits and controller R 232R and controller G 232G are controllers. (Office Action, page 5.) Referring to sub-array 201R, Bruning describes, "[t]he current through red LED 230R and thus the light output of red LED 230R, may be varied by switching switch Q5 on and off." (Bruning, col. 9, lines 8-10.) Bruning continues, "[c]ontroller 232R independently controls the switching of switch Q5." (Bruning, col. 9, lines 16-17.) Referring to the other sub-arrays, Bruning describes, "[i]n like manner, the light output of green and blue LED sub-arrays 210G, 210B are independently controlled by independent controllers 232G, 232B." (Bruning,

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col. 9, lines 45-47.) As illustrated in Figure 4 of Bruning and described by Bruning, each controller of Bruning has only one control output. As such, Bruning does not disclose or suggest each controller having two control outputs.

In sharp contrast to Bruning, Claim 47 recites "each of the current supply circuits (210R, 210G) comprising: a controller (232R, 232G) having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal." (*Emphasis added.*) For at least the reasons provided above, Bruning fails to disclose or suggest all of the recitations of Claim 47.

The Office Action does not allege and Morgan does not disclose or suggest, "a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal," as recited by Claim 47. As such, Bruning and Morgan, alone or in combination, fail to disclose or suggest the recitations of Claim 47. Accordingly, at least for these reasons, Claim 47 is patentable over the cited references, the allowance of which is respectfully requested.

Independent Claim 63 is Patentable Over the Cited References

Independent Claim 63 has been amended to include a portion of the recitations of Claim 64. Claims 63 and 64 stand rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over Bruning in view of Morgan. (Office Action, p. 5). Amended Claim 63 recites, in part, "a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings." (*Emphasis added.*)

Regarding Claim 64, a portion of which has been included in amended Claim 63, the Office Action alleges:

> Regarding claim 64, combination Bruning et al and Morgan et al disclose wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively. (Office Action, page 8, *emphasis added.*)

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Applicants respectfully disagree. For example, as discussed in reference to Claim 47, the sub-arrays 210R and 210G of Bruning each contain an independent controller 232R and 232G which provides a singular control output. Bruning does not disclose or suggest each controller having two control outputs. For at least these reasons, Bruning does not disclose or suggest a controller that provides two control outputs to ones of the current supply circuits.

In sharp contrast to Bruning, amended Claim 63 recites, "a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings." (*Emphasis added.*) For at least the reasons provided above, Bruning fails to disclose or suggest all of the recitations of Claim 63.

The Office Action does not allege and Morgan does disclose or suggest, "a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings," as recited by Claim 63. As such, Bruning and Morgan, alone or in combination, fail to disclose or suggest the recitations of amended Claim 63. Accordingly, at least for these reasons, Claim 63 is patentable over the cited references, the allowance of which is respectfully requested.

Dependent Claim 67 is Separately Patentable Over the Cited References

Claim 67 stands rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over Bruning in view of Morgan. (Office Action, p. 5). Applicants submits that Claim 67 is separately patentable over the cited references at least for the reasons that will be discussed below. For example, Claim 67 recites, "[t]he lighting system according to Claim 66, further comprising **a filter coupled to the sense resistor**, the filter configured to filter the feedback input." (*Emphasis added.*)

Regarding Claim 67, the Office Action alleges that the "combination Bruning et al and Morgan et al disclose further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input." (Office Action, page 9.)

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Applicants respectfully disagree. The Office Action alleges that a sense resistor is illustrated in Figure 4 of Bruning. (Office Action, page 6, in rejecting Claim 48.) Bruning describes, "[r]esistor R_1 has a low resistance to provide current sensing for controller 224." (Bruning, col. 7, lines 11-12.) However, Figure 4 of Bruning does not illustrate and Bruning is wholly silent regarding a filter coupled to resistor R_1 of Bruning. For at least these reasons, Bruning does not disclose or suggest "a filter coupled to the sense resistor" as recited in Claim 67.

The Office Action does not allege, and Morgan does not disclose or suggest, "a filter coupled to the sense resistor," as recited by Claim 67. As such, Bruning and Morgan, alone or in combination, fail to disclose or suggest the recitations of Claim 67. Accordingly, at least for these reasons, Claim 67 is separately patentable over the cited references, the allowance of which is respectfully requested.

The Remaining Dependent Claims Are Allowable

Applicants traverse the rejection of the remaining dependent claims. However, as each of these claims depends from a base claim that is believed to be in condition for allowance, Applicants do not believe that it is necessary to argue the allowability of each dependent claim individually. Applicants do not necessarily concur with the interpretation of these claims, nor with the bases for rejection set forth in the Office Action. Applicants therefore reserve the right to address the patentability of these claims individually as necessary in the future.

CONCLUSION

As all of the claims are now in condition for allowance, Applicants respectfully request allowance of the claims and passing of the application to issue in due course. Applicants urge the Examiner to contact Applicants' undersigned representative at (919) 854-1400 to resolve any remaining formal issues.

Petitioner Hisense USA Corporation
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Respectfully submitted,

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CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on November 8, 2013.

Michele P. McMahan

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 125 of 321

Attorney Docket No. 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: John K. Roberts et al. Confirmation No.: 9407
Application No.: 13/896,977 Examiner: A, Minh D.
Filing Date: May 17, 2013 Group Art Unit: 2821
For: SOLID STATE LIGHTING PANELS WITH VARIBLE VOLTAGE BOOST CURRENTL SOURCES

Date: November 8, 2013

Mail Stop Amendment
Commissioner for Patents
Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Sir:

Attached is an Information Disclosure Statement listing of documents previously of record in parent Application No. 13/469,188, filed May 11, 2012. As the benefit of this application is claimed under 35 U.S.C. § 120, no copies need to be furnished in accordance with 37 C.F.R. § 1.98(d); however, copies will be furnished on request. Cite Nos. 157, 158 and 168 are newly cited references and copies are provided herewith.

☐ In accordance with **37 CFR 1.97(b)**, the information disclosure statement is being filed:

- ☐ (1) within three months of the filing date of a national application other than a continued prosecution application under §1.53(d);
- ☐ (2) within three months of the date of entry of the national stage as set forth in §1.491 in an international application;
- ☐ (3) before the mailing of a first Office Action on the merits; or
- ☐ (4) before the mailing of a first Office Action after the filing of a request for continued examination under §1.114.

☒ In accordance with **37 CFR 1.97(c)**, the information disclosure statement is being filed after the period specified in 37 CFR 1.97(b) above, but before the mailing date of any of a final action under §1.113, a notice of allowance under §1.311, or an action that otherwise closes prosecution in the application, and is accompanied by **one** of the following:

☒ (1) The statement specified under **37 CFR 1.97(e)**, as follows:

☒ Each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement; **or**

☐ No item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in §1.56(c) more than three months prior to the filing of the information disclosure statement; **or**

☐ (2) The fee set forth in §1.17(p);

☐ In accordance with **37 CFR 1.97(d)**, the information disclosure statement is being filed after the period specified in 37 CFR 1.97(c) above, but on or before payment of the issue fee, and is accompanied by **both** of the following:

☐ (1) The statement specified under **37 CFR 1.97(e)**, as follows:

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement; **or**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in §1.56(c) more than three months prior to the filing of the information disclosure statement; **and**

☐ (2) The fee set forth in §1.17(p);

In accordance with **37 CFR 1.97(g)**, the information disclosure statement shall not be construed as a representation that a search has been made.

In accordance with **37 CFR 1.97(h)**, the information disclosure statement shall not be construed to be an admission that the information cited in the statement is, or is considered to be, material to patentability as defined in §1.56(b).

☐ The Director is hereby authorized to charge the fee specified in 37 C.F.R. § 1.17(p), and any fee deficiency or credit any overpayment, to Deposit Account No. 50-0220; or

☒ No fee is believed due. However, the Director is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 50-0220.

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CERTIFICATION OF TRANSMISSION

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Michele P. McMahan

Name: Michele P. McMahan

INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Complete if Known	
				Application Number	13/896,977
				Filing Date	May 17, 2013
				First Named Inventor	John Roberts
				Art Unit	2821
(use as many sheets as necessary)				Examiner Name	Minh D. A
Sheet	A1	of	A6	Attorney Docket Number	5308-706TSCT3

U.S. PATENT DOCUMENTS AND APPLICATIONS					
Examiner Initials*	Cite No.	Document Number Number-Kind Code (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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	2.	US- 7,387,406	06-17-2008	Swaris et al.	
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Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Complete if Known	
				Application Number	13/896,977
				Filing Date	May 17, 2013
				First Named Inventor	John Roberts
				Art Unit	2821
(use as many sheets as necessary)				Examiner Name	Minh D. A
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Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Complete if Known	
				Application Number	13/896,977
				Filing Date	May 17, 2013
				First Named Inventor	John Roberts
				Art Unit	2821
(use as many sheets as necessary)				Examiner Name	Minh D. A
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Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)* Sheet A4 of A6	*Complete if Known*	
	Application Number	13/896,977
	Filing Date	May 17, 2013
	First Named Inventor	John Roberts
	Art Unit	2821
	Examiner Name	Minh D. A
	Attorney Docket Number	5308-706TSCT3

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	152	US	5,877,595	03/1999	Nerone, Louis R.	315/209R
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Examiner Initials*	Cite No.	Foreign Patent Document Country Code, Number, Kind Code (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	154	GB 2 249 840	05-20-1992	Alfreza Ghazi Hessami (UK)		T
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Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(use as many sheets as necessary)* Sheet A5 of A6	*Complete if Known*	
	Application Number	13/896,977
	Filing Date	May 17, 2013
	First Named Inventor	John Roberts
	Art Unit	2821
	Examiner Name	Minh D. A
	Attorney Docket Number	5308-706TSCT3

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*	157	JP 2006-525664	09/11/2006	Koninklijke Philips Electronics N.V.		T
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Examiner Initials*	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published	T
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Examiner Signature		Date Considered	

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AN INTEGRATED LED DRIVING DEVICE WITH CURRENT SHARING FOR MULTIPLE LED STRINGS

No documents available for this priority number.

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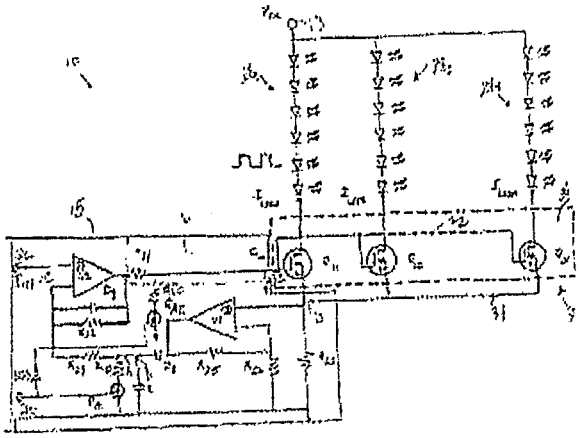
Classification: - **international:** ***H01L33/00; H05B33/08;*** (IPC1-7): H05B33/08
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Abstract of WO03015476 (A1)



An integrated LED driving device for multiple LED strings which employs a single linear regulator or other controller and a multiple-output current mirror which is almost independent of the DC input voltage source, almost independent of the transistor's or MOSFET's variations from the semiconductor integration process, and almost independent of temperature variation. The multiple-output current mirror includes a plurality of transistors or MOSFETs each of which are integrated on the same substrate, with identical width-to-length channel ratios and with identical source and gate connections. The integrated LED driving device provides for automatic current sharing in a DC mode and, alternately, with minimized phase delays in a PWM mode. The mirror-output current mirror may include mirror-cascade transistor pairs.

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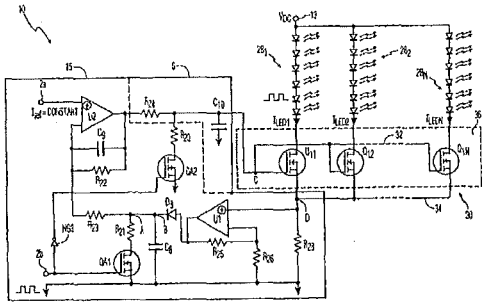
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(54)【発明の名称】複数の発光ダイオード列に対し電流分配を行なう集積化された発光ダイオード駆動装置

(57)【要約】
複数の発光ダイオード列に対する集積化された発光ダイオード駆動装置は、１つのリニアレギュレータ又はその他のコントローラと、マルチ出力電流ミラーとを有し、このマルチ出力電流ミラーは、直流入力電圧源、半導体集積処理によるＭＯＳＦＥＴトランジスタの変化及び温度変動に殆ど依存しない。このマルチ出力電流ミラーは、複数のＭＯＳＦＥＴトランジスタを有し、これらＭＯＳＦＥＴトランジスタの各々は、互いに同じ幅対長さのチャネル比と、互いに同じソース及びゲート接続ラインをもって同じ基板上に集積化する。この集積化された発光ダイオード駆動装置は、直流モードで電流分配を行なう、或いはまた、ＰＷＭモードでは位相遅延を最小にして電流分配を行なう。マルチ出力電流ミラーは、ミラー－カスコードトランジスタ対を有しうる。



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【特許請求の範囲】
【請求項１】
Ｎ個の発光ダイオード列を駆動する発光ダイオード駆動装置であって、この発光ダイオード駆動装置が、
基準電流信号を調整する調整手段と、
Ｎ個の発光ダイオード列に結合されたマルチ出力電流ミラーと
を具え、前記マルチ出力電流ミラーがＮ個のミラートランジスタを有するとともに前記調整手段に結合され、これらＮ個のミラートランジスタが１つの基板上に集積化され、これらＮ個のミラートランジスタが、互いにほぼ同じ幅対長さのチャネル比と、互いにほぼ同じゲート制御信号と、互いにほぼ同じソース接続ラインとを有するようにした発光ダイオード駆動装置。
【請求項２】
請求項１に記載の発光ダイオード駆動装置において、前記調整手段がリニア電流レギュレータを具え、このリニア電流レギュレータは、電流検出手段と、前記基板上に集積化されたノードに出力制御信号を生じるコントローラとを有し、前記ノードに前記Ｎ個のミラートランジスタのゲートが結合されている発光ダイオード駆動装置。
【請求項３】
請求項１又は２に記載の発光ダイオード駆動装置であって、前記調整手段がリニア電流レギュレータを具え、このリニア電流レギュレータが電流検出手段と、出力制御信号を生じるコントローラとを有し、前記マルチ出力電流ミラーが、前記出力制御信号を受けるノードと、Ｎ個のミラートランジスタとを有し、前記Ｎ個のミラートランジスタの各々が、前記ノードに結合されたゲートと、前記Ｎ個の発光ダイオード列の対応する１つに結合されたドレインと、前記電流検出手段に結合されたソースと、幅対長さのチャネル比とを有し、前記Ｎ個のミラートランジスタが１つの基板上に集積化され、互いにほぼ同じチャネル比を有する発光ダイオード駆動装置。
【請求項４】
請求項１～３のいずれか一項に記載の発光ダイオード駆動装置において、前記マルチ出力電流ミラーが更にＮ個のカスコードトランジスタを有し、
各カスコードトランジスタのソースがそれぞれ、前記Ｎ個のミラートランジスタの対応する１つのドレインに結合されて、Ｎ個のミラー－カスコードトランジスタ対を形成し、前記Ｎ個のカスコードトランジスタの各トランジスタのドレインがそれぞれ、前記Ｎ個の発光ダイオード列の対応する１つに直接結合されており、
前記Ｎ個のカスコードトランジスタの各々が互いにほぼ同じ幅対長さのチャネル比を有し、この幅対長さのチャネル比が前記Ｎ個のミラートランジスタの幅対長さのチャネル比ともほぼ同じであり、
前記Ｎ個のカスコードトランジスタは前記１つの基板上に集積化されている発光ダイオード駆動装置。
【請求項５】
請求項１～４のいずれか一項に記載の発光ダイオード駆動装置において、前記Ｎ個の発光ダイオード列に直流入力電圧端子が結合されている発光ダイオード駆動装置。
【請求項６】
請求項１～５のいずれか一項に記載の発光ダイオード駆動装置において、前記マルチ出力電流ミラーが、温度変動、直流入力電圧変動及びトランジスタの変化に殆ど依存しない自動的な電流分配を行なうようになっている発光ダイオード駆動装置。
【請求項７】
請求項１～４のいずれか一項に記載の発光ダイオード駆動装置において、前記Ｎ個のカスコードトランジスタのゲートが、前記Ｎ個の発光ダイオード列のうちの第１の発光ダイオード列に結合されている発光ダイオード駆動装置。
【請求項８】
請求項７に記載の発光ダイオード駆動装置において、前記マルチ出力電流ミラーが直流モ

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ードで、且つパルス幅変調モードでは位相遅延を最小にして電流分配を自動的に行なうようにした発光ダイオード駆動装置。
【請求項９】
請求項２に記載の発光ダイオード駆動装置において、前記マルチ出力電流ミラーが更にＮ個のカスコードトランジスタを有し、これらカスコードトランジスタの各々のソースがそれぞれ、前記Ｎ個のミラートランジスタのうちの対応する１つのトランジスタのドレインに結合されて、Ｎ個のミラー－カスコードトランジスタ対を形成しており、
前記Ｎ個のカスコードトランジスタの各々のドレインがそれぞれ、前記Ｎ個の発光ダイオード列の対応する１つに直接結合され、
前記Ｎ個のカスコードトランジスタの各ゲートが、前記Ｎ個のカスコードトランジスタのうちの第１のカスコードトランジスタのドレインに接続され、
前記Ｎ個のカスコードトランジスタの各々が互いにほぼ同じ幅対長さのチャネル比を有し、この幅対長さのチャネル比が前記Ｎ個のミラートランジスタの幅対長さのチャネル比ともほぼ同じであり、
前記Ｎ個のカスコードトランジスタは前記１つの基板上に集積化されている発光ダイオード駆動装置。
【請求項１０】
請求項４に記載の発光ダイオード駆動装置において、前記調整手段が、前記１つの基板上に集積化されたミラートランジスタ及びカスコードトランジスタを有し、
この調整手段のミラートランジスタのゲート制御信号及びソース接続ラインは、前記Ｎ個のミラートランジスタのゲート制御信号及びソース接続ラインとほぼ同じであり、この調整手段のミラートランジスタは、前記Ｎ個のミラートランジスタの幅対長さのチャネル比のｋ分の１の幅対長さのチャネル比を有し、
前記調整手段のカスコードトランジスタのゲート制御信号は、前記Ｎ個のカスコードトランジスタのゲート制御信号とほぼ同じであり、この調整手段のカスコードトランジスタは、この調整手段のミラートランジスタの幅対長さのチャネル比に等しい幅対長さのチャネル比を有する発光ダイオード駆動装置。
【請求項１１】
請求項１０に記載の発光ダイオード駆動装置において、
前記Ｎ個のミラートランジスタのソースが接地結合され、
これらＮ個のミラートランジスタのゲートが、前記調整手段のミラートランジスタのドレインに結合された接続路に結合されている発光ダイオード駆動装置。
【請求項１２】
請求項７～１１のいずれか一項に記載の発光ダイオード駆動装置において、前記マルチ出力電流ミラーは、温度変動及びトランジスタの変化に殆ど依存しない電流分配を自動的に行なうようになっている発光ダイオード駆動装置。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、発光ダイオード（ＬＥＤ）駆動装置に関するものであり、特に、複数のＬＥＤ列に対し、直流モードで電流分配を行なう、或いはまた、ＰＷＭモードでは位相遅延を最小にして電流分配を行なう、集積化したＬＥＤ駆動装置に関するものである。
【０００２】
（限定されるものではないが、液晶テレビジョンにおける直接型のバックライトにおけるような）多数個ＮのＬＥＤ列に対する大規模なＬＥＤ駆動装置を駆動するには、複雑な回路及び高価なコントローラ（制御装置）が必要である。更に、現在の技術によると、多数個のＬＥＤ列をＰＷＭモードで動作させる場合、コントローラ間に遅延変化があり、これによりＮ個のＬＥＤ列間に異なる位相を生ぜしめるおそれがある。
【０００３】
図１を参照するに、この図１には１つのＬＥＤ列８に対する通常のＬＥＤ駆動装置１の回

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路線図を示すもので、これは１つのリニアレギュレータ５を有している。このＬＥＤ列は、端子２ａに一定の基準電流信号I_{ref}を流す特定の定電流源と、端子３に直流入力電圧V_{DC}を生じる調整直流入力電圧源（図示せず）とにより駆動するのが好ましい。リニアレギュレータ５は、一定のＬＥＤ電流I_{LED}を維持するように機能する。このリニアレギュレータ５の一般的な動作を以下に詳細に説明する。

【０００４】

ＬＥＤ電流I_{LED}は検出抵抗R_{28}を介して検出される。抵抗R_{25}及びR_{26}と組み合わせた演算増幅器Ｕ１が適切な増幅を行ない、ＬＥＤ電流I_{LED}情報が演算増幅器Ｕ２（リニアレギュレータのコントローラ）の負端子、すなわち反転端子に帰還されるようにする。抵抗R_{25}は、演算増幅器Ｕ１の出力端子及び負端子、すなわち反転端子間に結合された帰還抵抗である。抵抗R_{26}は、演算増幅器Ｕ１の負端子、すなわち反転端子及び大地に結合されている。演算増幅器Ｕ２の伝達関数は、

【数１】

$$\frac{R22}{R23}\cdot\frac{1}{1+s\cdot R22\cdot C9} \qquad (1)$$

として表わされる。ここで、ｓは複素変数であり、抵抗R_{22}は演算増幅器Ｕ２の出力端子及び負端子、すなわち反転端子間に結合された帰還抵抗であり、キャパシタＣ９は帰還抵抗R_{22}と並列に結合され、抵抗R_{23}の一方の端子は演算増幅器Ｕ２の負端子、すなわち反転端子に結合され、この抵抗R_{23}の他方の端子はノードＡに結合されている。演算増幅器Ｕ２の正端子、すなわち非反転端子は端子２ａから一定の基準電流信号I_{ref}を受ける。

【０００５】

図１の回路線図を更に参照するに、リニアレギュレータ５のノードＡには、抵抗R_{21}の一方の端子が結合され、このノードＡはノードＢに隣接している。抵抗R_{21}の他方の端子は金属酸化物半導体電界効果トランジスタ（ＭＯＳＦＥＴ）又はその他のトランジスタＱＡ１のドレインに結合されている。ＭＯＳＦＥＴトランジスタＱＡ１のゲートは、端子２ｂから一定の基準電流信号I_{ref}を受ける。ＭＯＳＦＥＴトランジスタＱＡ１のソースは大地の結合されている。ノードＢはキャパシタC_8の一方の端子とダイオードD_8の陰極端子とに結合されている。キャパシタC_8の他方の端子は大地に結合されている。ダイオードD_8の陽極は演算増幅器Ｕ１の出力端子に結合されている。

【０００６】

制御出力は演算増幅器Ｕ２（リニアレギュレータのコントローラ）の出力端子に発生されて、ＲＣ低域通過フィルタ６を介してＭＯＳＦＥＴトランジスタＱ１又はその他のトランジスタのゲートに供給され、これによりゲート電圧V_{GS}をＭＯＳＦＥＴトランジスタＱ１に与える。ＲＣ低域通過フィルタ６は抵抗R_{24}とキャパシタC_{10}とを有している。抵抗R_{24}の第１端子は演算増幅器Ｕ２の出力端子に結合され、この抵抗R_{24}の第２端子はキャパシタC_{10}の第１端子に結合されている。キャパシタC_{10}の第２端子は大地に結合されている。

【０００７】

リニアレギュレータ５は更に抵抗R_{20}を有し、この抵抗R_{20}の一方の端子は抵抗R_{24}の第２端子に結合され、この抵抗R_{20}の他方の端子はＭＯＳＦＥＴトランジスタ又はその他のトランジスタＱＡ２のドレインに結合されている。ＭＯＳＦＥＴトランジスタＱＡ２のゲートはＮＯＴゲートＮＧ３の出力端子に結合され、ＭＯＳＦＥＴトランジスタＱＡ２のソースは大地に結合されている。ＮＯＴゲートＮＧ３の入力端子は、端子２ｂから一定の基準電流信号I_{ref}を受ける。

【０００８】

動作に当っては、I_{LED}に等しいＭＯＳＦＥＴトランジスタＱ１のドレイン－ソース電流が調整されて、一定の基準電流信号I_{ref}を追随する。図１におけるリニアレギュレータ

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５は、直流又はパルス幅変調（ＰＷＭ）動作するＬＥＤ列８に対し極めて良好に機能する。しかし、各ＬＥＤ列が複数のＬＥＤを有するＮ個のＬＥＤ列を駆動する必要がある場合には、Ｎ個のＬＥＤ列間で電流を等しく分配するために、一般に、図１の回路を単に重複して用いるにすぎない。容易に理解しうるように、このようにすると、リニアレギュレータの回路の複雑性及びコントローラの価格が増大する。更に、ＬＥＤ列をＰＷＭモードで動作させる場合には、コントローラやリニアレギュレータの重複回路間での遅延時間の変化によりＮ個のＬＥＤ列間の位相を異ならせるおそれがある。

【０００９】

本発明は、複数のＬＥＤ列に対し、直流モードと、位相遅延を最小にしたＰＷＭモードとで交互に電流を自動分配する、集積化したＬＥＤ駆動装置を提供する。本発明の集積化したＬＥＤ駆動装置は、基準電流を制御する１つのリニアレギュレータ又はその他のコントローラと、複数のＭＯＳＦＥＴ又はその他のトランジスタを有するマルチ（複数）出力電流ミラーとを採用する。これらＭＯＳＦＥＴ又はその他のトランジスタの各々は同じ基板上に集積化され、これらトランジスタの幅対長さのチャネル比を殆ど同にするとともに、同じソース接続ライン及び同じゲート接続ラインを用いる。これにより、マルチ出力電流ミラーは、直流入力電圧V_{DC}を生じる直流入力電圧源や、半導体集積処理によるＭＯＳＦＥＴの変化や、温度変動に殆ど依存しない電流分配を行なう。

【００１０】

本発明による、Ｎ個のＬＥＤ列28_1，28_2，…，28_Nに対する集積化したＬＥＤ駆動装置１０の一実施例を図２に示す。集積化したＬＥＤ駆動装置１０は、端子２ａにおける一定の基準電流信号I_{ref}で駆動される１つのリニアレギュレータ１５と、Ｎ個のＬＥＤ列28_1，28_2，…，28_Nを駆動するマルチ出力電流ミラー３０とを有する。各ＬＥＤ列は、複数のＬＥＤを有する。１つのリニアレギュレータ１５は本質的に図１のリニアレギュレータと同じであり、従って、図１と同じ符号を用いている。しかし、他のリニアレギュレータを採用することもできる。

【００１１】

マルチ出力電流ミラー３０を参照するに、このマルチ出力電流ミラー３０はＮ個のミラーＭＯＳＦＥＴトランジスタその他のトランジスタQ_{11}，Q_{12}，…，Q_{1N}を有し、これらの各トランジスタは、好ましくは同じ寸法及び同じ幅対長さのチャネル比（Ｗ／Ｌ）で同じ基板３６上に集積化する。ＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}のゲートは接続路３２を介して互いに結合されている。この接続路３２は、第１のＭＯＳＦＥＴトランジスタQ_{11}に近接するノードＣからＮ番目のＭＯＳＦＥＴトランジスタQ_{1N}のゲートまで延在し、リニアレギュレータ１５の低域通過フィルタ６の出力を受ける。これにより、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}のゲートの各々は、演算増幅器Ｕ２（リニアレギュレータのコントローラ）からの同じ制御出力を受ける。接続路３２及びノードＣは基板３６上に集積化されている。ＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}のソースは接続路３４を介して互いに接続され、一方、この接続路３４はリニアレギュレータ１５の電流検出抵抗R_{28}に結合されている為、この電流検出抵抗R_{28}はＭＯＳＦＥＴトランジスタからの電流を検出する。Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}の各ドレインは、Ｎ個のＬＥＤ列28_1，28_2，…，28_Nのうちの対応する１つの一端に結合されている。換言すれば、第１のＭＯＳＦＥＴトランジスタQ_{11}のドレインが第１のＬＥＤ列28_1の一端に結合され、第２のＭＯＳＦＥＴトランジスタQ_{12}のドレインが第２のＬＥＤ列28_2の一端に結合され、以下同様であり、最後にＮ番目のＭＯＳＦＥＴトランジスタQ_{1N}のドレインがＮ番目のＬＥＤ列28_Nの一端に結合されている。Ｎ個のＬＥＤ列28_1，28_2，…，28_Nの各々の他端は端子１３で直流入力電圧V_{DC}を受ける。

【００１２】

集積化したＬＥＤ駆動装置１０の動作を説明するに、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}は、同じ半導体製造処理（例えば、温度、材料、マスク、ドーピング、エッチング）を用いて同じ基板上に集積化されている為、Ｎ個のミラーＭＯＳＦ

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ＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}を$V_{DS} \geqq V_{GS} - V_T$とした飽和モードで動作させると、チャネルを流れる電流は、もはやドレイン－ソース電圧V_{DS}に殆ど依存しなくなる。V_{GS}は、ゲート－ソース電圧であり、V_Tは、しきい値電圧である。ドレイン電流は、I_Dが$V_{DS} \geqq V_{GS} - V_T$とした飽和領域における伝達特性を表わす次式（２）に応じてゲート－ソース電圧（ゲート電圧）V_{GS}により制御される。

【数２】

$$I_D = F \cdot Co \frac{W}{L} (V_{GS} - V_T)^2 \qquad (2)$$

この式（２）において、Ｆは電子の移動度であり、Ｃｏは単位面積当りの酸化物のキャパシタンスであり、Ｌはチャネルの長さであり、Ｗはチャネル幅である。

【００１３】

Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}は同じ処理で同じ基板３６上に集積化され、ノードＣから同じ制御信号を受け、ノードＤでリニアレギュレータ１５に対する同じソース接続ラインを有している為、Ｎ個のＬＥＤ列の電流I_{LED1}，I_{LED2}，…，I_{LEDN}に等しいドレイン電流がＭＯＳＦＥＴトランジスタの寸法（Ｗ／Ｌ比）に比例し、次式（３）で表わされる。

【数３】

$$I_{LED1} : I_{LED2} : \cdots : I_{LEDN} = (W/L)_1 : (W/L)_2 : \cdots : (W/L)_N \qquad (3)$$

上述したように、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{11}，Q_{12}，…，Q_{1N}は同じ寸法（Ｗ／Ｌ比）で集積化されている為、マルチ出力電流ミラー３０により、電圧V_{DC}を生じる直流入力電圧源や、半導体集積処理によるＭＯＳＦＥＴの変化や、温度変動に殆ど依存しない電流分配を自動的に行なうのに用いられる電流ミラー効果が得られる。

【００１４】

本発明による、Ｎ個のＬＥＤ列128_1，128_2，…，128_Nに対する集積化したＬＥＤ駆動装置１００の他の実施例を図３に線図的に示す。一般に、集積化したＬＥＤ駆動装置１００は、図２の実施例におけるマルチ出力電流ミラー３０の代わりに、Ｎ個のＬＥＤ列128_1，128_2，…，128_Nを駆動するマルチ出力カスコード電流ミラー１３０を有し、電流ミラーの出力インピーダンスを高めてこれら電流ミラーが殆ど一定の電流を生じるようにする。

【００１５】

マルチ出力カスコード電流ミラー１３０を以下に説明するに、このマルチ出力カスコード電流ミラー１３０は、Ｎ個のミラーＭＯＳＦＥＴトランジスタ又はその他のトランジスタQ_{101}，Q_{102}，…，Q_{10N}と、Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}とを有しており、これらの各々は同じ基板１３６上に、好ましくは、同じ寸法及び同じ幅対長さのチャネル比（Ｗ／Ｌ）で集積化する。ＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}のゲートは、接続路１３２を介して互いに結合されている。この接続路１３２は、第１のＭＯＳＦＥＴトランジスタQ_{101}に近接するノードＣ１００からＮ番目のＭＯＳＦＥＴトランジスタQ_{10N}のゲートまで延在し、リニアレギュレータ１５の低域通過フィルタ６の出力を受ける。これにより、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}のゲートの各々は、同じ制御出力を受ける。接続路１３２及びノードＣ１００は基板１３６上に集積化されている。ＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}のソースは接続路１３４を介して互いに接続され、一方、この接続路１３４はリニアレギュレータ１５の電流検出抵抗R_{28}に結合されている為、

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この電流検出抵抗R_{28}はこれらのＭＯＳＦＥＴトランジスタからの電流を検出する。Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}の各ドレインは、Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}のうちの対応する１つを介してＮ個のＬＥＤ列128_1，128_2，…，128_Nのうちの対応する１つの一端に結合されている。

【００１６】

Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}につき説明するに、これらＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}のゲートは接続路１４２を介して互いに結合されている。この接続路１４２は接続路１４４に結合され、この接続路１４４により、ノードＥにおける第１のカスコードＭＯＳＦＥＴトランジスタQ_{111}のドレイン電流をこれらＮ個のカスコードＭＯＳＦＥＴトランジスタのゲートに供給してゲート電圧V_{GS}を得る。第１のカスコードＭＯＳＦＥＴトランジスタQ_{111}のドレイン電流は第１のＬＥＤ列の電流I_{LED1}に等しい。これにより、Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}の各ゲートは互いに同じ制御信号を受ける。接続路１４２、１４４及びノードＥは基板１３６上に集積化されている。

【００１７】

Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}の各ドレインは、Ｎ個のＬＥＤ列128_1，128_2，…，128_Nのうちの対応する１つの一端に結合されている。換言すれば、第１のカスコードＭＯＳＦＥＴトランジスタQ_{111}のドレインが第１のＬＥＤ列128_1の一端に結合され、第２のカスコードＭＯＳＦＥＴトランジスタQ_{112}のドレインが第２のＬＥＤ列128_2の一端に結合され、以下同様であり、最後にＮ番目のＭＯＳＦＥＴトランジスタQ_{11N}のドレインがＮ番目のＬＥＤ列128_Nの一端に結合されている。Ｎ個のＬＥＤ列128_1，128_2，…，128_Nの各々の他端は端子１１３で、調整された直流入力電圧V_{DC}を受ける。Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}のソースはＮ個のミラーＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}のドレインにそれぞれ結合されている。

【００１８】

Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}及びＮ個のカスコードＭＯＳＦＥＴトランジスタQ_{111}，Q_{112}，…，Q_{11N}は、同じ処理及び同じ寸法（Ｗ／Ｌ比）で同じ基板上に集積化されており、この場合、各ミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１，ＭＣ２，…，ＭＣＮが同じソース及びゲート接続ラインを有し、マルチ出力カスコード電流ミラー１３０により、電圧V_{DC}を生じる直流入力電圧源や、半導体集積処理によるＭＯＳＦＥＴの変化や、温度変動に殆ど依存しない電流分配を自動的に行なうのに用いられる電流ミラー効果が得られ、しかも、電流ミラーの出力インピーダンスを高めてＬＥＤに定電流を与えるようにする。

【００１９】

本発明による、Ｎ個のＬＥＤ列228_1，228_2，…，228_Nに対する集積化したＬＥＤ駆動装置２００の更に他の実施例を図４に線図的に示す。集積化したＬＥＤ駆動装置２００では、リニアレギュレータ１５の代わりにミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１０（Q_{200}，Q_{210}）を用い、このミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１０をミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１１，ＭＣ１２，…，ＭＣ１Ｎとは異なるＷ／Ｌ比で同じ基板２３６上に集積化する。ミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１０（Q_{200}、Q_{210}）は、定電流源２０２から一定の基準電流I_{ref}を受ける電流コントローラ、すなわち電流レギュレータ２５０として機能する。

【００２０】

マルチ出力カスコード電流ミラー２３０を説明するに、このマルチ出力カスコード電流ミラー２３０は、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{201}，Q_{202}，…，Q_{20N}とＮ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}とを有しており、これらの各々は同じ基板２３６上に、好ましくは、同じ寸法及び同じ幅対長さのチャネル

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比（Ｗ／Ｌ）で集積化する。ＭＯＳＦＥＴトランジスタQ_{201}，Q_{202}，…，Q_{20N}のゲートは、接続路２３２を介して互いに結合されている。この接続路２３２は、Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{201}，Q_{202}，…，Q_{20N}のゲート及びミラーＭＯＳＦＥＴトランジスタQ_{200}のゲートを電流コントローラ、すなわち電流レギュレータ２５０のカスコードＭＯＳＦＥＴトランジスタQ_{210}のソースにノードＦで接続する接続路２３８に結合されている。これにより、これらのミラーＭＯＳＦＥＴトランジスタのゲートはそれぞれ同じ制御信号を受ける。Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{201}，Q_{202}，…，Q_{20N}のソース及びミラーＭＯＳＦＥＴトランジスタQ_{200}のソースはそれぞれ大地に結合されている。Ｎ個のミラーＭＯＳＦＥＴトランジスタQ_{201}，Q_{202}，…，Q_{20N}のドレイン及びミラーＭＯＳＦＥＴトランジスタQ_{200}のドレインはＮ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}のソース及びカスコードＭＯＳＦＥＴトランジスタQ_{210}のソースにそれぞれ結合されている。接続路２３２、２３８及びノードＦは同じ基板２３６上に集積化されている。

【００２１】

Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}につき説明するに、これらＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}のゲートは、接続路２４２を介して互いに結合されている。この接続路２４２は接続路２４４に結合され、この接続路２４４により、ノードＥ１０における一定の基準電流I_{ref}、すなわちカスコードＭＯＳＦＥＴトランジスタQ_{210}のドレイン電流を、これらＭＯＳＦＥＴトランジスタのゲートに供給する。これにより、Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}の各ゲートは、互いに同じ制御信号を受ける。接続路２４２、２４４及びノードＥ１０は基板２３６上に集積化されている。Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}のドレインの各々は、Ｎ個のＬＥＤ列228_1，228_2，…，228_Nのうちの対応する１つの一端に結合されている。Ｎ個のＬＥＤ列228_1，228_2，…，228_Nの各々の他端は、端子２１３にて、調整された直流入力電圧V_{DC}を受ける。Ｎ個のカスコードＭＯＳＦＥＴトランジスタQ_{211}，Q_{212}，…，Q_{21N}のソースはＮ個のミラーＭＯＳＦＥＴトランジスタQ_{101}，Q_{102}，…，Q_{10N}のドレインにそれぞれ結合されている。カスコードＭＯＳＦＥＴトランジスタQ_{210}のドレインは定電流源２０２に結合され、一定の基準電流I_{ref}を受ける。

【００２２】

マルチ出力電流ミラー２３０のＮ個のミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１１，ＭＣ１２，…，ＭＣ１Ｎ及び電流コントローラ、すなわち電流レギュレータ２５０のミラー－カスコードＭＯＳＦＥＴトランジスタ対ＭＣ１０（Q_{200}、Q_{210}）が同じ処理で同じ基板上に集積化され、且つ同じソース及びゲート接続ラインを有する為、動作中、Ｎ個のＬＥＤ列の電流I_{LED1}，I_{LED2}，…，I_{LEDN}のそれぞれに等しいドレイン電流がＭＯＳＦＥＴトランジスタの寸法（Ｗ／Ｌ比）に比例し、次式（４）で表わされる電流ミラー利得ｋが得られる。

【数４】

$$I_{ref}:I_{LED1}:I_{LED2}:\cdots:I_{LEDN}=1:k:k:\cdots:k \qquad (4)$$

【００２３】

上述したところから、当業者にとって種々の変形例が明らかとなるであろう。従って、本発明は、上述した実施例に限定されず、本発明の範囲内で種々の変更が可能となるものである。

【図面の簡単な説明】

【００２４】

【図１】単一のＬＥＤ列に対する通常のＬＥＤ駆動装置を示す回路線図である。

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【図２】本発明の、複数のＬＥＤ列に対する集積化したＬＥＤ駆動装置の一実施例を示す回路線図である。
【図３】本発明の、複数のＬＥＤ列に対する集積化したＬＥＤ駆動装置の他の実施例を示す回路線図である。
【図４】本発明の、複数のＬＥＤ列に対する集積化したＬＥＤ駆動装置の更に他の実施例を示す回路線図である。

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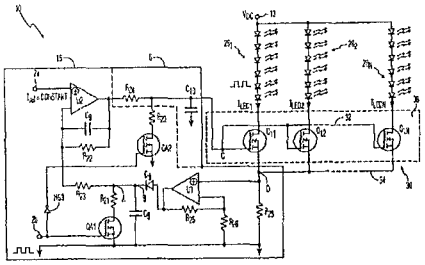
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(54) Title: AN INTEGRATED LED DRIVING DEVICE WITH CURRENT SHARING FOR MULTIPLE LED STRINGS



(57) Abstract: An integrated LED driving device for multiple LED strings which employs a single linear regulator or other controller and a multiple-output current mirror which is almost independent of the DC input voltage source, almost independent of the transistor's or MOSFET's variations from the semiconductor integration process, and almost independent of temperature variation. The multiple-output current mirror includes a plurality of transistors or MOSFETs each of which are integrated on the same substrate, with identical width-to-length channel ratios and with identical source and gate connections. The integrated LED driving device provides for automatic current sharing in a DC mode and, alternately, with minimized phase delays in a PWM mode. The mirror-output current mirror may include mirror-cascade transistor pairs.

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An integrated led driving device with current sharing for multiple led strings

This invention relates to light-emitting diode (LED) drivers, and more particularly to an integrated LED driving device with current sharing for multiple LED strings in a DC mode and, alternately, with minimized phase delays in a PWM mode.

Driving large scale LED drivers for a large amount N of LED strings (such as, without limitation, in LC-TV direct backlight) requires complex circuitry and expensive controllers. Moreover, with existing technology, when the multiple LED strings are operated in a PWM mode, time delay variations are present between the controllers, which could cause different phases among the N LED strings.

Referring now to Fig. 1, a schematic diagram of a conventional LED driving device 1 for a single LED string 8 is shown and includes a simple linear regulator 5. Preferably, the LED string is driven with a specified constant current source which follows a constant reference current signal I_{ref} at terminal 2a and a regulated DC input voltage source (NOT SHOWN), which delivers the DC input voltage V_{DC} at terminal 3. The linear regulator 5 functions in a manner which maintains a constant LED current I_{LED}. The general operation of the linear regulator 5 will now be described in detail below.

The LED current I_{LED} is sensed via a sensing resistor R28. Operational amplifier (OP-AMP) U1 in combination with resistors R25 and R26 provides proper amplification so that the LED current I_{LED} information is fed back to the negative or inverting terminal of the OP-AMP U2, the regulator's controller. Resistor R25 is a feedback resistor coupled between the output terminal and the negative or inverting terminal of OP-AMP U1. Resistor R26 is coupled to the negative or inverting terminal of OP-AMP U1 and ground. The transfer function of OP-AMP U2 is expressed as

$$\frac{R22}{R23}\ \frac{1}{1+sR22C9} \qquad (1)$$

wherein s is a complex variable; resistor R22 is a feedback resistor coupled between the output terminal and the negative or inverting terminal of OP-AMP U2; capacitor C9 is

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coupled in parallel with the feedback resistor R22; and resistor R23 has one terminal coupled to the negative or inverting terminal of OP-AMP U2 and the other terminal coupled to node A. The positive or non-inverting terminal of OP-AMP U2 receives the constant reference current signal I_{ref} from terminal 2a.

Referring still to the schematic diagram, node A of the linear regulator 5 also has one terminal of resistor R21 coupled thereto and is adjacent to node B. The other terminal of resistor R21 is coupled to the drain of transistor or metal-oxide semiconductor field-effect transistor (MOSFET) QA1. The gate of transistor or MOSFET QA1 receives the constant reference current I_{ref} from terminal 2b. The source of transistor or MOSFET QA1 is coupled to ground. Node B has coupled thereto one terminal of capacitor C8 and the cathode terminal of diode D8. The other terminal of the capacitor C8 is coupled to ground. The anode of diode D8 is coupled to the output terminal of OP-AMP U1.

A control output is generated at the output terminal of OP-AMP U2, the regulator's controller, and is coupled to the gate of transistor or MOSFET Q1 via a RC lowpass filter 6 thereby providing the gate voltage V_{GS} to the transistor or MOSFET Q1. The RC lowpass filter 6 comprises resistor R24 and capacitor C10. The first terminal of resistor R24 is coupled to the output terminal of OP-AMP U2 and to a first terminal of capacitor C10. The second terminal of capacitor C10 is coupled to ground.

The linear regulator 5 further includes resistor R20 having one terminal coupled to the second terminal of resistor R24 and to the drain of transistor or MOSFET QA2. The gate of transistor or MOSFET QA2 is coupled to the output terminal of NOT gate NG3 and the source of transistor or MOSFET QA2 is coupled to ground. The input terminal of NOT gate NG3 receives the constant reference current I_{ref} from the terminal 2b.

In operation, the drain-source current of transistor or MOSFET Q1, which is equal to I_{LED}, is regulated to follow the constant reference current I_{ref}. The linear regulator 5 in FIG. 1 works very well for a DC or a pulse-width modulated (PWM) operated LED string 8. However, when N LED strings, wherein each string includes a plurality of LEDs, are to be driven, simple duplication of the circuitry in FIG. 1 is commonly used in order to achieve equal current sharing among the N LED strings. As can be appreciated, this increases the complexity of the circuitry and controller costs of the linear regulator. Moreover, if the LED strings are operated in a PWM mode, time delay variations between the duplicated controllers and linear regulators could cause different phases among the N LED strings.

An integrated LED driving device for multiple LED strings with automatic current sharing in a DC mode and, alternately, with minimized phase delays in a PWM mode.

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The integrated LED driving device employs a single linear regulator or other controller for controlling a reference current and a multiple-output current mirror, which includes a plurality of transistors or MOSFETs. Each of transistors or MOSFETs are integrated on the same substrate, with almost identical width-to-length channel ratios and with identical source and gate connections. Thereby, the multiple-output mirror provides for current sharing which is almost independent of the DC input voltage source, which provides the DC input voltage V_{DC}, independent of the MOSFET's variation from the semiconductor integration process, and almost independent of temperature variation.

Fig. 1 illustrates a schematic diagram of a conventional LED driving device for a single LED string.

Fig. 2 illustrates a schematic diagram of an integrated LED driving device for multiple LED strings of the present invention.

Fig. 3 illustrates a schematic diagram of an alternate embodiment of the integrated LED driving device for multiple LED strings of the present invention.

Fig. 4 illustrates a schematic diagram of an another alternate embodiment of the integrated LED driving device for multiple LED strings of the present invention.

Referring now to Fig. 2, an exemplary embodiment of the schematic diagram of an integrated LED driving device 10 for N LED strings 28_1, 28_2, ..., 28_N according to the present invention is shown. The integrated LED driving device 10 includes a single linear regulator 15 driven with a constant reference current signal I_{ref} at terminal 2a and a multiple-output current mirror 30 for driving the N LED strings 28_1, 28_2, ..., 28_N. Each LED string includes a plurality of LEDs. The single linear regulator 15 is essentially identical to the linear regulator 5 of FIG. 1 and thus the same reference numerals have been used. Nevertheless, other linear regulators may be employed.

Referring now to the multiple-output current mirror 30, the multiple-output mirror 30 includes N-mirror transistors or MOSFETs Q11, Q12, ..., Q1N each of which are integrated on the same substrate 36 with preferably the same size and with identical width-to-length channel (W/L) ratios. The gates of transistor or MOSFET Q11, transistor or MOSFET Q12, ... and transistor or MOSFET Q1N are coupled together via path 32. Path 32 extends from node C in close proximity to the gate of the first transistor or MOSFET Q11 to the gate

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of the Nth transistor or MOSFET Q1N and receives the output of the lowpass filter 6 of the linear regulator 15. Thereby, each of the gates of the N-mirror transistors or MOSFETs Q11, Q12, ..., Q1N receive the same control output from OP-AMP U2, the regulator's controller. Path 32 and node C are integrated on the substrate 36. The sources of transistor or MOSFET Q11, transistor or MOSFET Q12, ... and transistor or MOSFET Q1N are tied together via path 34 wherein path 34 is coupled to the sensing resistor R28 of the linear regulator 15 so that current sensing resistor R28 senses the current therefrom. Each drain of the N-mirror transistors or MOSFETs Q11, Q12, ..., Q1N is coupled to one end of a respective one of the N LED strings 28_1, 28_2, ..., 28_N. In other words, the drain of first transistor or MOSFET Q11 is coupled to one end of the first LED string 28_1, the drain of the second transistor or MOSFET Q12 is coupled to one end of the second LED string 28_2, so on and so forth, until the drain of the Nth transistor or MOSFET Q1N is coupled to the Nth LED string 28_N. The other end of each of the N LED strings 28_1, 28_2, ..., 28_N receives a DC input voltage V_{DC} at terminal 13.

Referring now to the operation of the integrated LED driving device 10, since the N-mirror transistors or MOSFETs Q11, Q12 and Q1N are integrated on the same substrate 36 using the same semiconductor manufacturing process (e.g., temperature, material, mask, doping, etching) when the N-mirror transistors or MOSFETs Q11, Q12 and Q1N are operated in the saturation mode with $V_{DS} \geq V_{GS} - V_T$, the current flowing through the channel almost no longer depends on the drain-source voltage V_{DS}. V_{GS} is the gate-to-source voltage and V_T is the threshold level voltage. The drain current is controlled by the gate-to-source (gate) voltage V_{GS} via the equation (2) wherein I_D is representative of the transfer characteristic in the saturation region where $V_{DS} \geq V_{GS} - V_T$ and is expressed by:

$$I_D = FCo\frac{W}{L}(V_{GS} - V_T)^2 \qquad (2)$$

where F is the mobility of the electrons; Co is the oxide capacitance per unit area; L is the channel length; and W is the channel width.

Since, the N-mirror transistors or MOSFETs Q11, Q12 and Q1N are integrated on the same substrate 36 with the same process, receive the same gate control signal from node C and have the same source connection to the linear regulator 15 at node D, the drain currents, which are equivalent to their respective one of the N LED string currents I_{LED1},

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I_{LED2}, ..., I_{LEDN}, are scaled by the transistor or MOSFET size (the W/L ratio) and are expressed as:

$$I_{LED1}: I_{LED2}:...:I_{LEDN} = (W/L)_1:(W/L)_2:...:(W/L)_N \quad (3)$$

In view of the foregoing, since the N-mirror transistors or MOSFETs Q11, Q12, ..., Q1N are integrated with the same size (W/L ratio), the multiple-output current mirror 30 creates a current mirror effect which is used to generate automatic current sharing which is almost independent of the DC input voltage source providing voltage V_{DC}, almost independent of the MOSFET's variation from the semiconductor integration process, and almost independent of temperature variation.

Referring now to FIG. 3, the schematic diagram of an alternate embodiment of an integrated LED driving device 100 for N-LED strings 128_1, 128_2, ..., 128_N according to the present invention is shown. In general, the integrated LED driving device 100 includes a multiple-output cascode current mirror 130 for driving the N-LED strings 128_1, 128_2, ..., 128_N in lieu of the multiple-output current mirror 30, of the embodiment of FIG. 2, to improve the output impedance of the current mirrors which delivers the almost constant current.

Referring now to the multiple-output cascode current mirror 130, the multiple-output cascode current mirror 130 includes N-mirror transistors or MOSFETs Q101, Q102, ..., Q10N and N-cascode transistors or MOSFETs Q111, 112, ..., Q11N each of which are integrated on the same substrate 136 preferably with the same size and with identical width-to-length channel (W/L) ratios. The gates of transistor or MOSFET Q101, transistor or MOSFET Q102, ..., and transistor or MOSFET Q10N are coupled together via path 132. Path 132 extends from node C100 in close proximity to the gate of the first-mirror transistor or MOSFET Q101 to the gate of the Nth-mirror transistor or MOSFET Q10N and receives the output of the lowpass filter 6 of the linear regulator 15. Thereby, each of the gates of the N-mirror transistors or MOSFETs Q101, Q102, ..., Q10N receive the same control output. Path 132 and node C100 are integrated on the substrate 136. The sources of transistor or MOSFET Q101, transistor or MOSFET Q102, ... and transistor or MOSFET Q10N are tied together via path 134 wherein path 134 is coupled to the sensing resistor R28 of the linear regulator 15 so that current sensing resistor R28 senses the current therefrom. Each drain of the N-mirror transistors or MOSFETs Q101, Q102, ..., Q10N is coupled to one end of a respective one of

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the N LED strings 128_1, 128_2, ..., 128_N via a respective one of the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N.

Referring now to the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N, the gates of transistor or MOSFET Q111, transistor or MOSFET Q112, ... and transistor or MOSFET Q11N are coupled together via path 142. Path 142 is coupled to path 144, which connects to the drain current of the first-cascode transistor or MOSFET Q111 at node E to such gates to provide the gate voltage V_{GS}. The drain current of the first-cascode transistor or MOSFET Q111 is equivalent to the first LED string current I_{LED1}. Thereby, each gate of the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N receive the same control signal. Path 142, path 144 and node E are integrated on the substrate 136.

Each drain of the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N is coupled to one end of a respective one of the N LED strings 128_1, 128_2, ..., 128_N. In other words, the drain of first-cascode transistor or MOSFET Q111 is coupled to one end of the first LED string 128_1, the drain of the second-cascode transistor or MOSFET Q112 is coupled to one end of the second LED string 128_2, so on and so forth, until the drain of the Nth transistor or MOSFET Q11N is coupled to the Nth LED string 128_N. The other end of each if the N LED strings 128_1, 128_2, ..., 128_N receives a regulated DC input voltage V_{DC} at terminal 113. The sources of the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N are coupled to a respective drain of the N-mirror transistors or MOSFETs Q101, Q102, ..., Q10N.

Since the N-mirror transistors or MOSFETs Q101, Q102, ..., Q10N and the N-cascode transistors or MOSFETs Q111, Q112, ..., Q11N are integrated on the same substrate 136 with the same process and with the same size (W/L ratio) and wherein the each mirror-cascode transistor or MOSFET pair MC1, MC2, ..., MCN have the same source and gate connections, the multiple-output cascode current mirror 130 creates a current mirror effect which is used to generate automatic current sharing which is almost independent of the DC input voltage source V_{DC}, almost independent of the MOSFET's variation from the semiconductor integration process, and almost independent of temperature variation while also improving the output impedance of the constant current mirror which delivers the constant current in the LEDs.

Referring now to FIG. 4, the schematic diagram of a second alternate embodiment of an integrated LED driving device 200 for N-LED strings 228_1, 228_2, ..., 228_N according to the present invention is shown. The integrated LED driving device 100 substitutes a mirror-cascode transistor or MOSFET pair MC10 (Q200, Q210) for the linear

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regulator 15 and integrates the mirror-cascode transistor or MOSFET pair MC10 on the same substrate 236, but with a different W/L ratio as the mirror-cascode transistor or MOSFET pairs MC11, MC12, ..., MC1N. The mirror-cascode transistor or MOSFET pair MC10 (Q200, Q210) functions as a current controller or regulator 250 which receives the constant reference current I_{ref} from the constant current source 202.

Referring now to the multiple-output cascode current mirror 230, the multiple-output cascode current mirror 230 includes N-mirror transistors or MOSFETs Q201, Q202, ..., Q20N and N-cascode transistors or MOSFETs Q211, 212, ..., Q21N each of which are integrated on the same substrate 236 with the same size preferably and identical width-to-length channel (W/L) ratios. The gates of transistor or MOSFET Q201, transistor or MOSFET Q202, ... and transistor or MOSFET Q20N are coupled together via path 232. Path 232 is coupled to path 238, which connects to the gates of the N-mirror transistors or MOSFETs Q201, Q202, ..., Q20N and the gate of mirror transistor or MOSFET 200 to the source of the cascode transistor or MOSFET Q210, of the current controller or regulator 250, at node F. Thereby, each of such gates receive the same control signal. Each source of the N-mirror transistors or MOSFETs Q201, Q202, ..., Q20N and the source of mirror transistor or MOSFET 200 are coupled to ground. Each drain of the N-mirror transistors or MOSFETs Q201, Q202, ..., Q20N and the drain of mirror transistor or MOSFET 200 is coupled to a respective source of the N-cascode transistors or MOSFETs Q211, 212, ..., Q21N and the source of the cascode transistor or MOSFET Q210, respectively. Paths 232, 238 and node F are integrated on the same substrate 236.

Referring now to the N-cascode transistors or MOSFETs Q211, Q212, ..., Q21N, the gates of transistor or MOSFET Q211, transistor or MOSFET Q212, ... and transistor or MOSFET Q21N are coupled together via path 242. Path 242 is coupled to path 244, which connects to the constant reference current I_{ref} or the drain current of the cascode transistor or MOSFET Q210 at node E10 to such gates. Thereby, each gate of the N-cascode transistors or MOSFETs Q211, Q212, ..., Q21N receive the same control signal. Path 242, path 244 and node E10 are integrated on the substrate 236. Each drain of the N-cascode transistors or MOSFETs Q211, Q212, ..., Q21N is coupled to one end of a respective one of the N LED strings 228_1, 228_2, ..., 228_N. The other end of each of the N LED strings 228_1, 228_2, ..., 228_N receives a regulated DC input voltage V_{DC} at terminal 213. The sources of the N-cascode transistors or MOSFETs Q211, Q212, ..., Q21N are coupled to a respective one of the drains of the N-mirror transistors or MOSFETs Q201, Q202, ..., Q20N. The drain of the

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cascode transistor or MOSFET Q210 is coupled to constant reference current source 202 and receives the constant reference current source I_{ref}.

In operation, since the N mirror-cascode transistor or MOSFET pairs MC11, MC12, ..., MC1N of the multiple-output current mirror 230 and the mirror-cascode transistor or MOSFET pair MC10 (Q200, Q210) of the current controller or regulator 250 are integrated on the same substrate 236 with the same process, and have the same source and gate connections, the drain currents, which are equivalent to their respective one of the N LED string currents I_{LED1}, I_{LED2}, ..., I_{LEDN}, are scaled by the transistor or MOSFET size (the W/L ratio) and provide a current mirror gain k which is expressed as:

$$I_{ref}:I_{LED1}: I_{LED2}:...:I_{LEDN} = 1:k:k:...:k \quad (4)$$

Numerous modifications to and alternative embodiments of the present invention will be apparent to those skilled in the art in view of the foregoing description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. Details of the structure may be varied substantially without departing from the spirit of the invention and the exclusive use of all modifications which come within the scope of the appended claims is reserved.

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CLAIMS:

1. An LED driving device for driving N LED strings, comprising:
means for regulating a reference current signal (15); and
a multiple-output current mirror (30) coupled to N LED strings (28_1-28_N), the current mirror having N-mirror transistors (Q11-Q1N) and being coupled to the regulating means (15), wherein the N-mirror transistors (Q11-Q1N) are integrated on a single substrate (36) with substantially identical width-to-length channel (W/L) ratios, with substantially identical gate control signals, and with substantially identical source connections.

2. The device according to Claim 1, wherein the regulating means (15) comprises a linear current regulator having a means for sensing current (R28) and a controller (U2) for producing an output control signal to a node integrated on the substrate (36), and wherein gates of the N-mirror transistors (Q11-Q1N) are coupled to the node.

3. An LED driving device according to claim 1 or 2 for driving N LED strings, comprising:
a linear current regulator (15) having a means for sensing current and a controller (U2) having an output control signal; and,
a multiple-output current mirror (30) including a node for receiving said output control signal, N-mirror transistors (Q11-Q1N) each having a gate coupled to said node, a drain coupled to a respective one of the N LED strings (28_1-28_N), a source coupled to the current sensing means and a width-to-length channel (W/L) ratio wherein the N-mirror transistors (Q11-Q1N) are integrated on a single substrate (36) and have substantially identical W/L ratios.

4. The device according to Claim 1, 2 or 3, wherein the multiple-output current mirror (230) further comprises:
N-cascode transistors (Q211-Q21N) each having a source coupled to a drain of a respective one of the N-mirror transistors (Q201-Q20N) to form N mirror-cascode

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transistor pairs (MC11-MC1N), wherein each transistor of the N-cascode transistors (Q211-Q21N) has a drain coupled directly to the respective one of the N LED strings (228_1-228_N);

each one of the N-cascode transistor (Q211-Q21N) have substantially identical W/L ratios which are also substantially identical to the W/L ratios of the N-mirror transistors (Q201-Q20N); and

the N-cascode transistors (Q211-Q21N) are integrated on the single substrate (236).

5. The device according to Claim 1, 2, 3 or 4 further comprising a DC input voltage coupled to the N LED strings (28_1-28_N).

6. The device according to Claim 1 or 5, wherein the multiple-output current mirror (30) provides automatic current sharing which is almost independent of temperature variation, DC input voltage variation and transistor variation.

7. The device according to Claim 1, 2, 3 or 4 wherein the gates of the N-cascode transistors (Q111-Q11N) are coupled to a first LED string (128_1) of the N LED strings (128_1-128_N).

8. The device according to Claim 7, wherein the multiple-output current mirror (30) provides automatic current sharing in a DC mode with minimized phase delays in a PWM mode.

9. The device according to Claim 2, wherein the multiple-output current mirror (130) further comprises N-cascode transistors (Q111-Q11N) each having a source coupled to a drain of a respective one of the N-mirror transistors (Q101-Q10N) to form N mirror-cascode transistor pairs (MC1-MCN), and wherein:

each one of the N-cascode transistors (Q111-Q11N) has a drain coupled directly to the respective one of the N LED strings (128_1-128_N);

each gate of the N-cascode transistors (Q111-Q11N) is connected to a drain of a first cascode transistor (Q111) of the N-cascode transistors (Q111-Q11N);

each one of the N-cascode transistors (Q111-Q11N) have substantially identical W/L ratios which are also substantially identical to the W/L ratios of the N-mirror transistors (Q101-Q10N); and,

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the N-cascode transistors (Q111-Q11N) are integrated on the single substrate (136).

10. The device according to Claim 4, wherein the regulating means (250) includes:

a mirror transistor (Q200) integrated on the single substrate (236), the mirror transistor (Q200) having a gate control signal and a source connection which are substantially identical to the gate control signals and the source connections of the N-mirror transistors (Q201-Q20N) and having a second W/L ratio, wherein the W/L ratio of the N-mirror transistors (Q201-Q20N) are k times greater than the second W/L ratio; and,

a cascode transistor (Q210) integrated on the single substrate, the cascade transistor (Q210) having a gate control signal which is substantially identical to the gate control signals of the N-cascode transistors (Q211-Q21N) and having a second W/L ratio, wherein the second W/L ratio of the cascode transistor (Q210) is equal to the W/L ratio of the mirror transistor (Q200).

11. The device according to Claim 10, wherein:

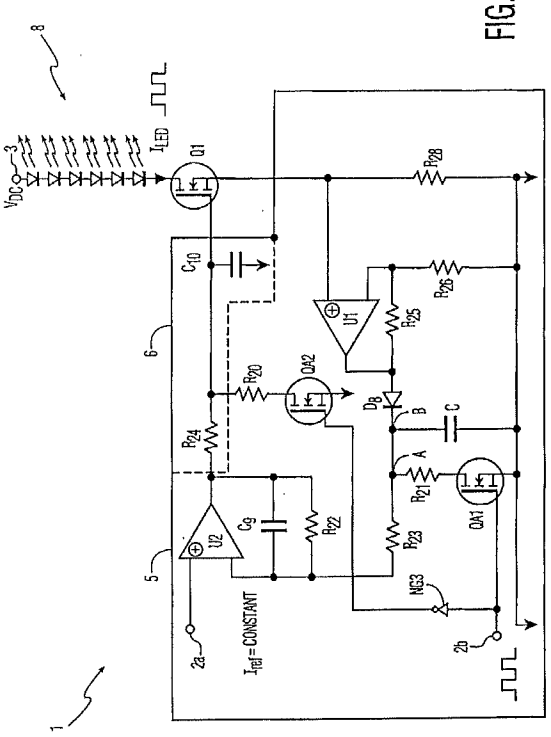
the sources of the N-mirror transistors (Q201-Q20N) are coupled to ground:

the gates of the N-mirror transistors (Q201-Q20N) are coupled to a path which is coupled to the drain of the mirror transistor (Q200) of the regulating means (250).

12. The device according to Claim 7 or 11, wherein the multiple-output current mirror (230) provides automatic current sharing which is almost independent of temperature variation and almost independent of transistor variation.

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FIG. 1



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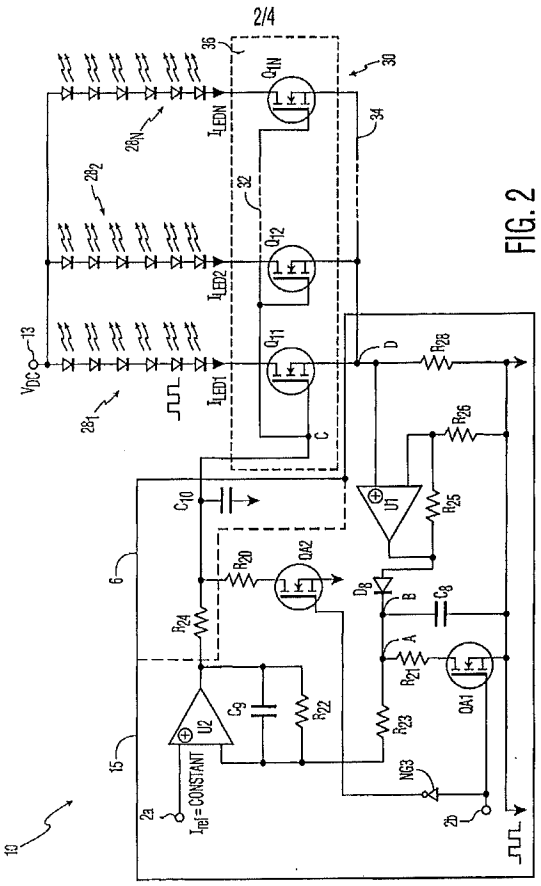


FIG. 2

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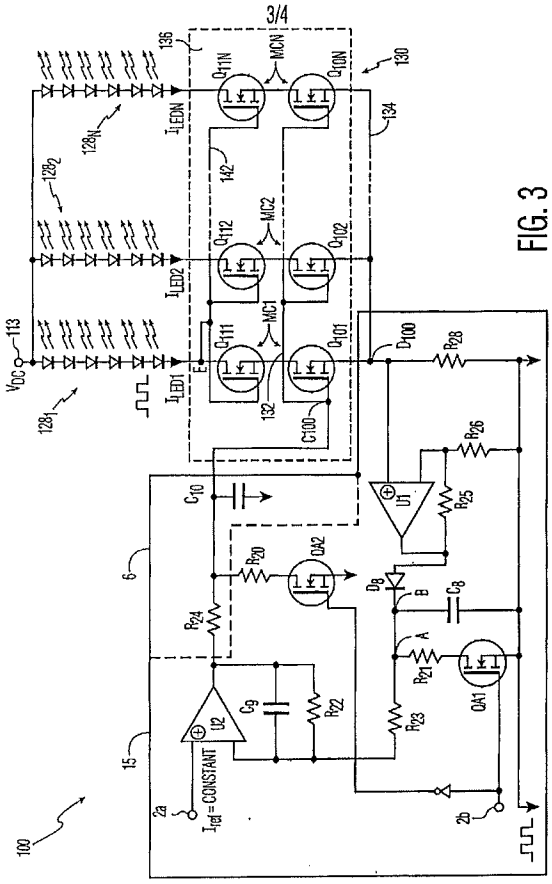


FIG. 3

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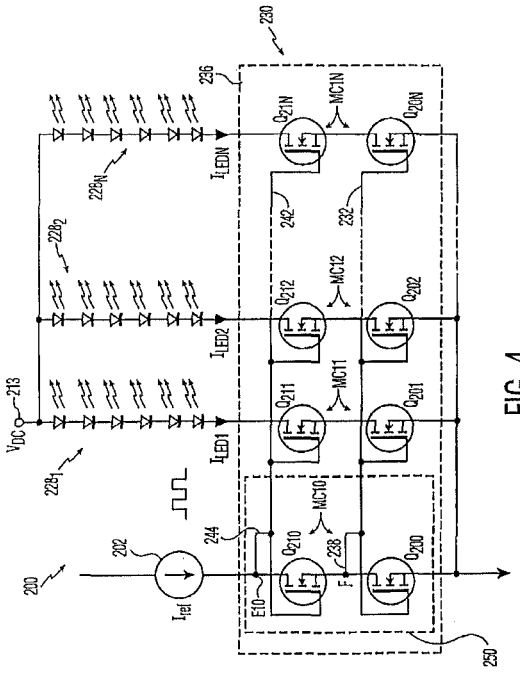


FIG. 4

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【国際調査報告】

INTERNATIONAL SEARCH REPORT

Interr Application No
PCT/IB 02/03224

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B G05F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	US 2002/105373 A1 (SUDO MINORU) 8 August 2002 (2002-08-08) page 1, paragraph 4 -page 1, paragraph 10; figure 15	1-3,5,6
Y	DE 199 50 135 A (PATRA PATENT TREUHAND) 19 April 2001 (2001-04-19) column 1, line 37 -column 2, line 49; figure 1	1-3,5,6
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[X] * Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2002	18/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax. (+31-70) 340-3016	Speiser, P

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INTERNATIONAL SEARCH REPORT

Inter 4 Application No
PCT/IB 02/03224

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Int. Application No
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Espacenet

Bibliographic data: WO2004100612 (A1) — 2004-11-18

SINGLE DRIVER FOR MULTIPLE LIGHT EMITTING DIODES

No documents available for this priority number.

Inventor(s):	XU PENG [US] ± (XU, PENG)
Applicant(s):	KONINKL PHILIPS ELECTRONICS NV [NL]; XU PENG [US] ± (KONINKLIJKE PHILIPS ELECTRONICS N.V, ; XU, PENG)
Classification:	- international: ***H05B33/08;*** (IPC1-7): H05B33/08 - cooperative: **H05B33/0809**; **H05B33/0815**; **H05B33/0824**; **H05B33/083**; **H05B33/0857**
Application number:	WO2004IB01351 20040422
Priority number (s):	US20030468538P 20030507
Also published as:	US2006232219 (A1) US7911151 (B2) JP2006525664 (A) JP4959324 (B2) EP1623603 (A1) CN1784931 (A) less

Abstract of WO2004100612 (A1)

A LED driver circuit (70, 80) employs a power source (IS, VS) for providing power at a power conversion frequency to a switching LED cell (30-32, 40-42). The switching LED cell (30-32, 40-42) switches between a radiating mode and a disabled mode at a LED driving frequency. In the radiating mode, the switching LED cell (30-32, 40-42) controls a flow of a LED current from the power source (IS, VS) through one or more LEDs (L11-LXY) to radiate a color of light from the LEDs (L11-LXY). In the disabled mode, the switching LED cell (30-32, 40-42) impedes the flow of the LED current from the power source (IS, VS) through the LEDs (L11-LXY).

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(87)国際公開番号　WO2004/100612
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最終頁に続く

(54)【発明の名称】複数の発光ダイオードのための単一ドライバ

(57)【要約】
ＬＥＤドライバ回路（７０、８０）は、スイッチングＬＥＤセル（３０乃至３２、４０乃至４２）に電力変換周波数における電力を供給するための電源（ＩＳ、ＶＳ）を用いる。スイッチングＬＥＤセル（３０乃至３２、４０乃至４２）はＬＥＤ駆動周波数において放射モードと動作不能モードとの間でスイッチングする。放射モードにおいて、スイッチングＬＥＤセル（３０乃至３２、４０乃至４２）は、ＬＥＤ（Ｌ１１乃至ＬＸＹ）から色の光を放射するために１つ又はそれ以上のＬＥＤ（Ｌ１１乃至ＬＸＹ）を通る電源（ＩＳ、ＶＳ）からのＬＥＤ電流の流れを制御する。動作不能モードにおいて、スイッチングＬＥＤセル（３０乃至３２、４０乃至４２）は、ＬＥＤ（Ｌ１１乃至ＬＸＹ）を通る電源（ＩＳ、ＶＳ）からのＬＥＤ電流の流れを遅らせる。

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【特許請求の範囲】
【請求項１】
ＬＥＤ駆動回路であって：
第１周波数において電力を与えるように動作する電源；及び
第１の少なくとも１つのＬＥＤを通って流れる第１ＬＥＤ電流に応じて光の第１色を放射するように動作する前記の第１の少なくとも１つのＬＥＤを有する第１スイッチングＬＥＤセル；
を有するＬＥＤ駆動回路であり、
前記第１スイッチングＬＥＤセルは第２周波数において第１放射モードと第１動作不能モードとの間でスイッチングされるように動作し；
前記第１放射モード中、前記第１スイッチングＬＥＤセルは前記の第１の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを制御し；そして
前記第１動作不能モード中、前記第１スイッチングＬＥＤセルは前記の第１の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを遅らせる；
ことを特徴とするＬＥＤ駆動回路。
【請求項２】
請求項１に記載のＬＥＤ駆動回路であって：
第２の少なくとも１つのＬＥＤを通って流れる第２ＬＥＤ電流に応じて光の第２色を放射するように動作する前記の第２の少なくとも１つのＬＥＤを有する第２スイッチングＬＥＤセル；
を更に有するＬＥＤ駆動回路であり、
前記第２スイッチングＬＥＤセルは第３周波数において第２放射モードと第２動作不能モードとの間でスイッチングされるように動作し；
前記第２放射モード中、前記第２スイッチングＬＥＤセルは前記の第２の少なくとも１つのＬＥＤを通る前記電源からの前記第２ＬＥＤ電流の流れを制御し；そして
前記第２動作不能モード中、前記第２スイッチングＬＥＤセルは前記の第２の少なくとも１つのＬＥＤを通る前記電源からの前記第２ＬＥＤ電流の流れを遅らせる；
ことを特徴とするＬＥＤ駆動回路。
【請求項３】
請求項２に記載のＬＥＤ駆動回路であって：
第３の少なくとも１つのＬＥＤを通って流れる第３ＬＥＤ電流に応じて光の第３色を放射するように動作する前記の第３の少なくとも１つのＬＥＤを有する第３スイッチングＬＥＤセル；
を更に有するＬＥＤ駆動回路であり、
前記第３スイッチングＬＥＤセルは第４周波数において第３放射モードと第３動作不能モードとの間でスイッチングされるように動作し；
前記第３放射モード中、前記第３スイッチングＬＥＤセルは前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第３ＬＥＤ電流の流れを制御し；そして
前記第３動作不能モード中、前記第１スイッチングＬＥＤセルは前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第３ＬＥＤ電流の流れを遅らせる；
ことを特徴とするＬＥＤ駆動回路。
【請求項４】
請求項１に記載のＬＥＤ駆動回路であって：
第２の少なくとも１つのＬＥＤを通って流れる第１ＬＥＤ電流に応じて光の第２色を放射するように動作する前記の第２の少なくとも１つのＬＥＤを有する第２スイッチングＬＥＤセル；
を更に有するＬＥＤ駆動回路であり、
前記第１スイッチングセル及び前記第２スイッチングＬＥＤセルは前記第２周波数において前記第１放射モードと前記第１動作不能モードとの間でスイッチングされるように動作し；

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前記第２放射モード中、前記第１スイッチングＬＥＤセル及び前記第２スイッチングＬＥＤセルは前記の第１の少なくとも１つのＬＥＤ及び前記の第２の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを制御し；そして

前記第２動作不能モード中、前記第１スイッチングＬＥＤセル及び前記第２スイッチングＬＥＤセルは前記の第１の少なくとも１つのＬＥＤ及び前記の第２の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを遅らせる；

ことを特徴とするＬＥＤ駆動回路。

【請求項５】

請求項４に記載のＬＥＤ駆動回路であって：

第３の少なくとも１つのＬＥＤを通って流れる第２ＬＥＤ電流に応じて光の第３色を放射するように動作する前記の第３の少なくとも１つのＬＥＤを有する第３スイッチングＬＥＤセル；

を更に有するＬＥＤ駆動回路であり、

前記第３スイッチングＬＥＤセルは第３周波数において第２放射モードと第２動作不能モードとの間でスイッチングされるように動作し；

前記第２放射モード中、前記第３スイッチングＬＥＤセルは前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第２ＬＥＤ電流の流れを制御し；そして

前記第２動作不能モード中、前記第２スイッチングＬＥＤセルは前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第２ＬＥＤ電流の流れを遅らせる；

ことを特徴とするＬＥＤ駆動回路。

【請求項６】

請求項４に記載のＬＥＤ駆動回路であって：

第３の少なくとも１つのＬＥＤを通って流れる第１ＬＥＤ電流に応じて光の第３色を放射するように動作する前記の第３の少なくとも１つのＬＥＤを有する第３スイッチングＬＥＤセル；

を更に有するＬＥＤ駆動回路であり、

前記第１スイッチングＬＥＤセル、前記第２スイッチングＬＥＤセル及び前記第３スイッチングＬＥＤセルは第２周波数において第１放射モードと第１動作不能モードとの間でスイッチングされるように動作し；

前記第１放射モード中、前記第１スイッチングＬＥＤセル、前記第２スイッチングＬＥＤセル及び前記第３スイッチングＬＥＤセルは、前記の第１の少なくとも１つのＬＥＤ、前記の第２の少なくとも１つのＬＥＤ及び前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを制御し；そして

前記第２動作不能モード中、前記第１スイッチングＬＥＤセル、前記第２スイッチングＬＥＤセル及び前記第３スイッチングＬＥＤセルは、前記の第１の少なくとも１つのＬＥＤ、前記の第２の少なくとも１つのＬＥＤ及び前記の第３の少なくとも１つのＬＥＤを通る前記電源からの前記第１ＬＥＤ電流の流れを制御する

ことを特徴とするＬＥＤ駆動回路。

【請求項７】

スイッチングＬＥＤセルであって：

入力端子；

出力端子；及び

少なくとも１つのＬＥＤを通って流れるＬＥＤ電流に応じて第１色の光を放射するように動作する前記の少なくとも１つのＬＥＤ；

を有するスイッチングＬＥＤセルであり、

前記スイッチングＬＥＤセルはＬＥＤ駆動周波数において放射モードと動作不能モードとの間でスイッチングされるように動作し；

前記放射モードは、電源が前記入力端子と前記出力端子との間に備えられるときはいつでも、前記の少なくとも１つのＬＥＤを通る前記電源からの前記ＬＥＤ電流の流れを制御するためのモードであり；

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前記動作無効モードは、前記電源が前記入力端子と前記出力端子との間に備えられるときはいつでも、第２の少なくとも１つのＬＥＤを通る前記電源からの前記ＬＥＤ電流の流れを遅らせるためのモードである；
ことを特徴とするスイッチングＬＥＤセル。
【請求項８】
請求項７に記載のスイッチングＬＥＤセルであって：
前記放射モード中は閉状態であるように及び前記動作不能モード中は開状態であるように動作する少なくとも１つのスイッチ；
を更に有する、ことを特徴とするスイッチングＬＥＤセル。
【請求項９】
請求項７に記載のスイッチングＬＥＤセルであって：
前記放射モード中は開状態であるように及び前記動作不能モード中は閉状態であるように動作する少なくとも１つのスイッチ；
を更に有する、ことを特徴とするスイッチングＬＥＤセル。
【請求項１０】
請求項９に記載のスイッチングＬＥＤセルであって：
前記放射モード中は開状態であるように及び前記動作不能モード中は閉状態であるように動作する第１の少なくとも１つのスイッチ；並びに
前記放射モード中は閉状態であるように及び前記動作不能モード中は開状態であるように動作する第２の少なくとも１つのスイッチ；
を更に有する、ことを特徴とするスイッチングＬＥＤセル。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、一般に、発光ダイオード（ＬＥＤ）に関する。本発明は、詳細には、白色光を有する種々の色の光の生成において複数のＬＥＤを動作するための駆動回路構成のファミリーに関する。
【背景技術】
【０００２】
当該技術分野において周知であるように、赤色ＬＥＤ、緑色ＬＥＤ、青色ＬＥＤ及びアンバーＬＥＤが、種々の用途（例えば、液晶のバックライト、白色光照明において、白色光を有する種々の色の光を生成するために用いられる。）所望の色の光を生成するために、各々の着色ＬＥＤは、所望の色の光（例えば、５０％赤色、２０％青色、２０％緑色及び１０％アンバー）を生成するために適切な比の赤色、緑色、青色及びアンバーの光を生成するように独立して制御される。このために、各々の着色ＬＥＤは、従来、それら自体のドライバ回路により動作されてきた。例えば、米国特許第６，５０７，１５９号明細書において、赤色ＬＥＤ、緑色ＬＥＤ、青色ＬＥＤそれぞれを制御する３つのＬＥＤドライバについて開示されている。
【発明の開示】
【発明が解決しようとする課題】
【０００３】
本発明は、複数のＬＥＤのための独立した光制御容量を有する単一ドライバ回路を提供する。
【課題を解決するための手段】
【０００４】
本発明の一実施形態は、電源とスイッチングＬＥＤセルとを有するＬＥＤドライバ回路であって、そのスイッチングＬＥＤセルは何れの色の光を放射するための１つ又はそれ以上のＬＥＤを用いている、ＬＥＤドライバ回路である。動作中、電源は電力変換周波数において電力を与え、スイッチングＬＥＤセルは、ＬＥＤ駆動周波数において放射モードと動作不能モードとの間でスイッチングする。放射モード中、ＬＥＤ電流がＬＥＤを通って

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電源から流れ、それにより、ＬＥＤは光を放射する。動作不能モード中、電源からＬＥＤを通って流れる電流は遅れ、ＬＥＤからの光の放射を妨げる。

【０００５】

本発明の第２実施形態は、何れの色の光を放射するために、入力端子、出力端子及び１つ又はそれ以上のＬＥＤを有するスイッチングＬＥＤセルである。スイッチングＬＥＤセルは、ＬＥＤ駆動周波数において放射モードと動作不能モードとの間でスイッチングする。放射モード中、ＬＥＤ電流が、ＬＥＤを通って入力端子と出力端子との間に備えられた電源から流れ、それにより、ＬＥＤは光を放射する。動作不能モード中、電源からＬＥＤを通って流れる電流は遅れ、ＬＥＤからの光の放射を妨げる。

【０００６】

本発明の上記の実施形態及び他の形態、特徴並びに有利点については、添付図面を参照して、以下の好適な実施形態の詳細説明から更に明らかになるであろう。それらの詳細説明及び添付図は制限的なものではなく、本発明の単なる例示であり、本発明の範囲は、同時提出の特許請求の範囲及びそれらと同等である範囲により規定される。

【発明を実施するための最良の形態】

【０００７】

図１乃至６及び図１２乃至１７は、本発明の電流電源駆動スイッチングＬＥＤセル（図１乃至６）又は電圧電源駆動スイッチングＬＥＤセルをデザインするためのベースラインＬＥＤマトリクスＬ１１乃至ＬＸＹを示している。何れかのスイッチングＬＥＤセルのＬＥＤデザインも、（１）ＬＥＤマトリクスＬ１１乃至ＬＸＹ内の１つ又はそれ以上のＬＥＤの選択と、（２）ＬＥＤマトリクスＬ１１乃至ＬＸＹから選択された各々のＬＥＤについての色の選択と、（３）複数のＬＥＤの実施形態に対する、ＬＥＤマトリクスＬ１１乃至ＬＸＹから選択された複数のＬＥＤの１つ又はそれ以上の直列接続及び／又は並列接続の選択とを有し、ここで、Ｘ≧１、Ｙ≧１である。複数のＬＥＤを用いる何れのスイッチングＬＥＤセルの実施形態に対して、類似する動作電流仕様を有するＬＥＤは、好適には、並列に接続される。当業者は、本発明のスイッチングＬＥＤセルのＬＥＤデザインには制限がないことを理解するであろう。

【０００８】

図１及び２は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに直列に接続されたスイッチＳＷ１（例えば、半導体スイッチ）と、ＬＥＤマトリクスＬ１１乃至ＬＸＹに並列に接続されたスイッチＳＷ２（例えば、半導体スイッチ）とを更に用いるベースライン電流電源駆動スイッチングＬＥＤセル３０を示している。セル３０の理解を容易にするために、以下のセル３０についての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内に各々のＬＥＤを含むことに基づいている。しかしながら、実際には、セル３０に基づく電流電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹからＬＥＤの何れの構成及び何れの数を有することができる。

【０００９】

図１に示すようなセル３０の放射モードにおいては、スイッチＳＷ１は閉状態であり、スイッチＳＷ２は開状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ１と、スイッチＳＷ１と、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ１とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図２において示されているセル３０の動作不能モードにおいては、スイッチＳＷ１は開状態であり、スイッチＳＷ２は閉状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ１及びＳＷ２の完全な開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。

【００１０】

スイッチングＬＥＤセル３０についての複数のＬＥＤの実施形態は、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ群に亘って分配された１つ又はそれ以上の付加スイッチ（例え

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ば、半導体スイッチ）を更に含むことができ、それにより、ＬＥＤにより放射される光の色レベル及び／又は色強度は、図１及び２に示されているスイッチＳＷ１及びＳＷ２の開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチＳＷ１及びＳＷ２並びに付加スイッチを動作することが可能である。電流i_{PM1}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００１１】

図３及び４は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに接続されたスイッチＳＷ１１乃至ＳＷ１Ｙ（例えば、半導体スイッチ）の回路構成を用いるベースライン電流電源駆動スイッチングＬＥＤセル３１を示している。セル３１は、ＬＥＤマトリクスＬ１１乃至ＬＸＹとスイッチＳＷ１１乃至ＳＷ１Ｙの回路構成に対して並列に接続されたスイッチＳＷ２（例えば、半導体スイッチ）を更に用いている。セル３１の理解を容易にするために、以下のセル３１の動作モードについての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内の各々のＬＥＤ及び各々のスイッチＳＷ１１乃至ＳＷ１Ｙを含むことに基づいている。しかしながら、実際には、セル３１に基づく電流電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ及びスイッチＳＷ１１乃至ＳＷ１Ｙの何れの構成及び何れの数を有することができる。

【００１２】

図３に示すようなセル３１の放射モードにおいては、スイッチＳＷ３は開状態であり、スイッチＳＷ１１乃至ＳＷ１Ｙは閉状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ２と、スイッチＳＷ１１乃至ＳＷ１Ｙと、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ２とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図４において示されているセル３１の動作不能モードにおいては、スイッチＳＷ３は閉状態であり、スイッチＳＷ１１乃至ＳＷ１Ｙは開状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。又、電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ１１乃至ＳＷ１Ｙ及びＳＷ３の完全な開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。代替としてのセル３１の動作の実施形態においては、スイッチＳＷ１１乃至ＳＷ１Ｙは、異なるＬＥＤ駆動周波数において群の状態で動作され又は異なるＬＥＤ駆動周波数において個別に動作されることができる。そのような場合、電流i_{PM1}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００１３】

スイッチングＬＥＤセル３１の実施形態は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに亘って分配された１つ又はそれ以上の付加スイッチ（例えば、半導体スイッチ）を更に含むことができ、それにより、光の色レベル及び／又は色強度は、図３及び４に示されているスイッチＳＷ１１乃至ＳＷ１Ｙ及びＳＷ３の開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチスイッチＳＷ１１乃至ＳＷ１Ｙ及びＳＷ３並びに付加スイッチを動作することが可能である。電流i_{PM1}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００１４】

図５及び６は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに接続されたスイッチＳＷ１１乃至ＳＷ１Ｙ（例えば、半導体スイッチ）の回路構成を用いるベースライン電流電源駆動スイッチングＬＥＤセル３２を示している。セル３２の理解を容易にするために、以下のセル

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３２の動作モードについての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内の各々のＬＥＤ及び各々のスイッチＳＷ１１乃至ＳＷ１Ｙを含むことに基づいている。しかしながら、実際には、セル３２に基づく電流電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ及びスイッチＳＷ１１乃至ＳＷ１Ｙの何れの構成及び何れの数を有することができる。

【００１５】

図５に示すようなセル３２の放射モードにおいては、スイッチＳＷ１１乃至ＳＷＸ１は開状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ３と、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ３とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図６において示されている動作不能モードにおいては、選択されたスイッチＳＷ１１乃至ＳＷＸ１は閉状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。又、電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ１１乃至ＳＷＸ１の完全な開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。代替としてのセル３２の動作の実施形態においては、スイッチＳＷ１１乃至ＳＷＸ１は、異なるＬＥＤ駆動周波数において群の状態で動作され又は異なるＬＥＤ駆動周波数において個別に動作されることができる。そのような場合、電流i_{PM1}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００１６】

スイッチングＬＥＤセル３２の実施形態は、選択されたＬＥＤに亘って分配された１つ又はそれ以上の付加スイッチ（例えば、半導体スイッチ）を更に含むことができ、それにより、光の色レベル及び／又は色強度は、図５及び６に示されているスイッチＳＷ１１乃至ＳＷＸ１の開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチスイッチＳＷ１１乃至ＳＷＸ１及び付加スイッチを動作することが可能である。電流i_{PM1}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００１７】

図１乃至６を参照するに、電流電源と電流電源駆動スイッチングＬＥＤセル３０乃至３２の１つとを用いる、本発明の電流電源ＬＥＤドライバの数及び構成には制限がない。図７乃至１１は、本発明の電流電源ＬＥＤドライバの幾つかの例示としての実施形態を示している。

【００１８】

図７は、バッテリＢ１、半導体スイッチＱ１、ダイオードＤ１及びインダクタＬ１の既知の配置を有するＢｕｃｋ型コンバータ方式にある電流電源ＣＳ１を用いている電流電源ＬＥＤドライバ４０を示している。電流電源ＣＳ１は、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）において半導体スイッチＱ１のゲートへのゲート信号の供給により、従来から動作されている。

【００１９】

図８は、バッテリＢ２、インダクタＬ２、半導体スイッチＱ２、コンデンサＣ１、ダイオードＤ２及びインダクタＬ３の既知の配置を有するＣｕｋ型コンバータ方式にある電流電源ＣＳ２を用いている電流電源ＬＥＤドライバ４１を示している。電流電源ＣＳ２は、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）において半導体スイッチＱ２のゲートへのゲート信号の供給により、従来から動作されている。

【００２０】

図９は、バッテリＢ３、半導体スイッチＱ３、インダクタＬ４、コンデンサＣ２、ダイオードＤ３及びインダクタＬ５の既知の配置を有するＺｅｔａ型コンバータ方式にある電流電源ＣＳ３を用いている電流電源ＬＥＤドライバ４２を示している。電流電源ＣＳ３は

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、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）において半導体スイッチＱ３のゲートへのゲート信号の供給により、従来から動作されている。

【００２１】

図１０は、バッテリＢ４、トランスＴ１、半導体スイッチＱ４、ダイオードＤ４、ダイオードＤ５及びインダクタＬ６の既知の配置を有するフォワードコンバータ方式にある電流電源ＣＳ４を用いている電流電源ＬＥＤドライバ４３を示している。ドライバ４３は、セル３２（図５及び６）のバージョン３２ａを更に用いている。電流電源ＣＳ４は、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）において半導体スイッチＱ４のゲートへのゲート信号の供給により、従来から動作されている。

【００２２】

図７乃至１０を参照するに、ドライバ４０乃至４３は、スイッチＳＷ１１乃至ＳＷ４１とＬＥＤＬ１１乃至Ｌ４１の例示としての回路構成を有するセル３２（図３及び４）のバージョン３２ａを更に用いている。ＬＥＤＬ１１、ＬＥＤＬ２１、ＬＥＤＬ３１及び／又はＬＥＤＬ４１は、付加スイッチを有することが可能である何れの所望の回路構成における複数のＬＥＤとして実施されることができる。一実施形態においては、ＬＥＤＬ１１は１つ又はそれ以上の赤色ＬＥＤを有し、ＬＥＤＬ２１は緑色ＬＥＤを有し、ＬＥＤＬ３１は青色ＬＥＤを有し、そしてＬＥＤＬ４１は１つ又はそれ以上のアンバーＬＥＤを有する。

【００２３】

セル３２ａは、１つ又はそれ以上のスイッチＳＷ１１乃至ＳＷ４１の選択的動作を有する、セル３２ａの各々の放射モードを有する１５個の放射モードを有し、それにより、電流i_{PM1}は１つ又はそれ以上のＬＥＤＬ１１乃至Ｌ４１を通って流れ、それにより、どのＬＥＤＬ１１乃至Ｌ４１が光を放射しているかに依存して、色の光を放射する。セル３２ａの動作不能モードにおいては、スイッチＳＷ１１乃至ＳＷ４１は閉状態であり、それ故、ＬＥＤＬ１１乃至Ｌ４１を通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤＬ１１乃至Ｌ４１は色の光を放射しない。セル３２ａは、スイッチＳＷ１１乃至ＳＷ４１に選択的に供給される従来の制御信号に依存して、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）において、放射モードの１つと動作不能モードとの間でスイッチングする。代替のセル３２ａの動作モードにおいては、スイッチＳＷ１１乃至ＳＷ４１は、異なるＬＥＤ駆動周波数において個別に動作される又は異なるＬＥＤ駆動周波数において群の状態で動作されることができる。そのような場合、電流i_{PM1}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００２４】

図１１は、スイッチＳＷ３、スイッチＳＷ１１乃至ＳＷ１４及びＬＥＤＬ１１乃至Ｌ１４の例示としての回路構成を有するセル３１（図３及び４）のバージョン３１ａと電流電源ＣＳ１とを用いている電流電源ＬＥＤドライバ４４を示している。ＬＥＤＬ１１、ＬＥＤＬ１２、ＬＥＤＬ１３及び／又はＬＥＤＬ１４は、付加スイッチを有することが可能である何れの所望の回路構成における複数のＬＥＤとして実施されることができる。一実施形態においては、ＬＥＤＬ１１は１つ又はそれ以上の赤色ＬＥＤを有し、ＬＥＤＬ１２は緑色ＬＥＤを有し、ＬＥＤＬ１３は青色ＬＥＤを有し、そしてＬＥＤＬ１４は１つ又はそれ以上のアンバーＬＥＤを有する。

【００２５】

セル３１ａは、１つ又はそれ以上のスイッチＳＷ１１乃至ＳＷ１４の選択的閉状態化及びＳＷ３の開状態化を有する、セル３１ａの各々の放射モードを有する１５個の放射モードを有し、それにより、電流i_{PM1}は１つ又はそれ以上のＬＥＤＬ１１乃至Ｌ１４を通って流れ、それにより、どのＬＥＤＬ１１乃至Ｌ１４が光を放射しているかに依存して、色の光を放射する。セル３１ａの動作不能モードにおいては、スイッチＳＷ１１乃至ＳＷ１４は閉状態であり、それ故、ＬＥＤＬ１１乃至Ｌ１４を通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤＬ１１乃至Ｌ１４は色の光を放射しない。セル３１ａは、スイ

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ッチＳＷ１１乃至ＳＷ１４に選択的に供給される従来の制御信号に依存して、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）において、放射モードの１つと動作不能モードとの間でスイッチングする。代替のセル３１ａの動作モードにおいては、スイッチＳＷ１１乃至ＳＷ１４は、異なるＬＥＤ駆動周波数において個別に動作される又は異なるＬＥＤ駆動周波数において群の状態で動作されることができる。そのような場合、電流i_{PM1}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００２６】

図１２及び１３は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに並列に接続されたスイッチＳＷ５（例えば、半導体スイッチ）と、スイッチＳＷ５とＬＥＤマトリクスＬ１１乃至ＬＸＹの並列接続に対して直列に接続されたスイッチＳＷ４（例えば、半導体スイッチ）とを更に用いるベースライン電圧電源駆動スイッチングＬＥＤセル５０を示している。セル５０の理解を容易にするために、以下のセル５０についての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内に各々のＬＥＤを含むことに基づいている。しかしながら、実際には、セル３０に基づく電圧電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹからＬＥＤの何れの構成及び何れの数を有することができる。

【００２７】

図１２に示すようなセル５０の放射モードにおいては、スイッチＳＷ４は閉状態であり、スイッチＳＷ５は開状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ４と、スイッチＳＷ４と、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ４とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図１３において示されているセル５０の動作不能モードにおいては、スイッチＳＷ４は開状態であり、スイッチＳＷ５は閉状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ４及びＳＷ５の完全な開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。

【００２８】

スイッチングＬＥＤセル５０についての複数のＬＥＤの実施形態は、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ群に亘って分配された１つ又はそれ以上の付加スイッチ（例えば、半導体スイッチ）を更に含むことができ、それにより、ＬＥＤにより放射される光の色レベル及び／又は色強度は、図１２及び１３に示されているスイッチＳＷ４及びＳＷ５の開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチＳＷ４及びＳＷ５並びに付加スイッチを動作することが可能である。電流i_{PM2}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００２９】

図１４及び１５は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに接続されたスイッチＳＷ１１乃至ＳＷ１Ｙ（例えば、半導体スイッチ）の回路構成を用いるベースライン電圧電源駆動スイッチングＬＥＤセル５１を示している。セル５１の理解を容易にするために、以下のセル５１の動作モードについての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内の各々のＬＥＤ及び各々のスイッチＳＷ１１乃至ＳＷ１Ｙを含むことに基づいている。しかしながら、実際には、セル５１に基づく電圧電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ及びスイッチＳＷ１１乃至ＳＷ１Ｙの何れの構成及び何れの数を有することができる。

【００３０】

図１４に示すようなセル５１の放射モードにおいては、スイッチＳＷ１１乃至ＳＷ１Ｙは閉状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ５と、スイッチＳＷ１１乃

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至ＳＷ１Ｙと、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ２とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図１５において示されているセル５１の動作不能モードにおいては、スイッチＳＷ１１乃至ＳＷ１Ｙは開状態であり、スイッチＳＷ１１乃至ＳＷ１Ｙは開状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。又、電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ１１乃至ＳＷ１Ｙ開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。代替としてのセル５１の動作の実施形態においては、スイッチＳＷ１１乃至ＳＷ１Ｙは、異なるＬＥＤ駆動周波数において群の状態で動作され又は異なるＬＥＤ駆動周波数において個別に動作されることができる。そのような場合、電流i_{PM1}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００３１】

スイッチングＬＥＤセル５１の実施形態は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに亘って分配された１つ又はそれ以上の付加スイッチ（例えば、半導体スイッチ）を更に含むことができ、それにより、光の色レベル及び／又は色強度は、図１４及び１５に示されているスイッチＳＷ１１乃至ＳＷ１Ｙの開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチＳＷ１１乃至ＳＷ１Ｙ及びＳＷ３並びに付加スイッチを動作することが可能である。電流i_{PM2}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００３２】

図１６及び１７は、ＬＥＤマトリクスＬ１１乃至ＬＸＹに接続されたスイッチＳＷ１１乃至ＳＷ１Ｙ（例えば、半導体スイッチ）の回路構成を用いるベースライン電圧電源駆動スイッチングＬＥＤセル５２を示している。セル５２は、スイッチＳＷ１１乃至ＳＷ１Ｙ及びＬＥＤマトリクスＬ１１乃至ＬＸＹの回路構成に対して直列に接続されたスイッチＳＷ６（例えば、半導体スイッチ）を更に用いる。セル５２の理解を容易にするために、以下のセル５２の動作モードについての説明は、ＬＥＤマトリクスＬ１１乃至ＬＸＹ内の各々のＬＥＤ及び各々のスイッチＳＷ１１乃至ＳＷ１Ｙを含むことに基づいている。しかしながら、実際には、セル５２に基づく電圧電源駆動スイッチングＬＥＤセルのセルデザインは、当業者により理解されるであろうように、ＬＥＤマトリクスＬ１１乃至ＬＸＹのＬＥＤ及びスイッチＳＷ１１乃至ＳＷ１Ｙの何れの構成及び何れの数を有することができる。

【００３３】

図１６に示すようなセル５２の放射モードにおいては、スイッチＳＷ６は閉状態であり、スイッチＳＷ１１乃至ＳＷＸ１は開状態であり、それにより、電流i_{PM1}は、入力端子ＩＮ３と、ＬＥＤマトリクスＬ１１乃至ＬＸＹと、出力端子ＯＵＴ３とを通って連続して流れ、それ故、選択されたＬＥＤの色に依存して色の光を放射する。図１７において示されている動作不能モードにおいては、選択されたスイッチＳＷ１１乃至ＳＷＸ１は閉状態であり、それ故、ＬＥＤマトリクスＬ１１乃至ＬＸＹを通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤは色の光を放射しない。又、電流i_{PM1}は、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）においてスイッチＳＷ１１乃至ＳＷＸ１の完全な開状態及び閉状態のためにパルス変調電流を構成し、このような状態は、当業者に理解されるであろうように、従来技術により達成されることができる。代替としてのセル５２の動作の実施形態においては、スイッチＳＷ６及びスイッチＳＷ１１乃至ＳＷＹ１は、異なるＬＥＤ駆動周波数において群の状態で動作され又は異なるＬＥＤ駆動周波数において個別に動作されることができる。そのような場合、電流i_{PM2}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

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【００３４】
スイッチングＬＥＤセル５２の実施形態は、選択されたＬＥＤに亘って分配された１つ又はそれ以上の付加スイッチ（例えば、半導体スイッチ）を更に含むことができ、それにより、光の色レベル及び／又は色強度は、図１６及び１７に示されているスイッチＳＷ６及びスイッチＳＷ１１乃至ＳＷＸ１の開状態及び閉状態に対する付加スイッチの開状態及び閉状態に依存して変えられる。そのような複数のＬＥＤの実施形態は、同じ又は異なるＬＥＤ駆動周波数においてスイッチＳＷ６及びスイッチＳＷ１１乃至ＳＷＸ１及び付加スイッチを動作することが可能である。電流i_{PM2}は、付加スイッチが異なるＬＥＤ駆動周波数で個別に動作される又は異なるＬＥＤ駆動周波数で複数の群において動作される実施形態における種々のＬＥＤ駆動周波数における複数のパルス変調電流を有することが可能である。

【００３５】
図１２乃至１７を参照するに、電圧電源と電圧流電源駆動スイッチングＬＥＤセル５０乃至５２の１つとを用いる、本発明の電圧電源ＬＥＤドライバの数及び構成には制限がない。図１８乃至１９は、本発明の電圧電源ＬＥＤドライバの幾つかの例示としての実施形態を示している。

【００３６】
図１８は、バッテリＢ５、インダクタＬ７、半導体スイッチＱ５、ダイオードＤ６及びコンデンサＣ２の既知の配置を有するＢｏｏｓｔ型コンバータ方式にある電圧電源ＶＳ１を用いている電圧電源ＬＥＤドライバ６０を示している。電圧電源ＶＳ１は、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）においてスイッチＱ５のゲートへのゲート信号の供給により、従来から動作されている。

【００３７】
ドライバ６０は、スイッチＳＷ１１乃至ＳＷ１４及びＬＥＤＬ１１乃至Ｌ１４の例示としての回路構成を有するセル５１（図１３及び１４）のバージョン５１ａを更に用いている。ＬＥＤＬ１１、ＬＥＤＬ１２、ＬＥＤＬ１３及び／又はＬＥＤＬ１４は、付加スイッチを有することが可能である何れの所望の回路構成における複数のＬＥＤとして実施されることができる。一実施形態においては、ＬＥＤＬ１１は１つ又はそれ以上の赤色ＬＥＤを有し、ＬＥＤＬ１２は緑色ＬＥＤを有し、ＬＥＤＬ１３は青色ＬＥＤを有し、そしてＬＥＤＬ１４は１つ又はそれ以上のアンバーＬＥＤを有する。

【００３８】
セル５１ａは、１つ又はそれ以上のスイッチＳＷ１１乃至ＳＷ１４の選択的動作を有する、セル５１ａの各々の放射モードを有する１５個の放射モードを有し、それにより、電流i_{PM1}は１つ又はそれ以上のＬＥＤＬ１１乃至Ｌ１４を通って流れ、それにより、どのＬＥＤＬ１１乃至Ｌ１４が光を放射しているかに依存して、色の光を放射する。セル５１ａの動作不能モードにおいては、スイッチＳＷ１１乃至ＳＷ４１は閉状態であり、それ故、ＬＥＤＬ１１乃至Ｌ１４を通って流れる電流i_{PM1}を遅らせ、それにより、ＬＥＤＬ１１乃至Ｌ１４は色の光を放射しない。セル５１ａは、スイッチＳＷ１１乃至ＳＷ１４に選択的に供給される従来の制御信号に依存して、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）において、放射モードの１つと動作不能モードとの間でスイッチングする。代替のセル５１ａの動作モードにおいては、スイッチＳＷ１１乃至ＳＷ１４は、異なるＬＥＤ駆動周波数において個別に動作される又は異なるＬＥＤ駆動周波数において群の状態で動作されることができる。そのような場合、電流i_{PM2}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。

【００３９】
図１９は、バッテリＢ６、半導体スイッチＱ６、トランスＴ２及びダイオードＤ７の既知の配置を有するＦｌｙｂａｃｋ型コンバータ方式にある電圧電源ＶＳ２を用いている電圧電源ＬＥＤドライバ６１を示している。電圧電源ＶＳ２は、当業者には理解できるであろうように、電力変換周波数（例えば、１００ｋＨｚ）においてスイッチＱ６のゲートへのゲート信号の供給により、従来から動作されている。

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【００４０】
ドライバ６１は、スイッチＳＷ６，スイッチＳＷ１１乃至ＳＷ４１及びＬＥＤＬ１１乃至Ｌ４１の例示としての回路構成を有するセル５２（図１６及び１７）のバージョン５２ａを更に用いている。ＬＥＤＬ１１、ＬＥＤＬ２１、ＬＥＤＬ３１及び／又はＬＥＤＬ４１は、付加スイッチを有することが可能である何れの所望の回路構成における複数のＬＥＤとして実施されることができる。一実施形態においては、ＬＥＤＬ１１は１つ又はそれ以上の赤色ＬＥＤを有し、ＬＥＤＬ２１は緑色ＬＥＤを有し、ＬＥＤＬ３１は青色ＬＥＤを有し、そしてＬＥＤＬ４１は１つ又はそれ以上のアンバーＬＥＤを有する。
【００４１】
セル５２ａは、１つ又はそれ以上のスイッチＳＷ１１乃至ＳＷ４１の選択的開状態化及びスイッチＳＷ６の閉状態化を有する、セル５２ａの各々の放射モードを有する１５個の放射モードを有し、それにより、電流i_{PM2}は１つ又はそれ以上のＬＥＤＬ１１乃至Ｌ４１を通って流れ、それにより、どのＬＥＤＬ１１乃至Ｌ４１が光を放射しているかに依存して、色の光を放射する。セル５２ａの動作不能モードにおいては、スイッチＳＷ６は開状態であり、スイッチＳＷ１１乃至ＳＷ４１は閉状態であり、それ故、ＬＥＤＬ１１乃至Ｌ４１を通って流れる電流i_{PM2}を遅らせ、それにより、ＬＥＤＬ１１乃至Ｌ４１は色の光を放射しない。セル５２ａは、スイッチＳＷ１１乃至ＳＷ４１に選択的に供給される従来の制御信号に依存して、ＬＥＤ駆動周波数（例えば、２００Ｈｚ）において、放射モードの１つと動作不能モードとの間でスイッチングする。代替のセル５２ａの動作モードにおいては、スイッチＳＷ１１乃至ＳＷ４１は、異なるＬＥＤ駆動周波数において個別に動作される又は異なるＬＥＤ駆動周波数において群の状態で動作されることができる。そのような場合、電流i_{PM2}は、可変ＬＥＤ駆動周波数において複数のパルス変調電流を有することが可能である。
【００４２】
図２０は、本発明の電流電源ＬＥＤドライバについての多くの実施形態の１つをデザインするためにセルマトリクス３０（１１）乃至３０（ＸＹ）と電流電源I_Sとを用いるベースライン電流電源ＬＥＤドライバ７０を示している。本発明の電流電源ＬＥＤドライバのドライバデザインは、（１）セルマトリクス３０（１１）乃至３０（ＸＹ）内の１つ又はそれ以上の電流電源駆動スイッチングＬＥＤセル３０の選択、（２）セルマトリクス３０（１１）乃至３０（ＸＹ）から選択された各々のセル３０のＬＥＤデザイン、そして（３）複数のセルの実施形態に対して、セルマトリクス３０（１１）乃至３０（ＸＹ）から選択された複数のセル３０の１つ又はそれ以上の直列接続及び／又は並列接続の選択を有し、ここで、Ｘ≧１及びＹ≧１である。複数のセル３０を用いるドライバの実施形態に対しては、類似する動作電流仕様を有するセル３０は、好適には、直列に接続され、類似する動作電圧仕様を有するセル３０は、好適には、並列に接続される。当業者は、ドライバ７０に基づく電流電源ＬＥＤドライバのドライバデザインには制限がないことを理解するであろう。図２２乃至２５は、ドライバ７０に基づく電流電源ＬＥＤドライバの幾つかの例示としての実施形態を示している。
【００４３】
図２２は、電流電源I_Sに並列に接続された赤色セル３０Ｒ、緑色セル３０Ｇ及び青色セル３０Ｂを示している。図２３は、電流電源I_Sに直列に接続された赤色セル３０Ｒ、緑色セル３０Ｇ及び青色セル３０Ｂを示している。図２４は、電流電源I_Sに直列に接続された赤色セル３０Ｒと緑色セル３０Ｇ及び青色セル３０Ｂの並列接続とを示している。図２５は、電流電源I_Sに並列に接続された緑色セル３０Ｇ及び青色セル３０Ｂの直列接続と赤色セル３０Ｒとを示している。図２２乃至２５を参照するに、電流電源（例えば、図７乃至１０に示しているＣＳ１乃至ＣＳ４）は、種々のＬＥＤ駆動周波数において電流I_{PM1}が複数のパルス変調電流を有することが可能である、種々のＬＥＤ駆動周波数又は同じＬＥＤ駆動周波数におけるそれぞれの放射モードと動作不能モード間の各々のセル３０Ｒ、３０Ｇ及び３０Ｂのスイッチングに依存して、セル３０Ｒ、３０Ｇ及び３０Ｂに対してパルス変調電流I_{PM1}を供給する。

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【００４４】
図２１は、本発明の電圧電源ＬＥＤドライバについての多くの実施形態の１つをデザインするためにセルマトリクス５０（１１）乃至５０（ＸＹ）と電圧電源V_Sとを用いるベースライン電圧電源ＬＥＤドライバ８０を示している。本発明の電圧電源ＬＥＤドライバのドライバデザインは、（１）セルマトリクス５０（１１）乃至５０（ＸＹ）内の１つ又はそれ以上の電圧電源駆動スイッチングＬＥＤセル５０の選択、（２）セルマトリクス５０（１１）乃至５０（ＸＹ）から選択された各々のセル５０のＬＥＤデザイン、そして（３）複数のセルの実施形態に対して、セルマトリクス５０（１１）乃至５０（ＸＹ）から選択された複数のセル５０の１つ又はそれ以上の直列接続及び／又は並列接続の選択を有し、ここで、Ｘ≧１及びＹ≧１である。複数のセル５０を用いるドライバの実施形態に対しては、類似する動作電流仕様を有するセル５０は、好適には、直列に接続され、類似する動作電圧仕様を有するセル５０は、好適には、並列に接続される。当業者は、ドライバ８０に基づく電流電源ＬＥＤドライバのドライバデザインには制限がないことを理解するであろう。図２６乃至２９は、ドライバ８０に基づく電圧電源ＬＥＤドライバの幾つかの例示としての実施形態を示している。
【００４５】
図２６は、電圧電源V_Sに並列に接続された赤色セル５０Ｒ、緑色セル５０Ｇ及び青色セル５０Ｂを示している。図２７は、電圧電源V_Sに直列に接続された赤色セル３０Ｒ、緑色セル５０Ｇ及び青色セル５０Ｂを示している。図２８は、電圧電源V_Sに直列に接続された赤色セル５０Ｒと緑色セル５０Ｇ及び青色セル５０Ｂの並列接続とを示している。図２９は、電流電源V_Sに並列に接続された緑色セル５０Ｇ及び青色セル５０Ｂの直列接続と赤色セル５０Ｒとを示している。図２６乃至２９を参照するに、電流電源（例えば、図１８及び１９に示しているV_{S1}及びV_{S2}）は、種々のＬＥＤ駆動周波数において電流I_{PM1}が複数のパルス変調電流を有することが可能である、種々のＬＥＤ駆動周波数又は同じＬＥＤ駆動周波数におけるそれぞれの放射モードと動作不能モード間の各々のセル５０Ｒ、５０Ｇ及び５０Ｂのスイッチングに依存して、セル５０Ｒ、５０Ｇ及び５０Ｂに対してパルス変調電流I_{PM1}を供給する。
【００４６】
以上、詳述した本発明の実施形態は好適であると考えられる一方、本発明の主旨及び範囲から逸脱することなく、種々の変形及び修正を実施することができる。本発明の範囲は同時提出の特許請求に記載されていて、同等の意味及び範囲内にある全ての変形はその範囲内に入ることが意図されている。
【図面の簡単な説明】
【００４７】
【図１】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第１ベースラインの実施形態の模式図である。
【図２】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第１ベースラインの実施形態の模式図である。
【図３】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第２ベースラインの実施形態の模式図である。
【図４】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第２ベースラインの実施形態の模式図である。
【図５】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第３ベースラインの実施形態の模式図である。
【図６】電流電源駆動スイッチングＬＥＤセルについての本発明に従った第３ベースラインの実施形態の模式図である。
【図７】単一電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第１実施形態の模式図である。
【図８】単一電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第２実施形態の模式図である。

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【図９】単一電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第３実施形態の模式図である。
【図１０】単一電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第４実施形態の模式図である。
【図１１】単一電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第５実施形態の模式図である。
【図１２】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第１ベースラインの実施形態の模式図である。
【図１３】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第１ベースラインの実施形態の模式図である。
【図１４】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第２ベースラインの実施形態の模式図である。
【図１５】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第２ベースラインの実施形態の模式図である。
【図１６】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第３ベースラインの実施形態の模式図である。
【図１７】電圧電源駆動スイッチングＬＥＤセルについての本発明に従った第３ベースラインの実施形態の模式図である。
【図１８】単一電流駆動スイッチングＬＥＤセルを用いた電圧電源ＬＥＤドライバ回路についての本発明に従った第１実施形態の模式図である。
【図１９】単一電流駆動スイッチングＬＥＤセルを用いた電圧電源ＬＥＤドライバ回路についての本発明に従った第２実施形態の模式図である。
【図２０】複数の電流駆動スイッチングＬＥＤセルを用いた電流電源ＬＥＤドライバ回路についての本発明に従った第１ベースラインの実施形態の模式図である。
【図２１】複数の電流駆動スイッチングＬＥＤセルを用いた電圧電源ＬＥＤドライバ回路についての本発明に従った第１ベースラインの実施形態の模式図である。
【図２２】図２０に示している電流電源ＬＥＤドライバについての本発明に従った第１実施形態の模式図である。
【図２３】図２０に示している電流電源ＬＥＤドライバについての本発明に従った第２実施形態の模式図である。
【図２４】図２０に示している電流電源ＬＥＤドライバについての本発明に従った第３実施形態の模式図である。
【図２５】図２０に示している電流電源ＬＥＤドライバについての本発明に従った第４実施形態の模式図である。
【図２６】図２１に示している電圧電源ＬＥＤドライバについての本発明に従った第１実施形態の模式図である。
【図２７】図２１に示している電圧電源ＬＥＤドライバについての本発明に従った第２実施形態の模式図である。
【図２８】図２１に示している電圧電源ＬＥＤドライバについての本発明に従った第３実施形態の模式図である。
【図２９】図２１に示している電圧電源ＬＥＤドライバについての本発明に従った第４実施形態の模式図である。

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【図１】

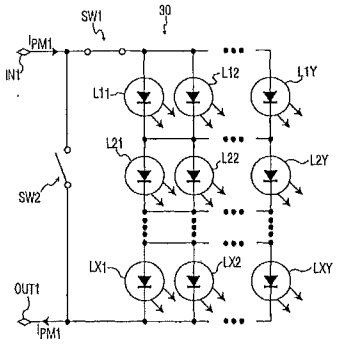


FIG. 1

【図２】

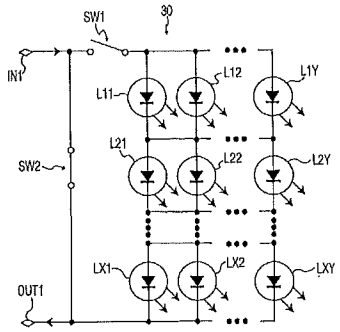


FIG. 2

【図３】

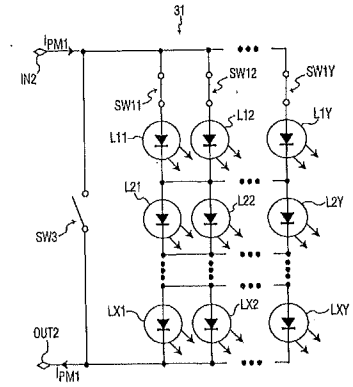


FIG. 3

【図４】

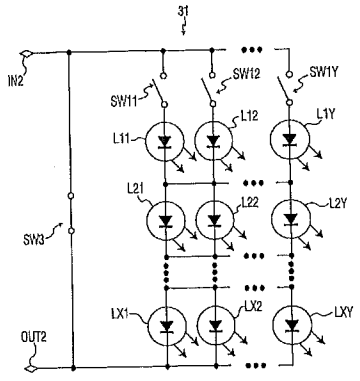


FIG. 4

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【図５】

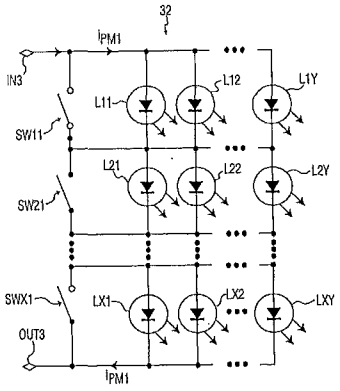


FIG. 5

【図６】

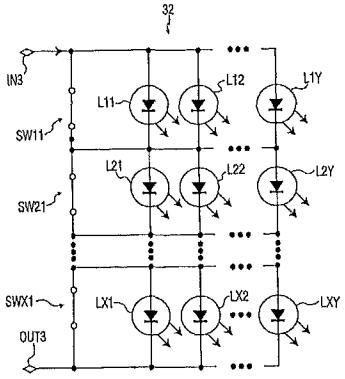


FIG. 6

【図７】

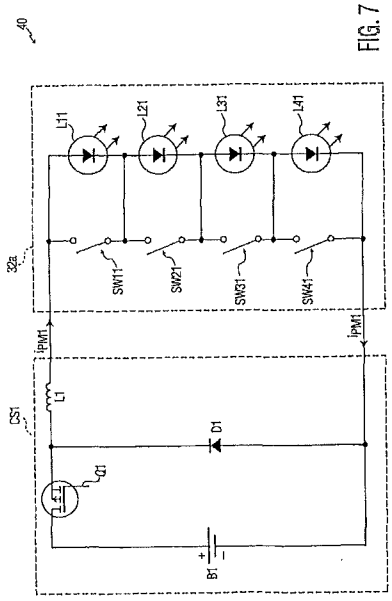


FIG. 7

【図８】

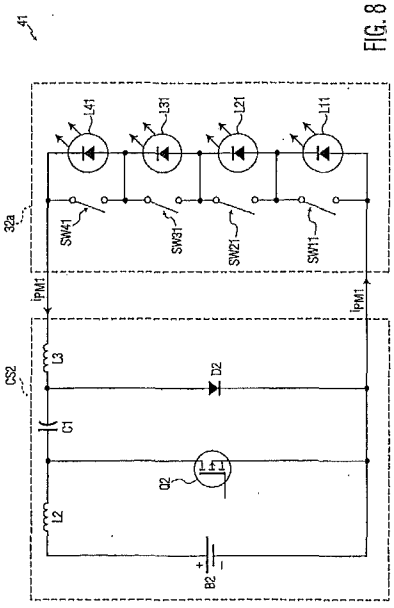


FIG. 8

【図９】

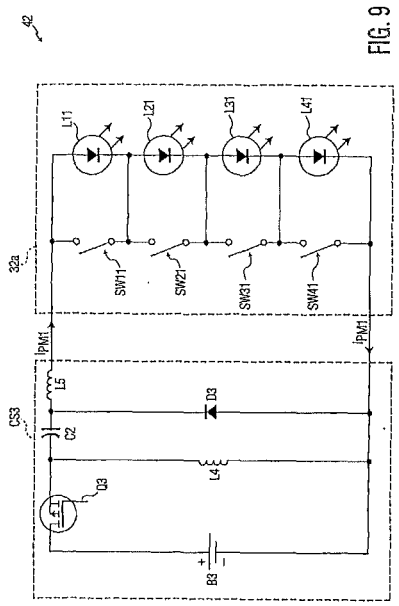


FIG. 9

【図１０】

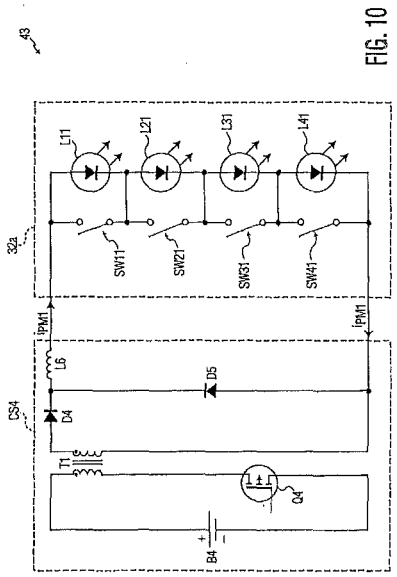


FIG. 10

【図１１】

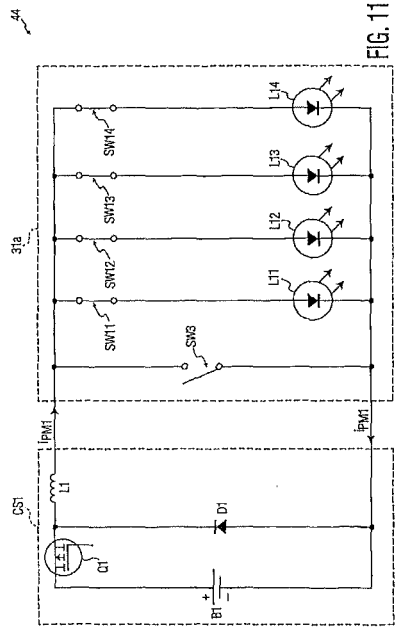


FIG. 11

【図１２】

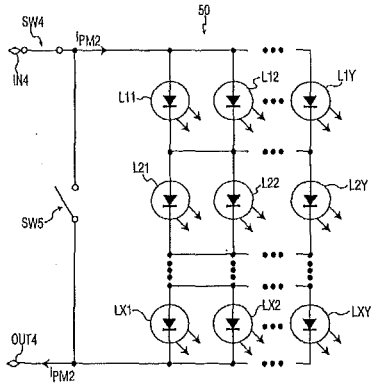


FIG. 12

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【図１３】

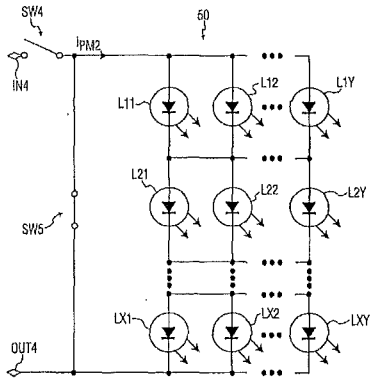


FIG. 13

【図１４】

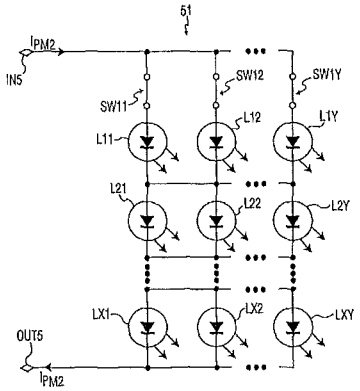


FIG. 14

【図１５】

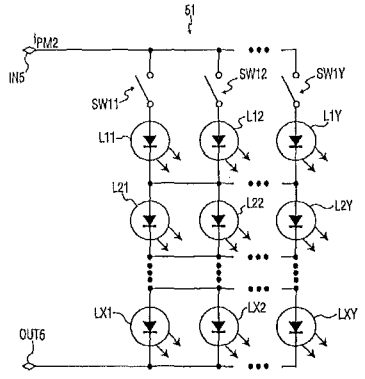


FIG. 15

【図１６】

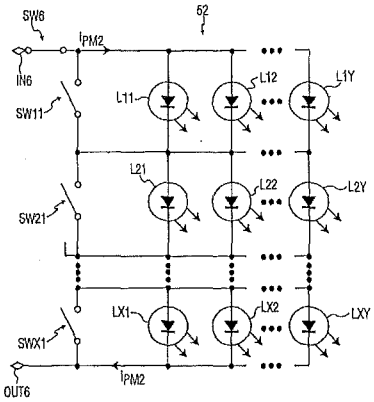


FIG. 16

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【図１７】

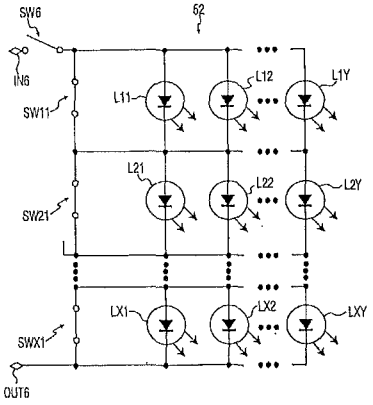


FIG. 17

【図１８】

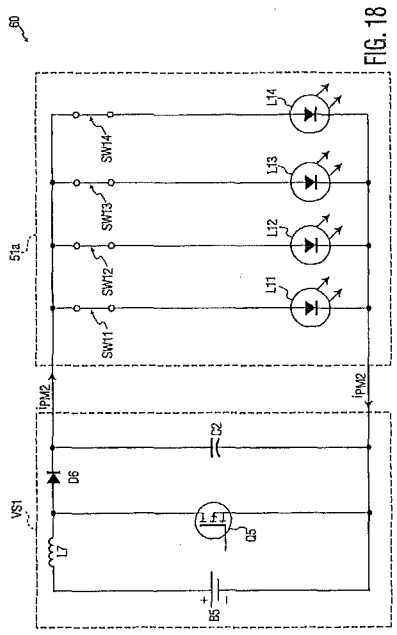


FIG. 18

【図１９】

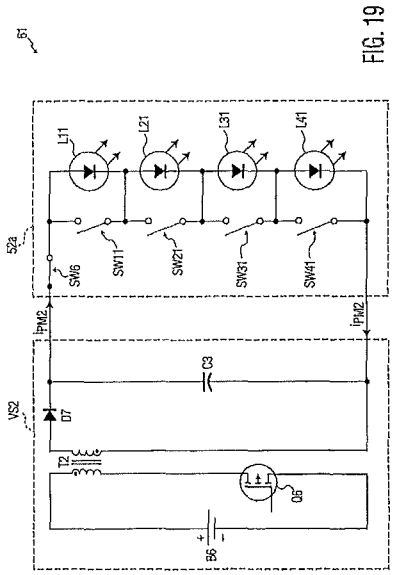


FIG. 19

【図２０】

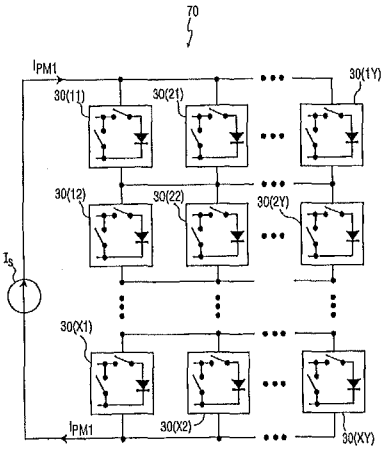


FIG. 20

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【図２１】

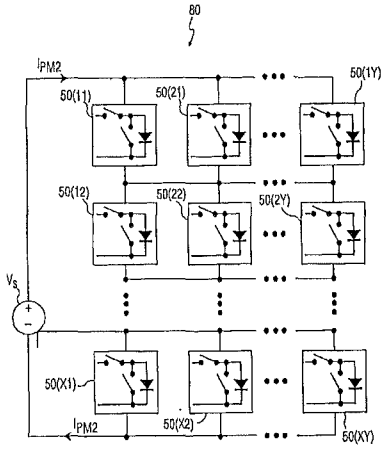


FIG. 21

【図２２】

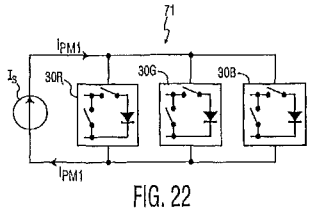


FIG. 22

【図２３】

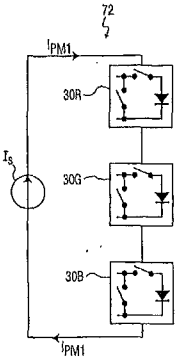


FIG. 23

【図２４】

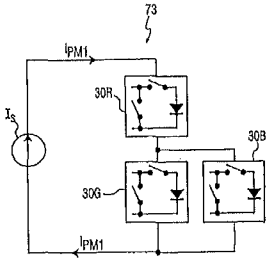


FIG. 24

【図２５】

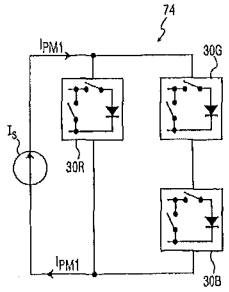


FIG. 25

【図２６】

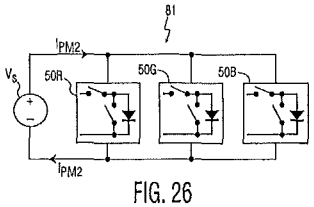


FIG. 26

【図２７】

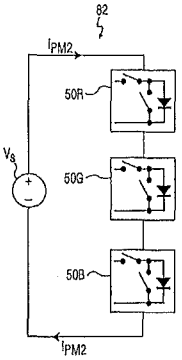


FIG. 27

【図２８】

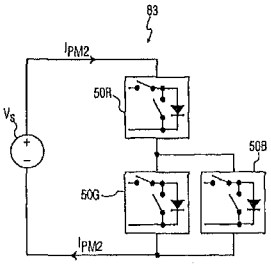


FIG. 28

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【図２９】

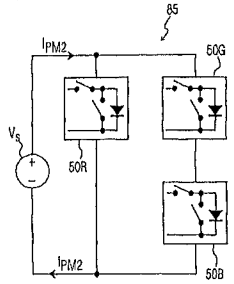


FIG. 29

【国際調査報告】

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/001351

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 201 454 A (NISHIZAWA JUNICHI) 1 September 1988 (1988-09-01) page 22, line 17 - line 18; figures 12-17,19 page 25, line 7 - line 11 page 26, line 7 - line 25 page 28, line 16 - page 29, line 4	1-10
X Y	US 2003/057888 A1 (ANDERSON KEITH ET AL) 27 March 2003 (2003-03-27) paragraph '0041! - paragraph '0044!; figures 5,8,9	1-3,7 5,6,8-10
Y	US 2002/101198 A1 (KEMP WILLIAM HARRY) 1 August 2002 (2002-08-01) page 1, paragraph 2; figure 3	5,6,8-10

-/--

[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

* Special categories of cited documents :

'A' document defining the general state of the art which is not considered to be of particular relevance
'E' earlier document but published on or after the international filing date
'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
'O' document referring to an oral disclosure, use, exhibition or other means
'P' document published prior to the international filing date but later than the priority date claimed

'T' later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
'X' document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
'Y' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
'&' document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 August 2004	12/08/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-- 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Henderson, R

Form PCT/ISA/210 (second sheet) (January 2004)

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB2004/001351

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01/73818 A (HONG SAM PYO) 4 October 2001 (2001-10-04) the whole document	1-10

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB2004/001351

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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			JP	1941250 C	23-06-1995
			JP	6058021 B	03-08-1994
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			WO	0173818 A1	04-10-2001
			US	2004066652 A1	08-04-2004

Form PCT/ISA/210 (patent family annex) (January 2004)

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フロントページの続き

(81)指定国 AP(BW,GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZM,ZW),EA(AM,AZ,BY,KG,KZ,MD,RU,TJ,TM),EP(AT,BE,BG,CH,CY,CZ,DE,DK,EE,ES,FI,FR,GB,GR,HU,IE,IT,LU,MC,NL,PL,PT,RO,SE,SI,SK,TR),OA(BF,BJ,CF,CG,CI,CM,GA,GN,GQ,GW,ML,MR,NE,SN,TD,TG),AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BW,BY,BZ,CA,CH,CN,CO,CR,CU,CZ,DE,DK,DM,DZ,EC,EE,EG,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NA,NI,NO,NZ,OM,PG,PH,PL,PT,RO,RU,SC,SD,SE,SG,SK,SL,SY,TJ,TM,TN,TR,TT,TZ,UA,UG,US,UZ,VC,VN,YU,ZA,ZM,ZW

(74)代理人 100107766
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Ｆターム(参考) 5F041 AA12 AA21 BB03 BB13 BB23 BB25 BB27 BB33

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Espacenet

Bibliographic data: JP2001215913 (A) — 2001-08-10

LIGHTING CIRCUIT

No documents available for this priority number.

Inventor(s): TAKAHASHI JUN; KOGA TOMOYUKI ± (TAKAHASHI JUN, ; KOGA TOMOYUKI)

Applicant(s): TOKO INC ± (TOKO INC)

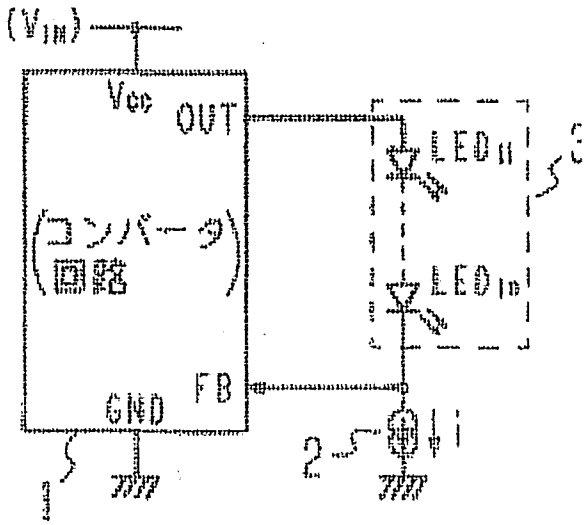
Classification: - international: ***G09G3/14; G09G3/20; G09G3/32; H01L33/00; H02M3/155; H05B37/02;*** (IPC1-7): G09G3/14; H01L33/00; H02M3/155; H05B37/02

- cooperative:

Application number: JP20000027099 20000204

Priority number (s): JP20000027099 20000204

Abstract of JP2001215913 (A)



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PROBLEM TO BE SOLVED: To provide a
lighting circuit capable of making a constant
current flow through light emitting diodes and the value of the current correctly and easily
SOLUTION: A constant current circuit 2 is connected in series with a light emitting unit 3 consisting of light emitting diodes LED11 to LED1n. The DC power is supplied from a converter circuit 1 to the series circuit of the light emitting unit 3 and the constant current circuit 2 while controlling its output voltage so that the voltage across terminals of the circuit 2 becomes constant. In constitution like this, a current i passing through the unit 3 and the circuit 2 is held at a constant value by the current stabilizing action of the inside of the circuit 2. As a result, the current passing through the unit 3 is hardly affected by ripples of the output voltage of the circuit 1 and ambient temperatures as compared with a case that a resistance R1 is used.

Last updated: 13.03.2013 Worldwide Database 5.8.11.4; 93p

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(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2001－215913
(P2001－215913A)
(43)公開日　平成13年８月10日(2001.8.10)

(51)Int.Cl.⁷	識別記号	ＦＩ		テーマコード(参考)
Ｇ０９Ｇ　3/14		Ｇ０９Ｇ　3/14	Ｊ	３Ｋ０７３
Ｈ０１Ｌ　33/00		Ｈ０１Ｌ　33/00	Ｊ	５Ｃ０８０
Ｈ０２Ｍ　3/155		Ｈ０２Ｍ　3/155	Ｊ	５Ｆ０４１
			Ｆ	５Ｈ７３０
Ｈ０５Ｂ　37/02		Ｈ０５Ｂ　37/02	Ｊ	

審査請求　未請求　請求項の数６　ＯＬ　（全９頁）

(21)出願番号　特願2000－27099(P2000－27099)

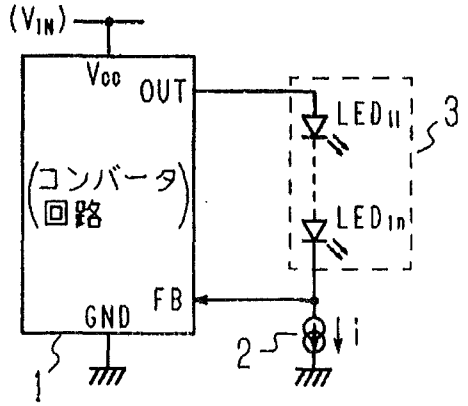
(22)出願日　平成12年２月４日(2000.2.4)

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(74)代理人　100073737
弁理士　大田　優

最終頁に続く

(54)【発明の名称】　点灯回路

(57)【要約】
【課題】　発光ダイオードに安定した電流を流すことができ、しかもその電流値を正確かつ容易に設定することが可能な点灯回路を提供する。
【解決手段】　発光ダイオードＬＥＤ$_{11}$～ＬＥＤ$_{1n}$からなる発光ユニット３に定電流回路２を直列接続する。当該発光ユニット３と定電流回路２の直列回路に対して、コンバータ回路１から、定電流回路２の端子間電圧が一定になるよう出力電圧を制御しながら直流電力を供給する。このような構成では、発光ユニット３と定電流回路２を通過する電流ｉは定電流回路２の内部の電流安定化作用により一定の値に保持される。このため発光ユニット３を通過する電流は、抵抗Ｒ１を使用した時に比べてコンバータ回路１の出力電圧のリップルや周囲温度の影響をほとんど受けないものとなる。



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【特許請求の範囲】

【請求項１】　少なくとも１つの発光ダイオードからなる発光ユニットに対し、該発光ダイオードが点灯するのに必要な直流電力を供給する点灯回路において、

該発光ユニットに対して直列に接続される定電流回路と、

該定電流回路の端子間電圧が一定になるよう出力電圧を制御しながら、該発光ユニットと該定電流回路の直列回路に直流電力を供給するコンバータ回路とを具備することを特徴とする点灯回路。

【請求項２】　前記定電流回路は、

電流源と、

該電流源にその主電流路が直列に接続された第１のトランジスタと、

前記発光ユニットにその主電流路が直列に接続され、該第１のトランジスタの制御端子にその制御端子が接続された第２のトランジスタとを具備することを特徴とする、請求項１に記載した点灯回路。

【請求項３】　前記定電流回路は、

前記発光ユニットに直列接続された第３のトランジスタと、

該発光ユニットを流れる電流に応じて該第３のトランジスタの導通状態を制御する誤差増幅器とを具備することを特徴とする、請求項１に記載した点灯回路。

【請求項４】　前記コンバータ回路は、前記定電流回路の端子間電圧を、該定電流回路が所定の大きさの電流を安定的に流すことができるサチレーション電圧以上の電圧値に保持することを特徴とする、請求項１から請求項３のいずれかに記載した点灯回路。

【請求項５】　複数の発光ダイオードを直列接続してなるダイオード列を複数並設した発光ユニットに対して、該発光ダイオードが点灯するのに必要な直流電力を供給する点灯回路において、

電流源と、該電流源にその主電流路が直列に接続された第１のトランジスタと、該発光ユニットの各ダイオード列にそれぞれ主電流路が接続され、該第１のトランジスタの制御端子に各制御端子が接続された複数個の第２のトランジスタとを有する定電流回路と、

所定のダイオード列と第２のトランジスタの接続点の電圧を検出し、該所定の第２のトランジスタの主電流路の端子間電圧が一定になるよう出力電圧を制御しながら、それぞれのダイオード列と第２のトランジスタの直列回路に直流電力を供給するコンバータ回路とを具備することを特徴とする点灯回路。

【請求項６】　前記コンバータ回路は、前記所定の第２のトランジスタの主電流路の端子間電圧を、該所定の第２のトランジスタが所定の大きさの電流を安定して流すことのできるサチレーション電圧以上の電圧値に保持することを特徴とする、請求項５に記載した点灯回路。

【発明の詳細な説明】

2

【０００１】

【発明の属する技術分野】本発明は、発光ダイオードを定電流で駆動し、発光ユニットを安定して点灯させるための点灯回路の改良技術に関する。

【０００２】

【従来の技術】発光ダイオードを点灯させた時、その発光輝度は電流の大きさに依存する。このため、発光ダイオードに安定して点灯させるには、発光ダイオードを定電流にて駆動することが望ましい。図７には、発光ダイオードを定電流駆動するよう構成された点灯回路の、従来の一例の回路図を示した。図７に示す回路は以下のような構成としている。チョークコイルＬ１の一端を電源供給点（V_{IN}）に接続し、チョークコイルＬ１の他端をＮＰＮ型のスイッチングトランジスタＱ１のコレクタに接続する。スイッチングトランジスタＱ１のコレクタにダイオードＤ１のアノードを接続し、ダイオードＤ１のカソードをコンデンサＣ１を介してグランドに接続する。

【０００３】スイッチングトランジスタＱ１のエミッタはグランドに接続し、ベースは制御回路ＤＲ１に接続する。制御回路ＤＲ１はさらに誤差増幅器ＥＡ１の出力側と接続し、誤差増幅器ＥＡ１の２つある入力側のうちの第１の入力側は基準電圧源V_{ref}を介してグランドに接続する。このチョークコイルＬ１、スイッチングトランジスタＱ１、ダイオードＤ１、コンデンサＣ１、制御回路ＤＲ１、誤差増幅器ＥＡ１および基準電圧源V_{ref}によりコンバータ回路１ａが構成されている。複数の発光ダイオードLED_{11}～LED_{1n}を全て直列に接続し、発光ユニット３を構成する。この発光ユニット３に抵抗Ｒ１を直列に接続し、この直列接続された発光ユニット３と抵抗Ｒ１をコンバータ回路１ａのコンデンサＣ１に対して並列に接続する。そして、発光ユニット３と抵抗Ｒ１の接続点を誤差増幅器ＥＡ１の２つある入力側のうちの第２の入力側に接続する。

【０００４】以上のような構成の回路では、先ず、スイッチングトランジスタＱ１が制御回路ＤＲ１からの駆動信号に応じてオン、オフ動作を繰り返し、電流を断続する。スイッチングトランジスタＱ１がオン状態からオフ状態に転換した時、チョークコイルＬ１に逆起電圧が発生し、入力電圧V_{IN}と逆起電圧による電圧値の高い合成電圧がダイオードＤ１のアノードの位置に現れる。するとダイオードＤ１を介してコンデンサＣ１に充電電流が流入し、コンデンサＣ１の端子間に入力電圧V_{IN}より高い電圧が出現する。このコンデンサＣ１の端子間電圧がコンバータ回路１ａの出力電圧として直列接続された発光ユニット３と抵抗Ｒ１に供給される。これにより発光ユニット３の各発光ダイオードLED_{11}～LED_{1n}に電流が流れ、各発光ダイオードLED_{11}～LED_{1n}が点灯する。

【０００５】ここで図７の回路では、誤差増幅器ＥＡ１

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の第１の入力側は基準電圧源V_{ref}を介してグランドに接続されている。一方、誤差増幅器ＥＡ１の第２の入力側は抵抗Ｒ１を介してグランドに接続された形となっている。このため図７の回路のコンバータ回路１ａは、抵抗Ｒ１の端子間電圧と基準電圧V_{ref}がほぼ等しくなるよう、スイッチングトランジスタＱ１のオン、オフ期間を変化させ、その出力電圧であるコンデンサＣ１の端子間電圧を制御する。例えば、図７の回路が定常運転状態に有り、抵抗Ｒ１の端子間電圧がほぼ基準電圧V_{ref}に等しい電圧値に保持されているものとする。この時、抵抗Ｒ１を流れる電流I_Rは、ほぼ（V_{ref}／Ｒ１）で一定となる。発光ユニット３は抵抗Ｒ１に直列接続されているため、発光ユニット３を流れる電流は抵抗Ｒ１を流れる電流I_Rと等しくなる。これにより、発光ユニット３を構成する各発光ダイオードLED_{11}～LED_{1n}は定電流にて駆動されることになる。

【０００６】周知のように、発光ダイオードに電流を流すと、その端子間には順方向電圧が現れる。複数個の発光ダイオードを直列に接続すると、当然、発光ダイオードを点灯するために発光ユニット３の両端に印加するべき電圧も高くなってしまう。しかし、実際に使用される素子の耐圧性能や回路の絶縁などの観点からすると、コンバータ回路１ａの出力電圧をあまり高い値にすることは望ましくない。このため、数多くの発光ダイオードを同時に点灯しなければならない場合には、図８に示すようにｎ個の発光ダイオードを直列接続した発光ダイオード列をｍ列配置し、発光ユニット３ａを形成する。これならば、ｎ×ｍ個の発光ダイオードを点灯する際にも、発光ユニット３ａに印加すべき電圧は発光ダイオードｎ個の順方向電圧の合計値以上で済み、コンバータ回路１ａの出力電圧の低電圧化を図ることができる。

【０００７】なお、ｎ個の発光ダイオードを直列接続した発光ダイオード列をｍ列配置し、発光ユニット３ａを形成した場合、第１列目から第ｍ列目の各発光ダイオード列には、それぞれ抵抗Ｒ１～Ｒｍが直列に接続される。そして、特定の発光ダイオード列と抵抗の接続点、具体的には第１列目の発光ダイオード列LED_{11}～LED_{1n}と抵抗Ｒ１との接続点がコンバータ回路１ａの誤差増幅器ＥＡ１の第２の入力側に接続されることになる。

【０００８】

【発明が解決しようとする課題】図７の点灯回路は、コンバータ回路１ａと、発光ユニット３に直列接続した抵抗Ｒ１とにより、簡易な構成で発光ダイオードの定電流駆動を実現している。ところで、図７では、コンバータ回路１ａがスイッチングレギュレータの形態となっている。スイッチングレギュレータは、シリーズレギュレータに比べて回路の効率は高いものの、そのフィードバック制御作用とスイッチング動作の関係に起因して、出力電圧にリップルを生じることが避けられない。このため図７の回路では抵抗Ｒ１の両端に現れる電圧にリップルが生じ、電圧のリップルに伴って発光ユニット３を流れる電流にもリップルが生じるといった問題があった。

【０００９】また、発光ダイオード素子の製品毎の順方向電圧のばらつきは、各種電子素子の特性値のばらつきの中でも最も大きい部類に属する。このため、図８に示すような構成として数多くの発光ダイオードを点灯させようとした場合、各発光ダイオードLED_{11}～LED_{mn}の順方向電圧値のばらつきによって、第１から第ｍの各発光ダイオード列の列毎の順方向電圧の合計値にも大きなばらつきが生じる。こうなると、製品毎に第１列から第ｍ列の各発光ダイオード列を流れる電流の値を厳密に設定することは不可能となり、例えば、抵抗Ｒ１～Ｒｍの各抵抗値を同一に設定し、かつ、各列毎の発光ダイオードの直列数を同じにしても、第１列から第ｍ列の各発光ダイオード列を流れる電流の値を全て同一にすることは困難であった。

【００１０】これに加え、周囲温度の変化などによって発光ダイオードLED_{11}～LED_{mn}の順方向電圧の値が変化すると、フィードバック制御がなされていない第１列目以外の各発光ダイオード列を通過する電流の値が本来の設定値から変化してしまう、などの問題もあった。そこで本発明は、発光ダイオードに安定した電流を流すことができ、しかもその電流値を正確かつ容易に設定することが可能な点灯回路を提供することを目的とした。

【００１１】

【課題を解決するための手段】上記課題を解決するための本発明による点灯回路は、少なくとも１つの発光ダイオードからなる発光ユニットに対し、当該発光ダイオードが点灯するのに必要な直流電力を供給する点灯回路において、発光ユニットに対して直列に接続される定電流回路と、定電流回路の端子間電圧が一定になるよう出力電圧を制御しながら、発光ユニットと定電流回路の直列回路に直流電力を供給するコンバータ回路とを具備することを特徴とする。

【００１２】ここで具体的には、電流源と、電流源にその主電流路が直列に接続された第１のトランジスタと、発光ユニットにその主電流路が直列に接続され、第１のトランジスタの制御端子にその制御端子が接続された第２のトランジスタとによって定電流回路を構成する。あるいは、発光ユニットに直列接続された第３のトランジスタと、発光ユニットを流れる電流に応じて第３のトランジスタの導通状態を制御する誤差増幅器とによって定電流回路を構成する。コンバータ回路については、定電流回路の端子間電圧を、定電流回路が所定の値の電流を安定して流すことのできるサチレーション電圧以上の電圧値に保持するよう構成するものとする。

【００１３】

【発明の実施の形態】少なくとも１つの発光ダイオード

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からなる発光ユニットに定電流回路を直列接続する。そして、当該発光ユニットと定電流回路の直列回路に対して、コンバータ回路から、定電流回路の端子間電圧が一定になるよう出力電圧を制御しながら直流電力を供給する。ここで、駆動電圧供給点とグランドとの間に電流源と第１のトランジスタの主電流路を直列接続し、第１のトランジスタの主電流路の一端と制御端子とを接続する。第１のトランジスタの制御端子に第２のトランジスタの制御端子を接続し、第２のトランジスタの主電流路を発光ユニットと直列状態でコンバータ回路とグランドとの間に接続する。この電流源と第１および第２のトランジスタによって定電流回路を構成するものとする。コンバータ回路についてはスイッチングレギュレータを使用し、コンバータ回路の出力検出端子を発光ユニットと定電流回路の接続点に接続する。

【００１４】別の実施の形態では、第３のトランジスタの主電流路と抵抗と発光ユニットを直列状態でコンバータ回路とグランドとの間に接続する。第３のトランジスタの制御端子に誤差増幅器の出力側を接続し、誤差増幅器の２つある入力側のうちの第１の入力側を前記抵抗の第３のトランジスタ側の一端に接続する。誤差増幅器の第２の入力側は前記抵抗の第３のトランジスタとは逆側の他端に、基準電圧源を介して接続する。この第３のトランジスタ、誤差増幅器、抵抗および基準電圧源によって定電流回路を構成するものとする。コンバータ回路についてはスイッチングレギュレータを使用し、コンバータ回路の出力検出端子を発光ユニットと定電流回路の接続点に接続する。

【００１５】さらに別の実施の形態では、ｎ×ｍ個の発光ダイオードを各々ｎ個ずつ直列接続し、これによって得られたｍ個の発光ダイオード列を並列に配置し、発光ユニットを構成する。ここで、駆動電圧供給点とグランドとの間に電流源と第１のトランジスタの主電流路を直列接続し、第１のトランジスタの主電流路の一端と制御端子とを接続する。第１のトランジスタの制御端子に対し、発光ダイオード列と同数のｍ個の第２のトランジスタのそれぞれの制御端子を接続する。この電流源と第１のトランジスタ、ｍ個の第２のトランジスタによって定電流回路を構成する。発光ユニットと定電流回路の、それぞれ対応する発光ダイオード列と第２のトランジスタを各１づつ直列に接続し、こうして得られたｍ個の発光ダイオード列と第２のトランジスタの直列回路をコンバータ回路とグランドとの間に並列に接続する。コンバータ回路にはスイッチングレギュレータを使用し、コンバータ回路の出力検出端子を所定の発光ダイオード列と第２のトランジスタの接続点に接続する。

【００１６】

【実施例】本発明の点灯回路の基本概念は、電圧変化や周囲温度変化が生じても流通電流の設定値が変化しない安定度の高い電流の流通手段と、発光ダイオードと電流の流通手段が動作する上で必要な電圧を確保すると同時に、その電圧の安定化によって副次的に電流の安定化に寄与する直流電力の供給手段とを組み合わせることにある。図１はこの基本概念に基づく点灯回路を示している。図１に示す点灯回路は、複数の発光ダイオードLED_{11}～LED_{1n}からなる発光ユニット３に対して定電流回路２を接続し、この発光ユニット３と定電流回路２の直列回路に対してコンバータ回路１の出力端子ＯＵＴを接続する。発光ユニット３と定電流回路２の接続点をコンバータ回路１の出力検出端子ＦＢに接続し、コンバータ回路１の電源端子V_{CC}とグランド端子ＧＮＤをそれぞれ電源供給点（V_{IN}）とグランドに接続した構成となっている。

【００１７】以上のような図１の点灯回路では、先ず、コンバータ回路１が定電流回路２の端子間電圧が一定になるように出力電圧を制御する。定電流回路２は、リップルによる変動が多少有るものの、安定化された電圧の供給を受け、通過する電流ｉの値が一定になるよう電流制御を行う。これにより発光ユニット３を通過する電流は一定になり、各発光ダイオードLED_{11}～LED_{1n}は定電流駆動される。ここで、発光ユニット３と定電流回路２を通過する電流ｉは定電流回路２の内部の電流安定化作用により一定の値に保持される。このため発光ユニット３を通過する電流は、抵抗Ｒ１を使用した時に比べてコンバータ回路１の出力電圧のリップルや周囲温度の影響をほとんど受けないものとなる。

【００１８】図２は本発明の点灯回路の第１の実施例の回路図であり、図１の概念をより具体化したものである。すなわち、チョークコイルＬ１、スイッチングトランジスタＱ１、ダイオードＤ１、コンデンサＣ１、制御回路ＤＲ１、誤差増幅器ＥＡ１および基準電圧源V_{ref}により、図７と同じコンバータ回路１ａを構成する。複数の発光ダイオードLED_{11}～LED_{1n}を直列に接続し、発光ユニット３を構成する。発光ユニット３に定電流回路２ａを直列に接続し、この直列接続された発光ユニット３と定電流回路２ａをコンデンサＣ１に対して並列に接続する。そして、発光ユニット３と定電流回路２ａの接続点を、コンバータ回路１ａの出力検出端子としての誤差増幅器ＥＡ１の第２の入力側に接続する。

【００１９】ここで定電流回路２ａについては以下のような回路構成とする。駆動電圧の供給点（V_D）を電流源ＣＳ１を介してＮＰＮ型のトランジスタＱ２のコレクタに接続し、トランジスタＱ２のエミッタをグランドに接続する。トランジスタＱ２のコレクタ、ベース間を短絡し、トランジスタＱ２のベースにＮＰＮ型のトランジスタＱ３のベースを接続する。トランジスタＱ３のエミッタをグランドに接続し、トランジスタＱ３のコレクタを発光ユニット３に接続する。このような構成の回路では、コンバータ回路１ａが動作し、コンデンサＣ１の端

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子間電圧がコンバータ回路１ａの出力電圧として発光ユニット３と定電流回路２ａの直列回路に供給される。なお、コンバータ回路１ａの動作については図７の回路と同じである。

【００２０】定電流回路２ａはトランジスタＱ２とＱ３の接続構成によってカレントミラー定電流回路の形態となっている。このためトランジスタＱ３の主電流路には、トランジスタＱ２の主電流路を通過する電流と各トランジスタＱ２とＱ３のエミッタ面積比によって決定される電流が流れる。トランジスタＱ２とＱ３のカレントミラー動作の結果として得られるこの電流は、周囲温度やトランジスタＱ３のコレクタに印加される電圧の変動に対して安定度の高いものとなる。勿論、コンバータ回路１ａの出力電圧としてのコンデンサＣ１の端子間電圧に多少のリップルが含まれていても電流の安定度にほとんど影響は無い。したがって、発光ユニット３を構成する各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{1n}$ は、トランジスタＱ３の主電流路を通過する安定度の高い電流によって定電流駆動されることになる。

【００２１】図３には本発明の点灯回路の第２の実施例の回路図を示した。図２に示す回路では、ｎ個全ての発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{1n}$ を直列接続し、発光ユニット３を構成していた。これに対して図３の回路では、ｎ×ｍ個の発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ をｎ個ずつ直列接続し、これによって得られたｍ個の発光ダイオード列を並列に配置し、発光ユニット３ａを構成している。このような構成の発光ユニット３ａに対応するため、図３の回路では、駆動電圧の供給点（Ｖ$_D$）に接続された電流源ＣＳ１と、電流源ＣＳ１にそのコレクタとベースとが接続されたＮＰＮ型のトランジスタＱ１０と、トランジスタ１０のベースにそのベースが接続されたｍ個のトランジスタＱ１１～Ｑ１ｍによって定電流回路２ｂを構成している。

【００２２】そして、例えば第１列目の発光ダイオード列（ＬＥＤ$_{11}$ ～ＬＥＤ$_{1n}$ ）にはトランジスタＱ１１の主電流路を接続する、第２列目の発光ダイオード列（ＬＥＤ$_{21}$ ～ＬＥＤ$_{2n}$ ）にはトランジスタＱ１２の主電流路を接続する、というように、発光ユニット３ａのｍ列有る発光ダイオード列のそれぞれに、１つづつ定電流回路２ｂのトランジスタＱ１１～Ｑ１ｍの主電流路を接続する。このようにして接続された発光ユニット３ａと定電流回路２ｂをコンバータ回路１ａのコンデンサＣ１に並列に接続する。第１列目の発光ダイオード列（ＬＥＤ$_{11}$ ～ＬＥＤ$_{1n}$ ）とトランジスタＱ１１の主電流路の接続点を、コンバータ回路１ａ内に設けられた誤差増幅器ＥＡ１の出力検出端子としての第２の入力側に接続する。なお、コンバータ回路１ａの構成は図２、図７の回路と同一とする。

【００２３】このような図３の回路では、定電流回路２ｂのトランジスタＱ１０とトランジスタＱ１１～Ｑ１ｍがそれぞれカレントミラー回路を構成し、トランジスタＱ１１～Ｑ１ｍの各主電流路にはカレントミラー動作による安定度の高い電流が流れる。これに伴って発光ユニット３ａを構成する第１から第ｍの各発光ダイオード列にもカレントミラー動作による安定度の高い電流が流れ、各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ は定電流駆動される。解決すべき課題の項の中でも述べているように、各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ の順方向電圧値のばらつきによって第１から第ｍの各発光ダイオード列の順方向電圧の合計値がかなり異なってしまうことがある。

【００２４】しかしカレントミラー回路においては、第２のトランジスタの主電流路を流れる電流は、第１と第２のトランジスタのエミッタ面積の比率と、コレクタ、エミッタ間が接続された第１のトランジスタの主電流路を流れる電流の大きさによってほぼ決定される。ここで、図３中のトランジスタＱ１０が第１のトランジスタ、トランジスタＱ１１～Ｑ１ｍが第２のトランジスタに相当する。このため、各トランジスタＱ１１～Ｑ１ｍの主電流路を通過するそれぞれの電流の値は、実質的に、各発光ダイオード列の順方向電圧の合計値の影響を受けない。その結果、各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ の順方向電圧値にばらつきがあっても、トランジスタＱ１０～Ｑ１ｍと電流源ＣＳ１の設定次第で、容易に希望する値に設定することが可能となる。

【００２５】また、従来の回路では、その出力電圧、すなわちコンデンサＣ１の端子間電圧を安定化し、間接的に、第１から第ｍの各発光ダイオード列を通過する電流の安定化を図っていた。このような間接的な電流の安定化では、フィードバック制御がなされていない第１列目以外の各発光ダイオード列を通過する電流の値が、各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ の順方向電圧の変化に伴って変わってしまう、という問題があった。しかし図３の回路では、第１から第ｍの各発光ダイオード列を通過する電流の安定化は、各発光ダイオード列に直列に接続されたトランジスタＱ１１～Ｑ１ｍのカレントミラー動作によって直接的に行われる。このため、仮に、周囲温度の変化によって各発光ダイオードＬＥＤ$_{11}$ ～ＬＥＤ$_{mn}$ の順方向電圧値が変化しても、フィードバック制御がなされていない第１列目以外の各発光ダイオード列を通過する電流の値が変化するということは無くなる。

【００２６】なお、図３の回路では、コンバータ回路１ａのフィードバック制御は、定電流回路２ｂの端子間電圧を、カレントミラー回路が安定的に動作できるサチレーション電圧以上の値で安定化するために行われる。この定電流回路２ｂの端子間電圧を安定化することにより定電流回路２ｂでのカレントミラー動作がほぼ一定の状態で行われるようにする。そして、入力電圧や各発光ダイオード列の列毎の順方向電圧の合計値が変化した場合

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にも定電流回路２ｂの動作と各発光ダイオードＬＥＤ$_{11}$～ＬＥＤ$_{mn}$の発光状態が不安定化することを防止する。話が前後するが、図２の回路もこれに同じである。

【００２７】図４には本発明の点灯回路の第３の実施例の回路図を示した。この図４に示す回路は、チョークコイルＬ１、スイッチングトランジスタＱ１、ダイオードＤ１、コンデンサＣ１、制御回路ＤＲ１、誤差増幅器ＥＡ１および基準電圧源V_{ref}によりコンバータ回路１ｂを構成する。なお、図２、図７のコンバータ回路１ａでは、誤差増幅器ＥＡ１の第１の入力側は基準電圧源V_{ref}を介してグランドに接続されていた。これに対し、図４のコンバータ回路１ｂでは、誤差増幅器ＥＡ１の第１の入力側は基準電圧源V_{ref}を介してコンデンサＣ１とダイオードＤ１の接続点に接続する。その他のコンバータ回路１ｂの回路部分については図２、６のコンバータ回路１ａと同一である。

【００２８】複数の発光ダイオードＬＥＤ$_{11}$～ＬＥＤ$_{1n}$を直列に接続し、発光ユニット３を構成する。発光ユニット３に定電流回路２ｃを直列に接続し、この直列接続された発光ユニット３と定電流回路２ｃを、発光ユニット３がグランド側となるようにコンバータ回路１ｂのコンデンサＣ１に対して並列に接続する。ここで、コンバータ回路１ｂのコンデンサＣ１とダイオードＤ１の接続点にＰＮＰ型のトランジスタＱ４とＱ５の各エミッタを接続し、トランジスタＱ４とＱ５の各ベースを共通接続する。トランジスタＱ４のコレクタは電流源ＣＳ２を介してグランドに接続し、トランジスタＱ５のコレクタは発光ユニット３に接続する。トランジスタＱ４のコレクタ、ベース間を接続し、このトランジスタＱ４、Ｑ５および電流源ＣＳ２により定電流回路２ｃを構成する。

【００２９】この図４の回路は、実質的に、図２の回路の発光ユニット３と定電流回路２ａの接続位置を逆にするよう構成したものであり、その概略の動作は図２の回路とほぼ同じになる。そして、図４においても、発光ユニット３を通過する電流の安定化は定電流回路２ｃのカレントミラー動作によって行われる。また、図４のコンバータ回路１ｂのフィードバック制御は、定電流回路２ｃの端子間電圧をカレントミラー回路のサチレーション電圧以上の値で安定化するために行われる。ちなみに、図４の回路では、発光ユニット３の一端がグランドに接続された回路形態となっている。配線基板上ではグランドの導体パターンは至る所に配置されている。このため、図４の回路は図２の回路に比べて発光ユニット３を配線基板上に配置する上で自由度が高いという利点がある。

【００３０】図５には本発明の点灯回路の第４の実施例の回路図を示した。今まで説明した図２から図４の中に示されたコンバータ回路（１ａ、１ｂ）は昇圧チョッパ型のコンバータの構成であった。これに対して図５のコンバータ回路１ｃは降圧チョッパ型のコンバータの構成となっている。すなわち、ＰＮＰ型のスイッチングトランジスタＱ６のエミッタを電源供給点（V_{IN}）に接続し、そのコレクタをチョークコイルＬ２の一端に接続する。チョークコイルＬ２の一端には、アノードがグランドに接続されたダイオードＤ２のカソードを接続し、チョークコイルＬ２の他端には、他端がグランドに接続されたコンデンサＣ２の一端を接続する。

【００３１】スイッチングトランジスタＱ６のベースは制御回路ＤＲ２に接続する。制御回路ＤＲ２はさらに誤差増幅器ＥＡ２の出力側と接続し、誤差増幅器ＥＡ２の２つある入力側のうちの第１の入力側とグランドの間に基準電圧源V_{ref}を接続する。このスイッチングトランジスタＱ６、チョークコイルＬ２、ダイオードＤ２、コンデンサＣ２、制御回路ＤＲ２、誤差増幅器ＥＡ２および基準電圧源V_{ref}によりコンバータ回路１ｃを構成する。発光ユニット３と定電流回路２ａを直列に接続し、この直列接続された発光ユニット３と定電流回路２ａをコンデンサＣ２に対して並列に接続する。そして、発光ユニット３と定電流回路２ａの接続点を誤差増幅器ＥＡ２の２つある入力側のうちの第２の入力側に接続する。なお、発光ユニット３と定電流回路２ａの構成は図２の回路と同一である。

【００３２】このような構成とした図５の回路は、コンバータ回路１ｃが降圧型のため、入力電圧V_{IN}が発光ユニット３を構成する発光ダイオードＬＥＤ$_{11}$～ＬＥＤ$_{1n}$の順方向電圧の合計値よりもはるかに高い場合に使用される。ここで、コンバータ回路１ｃは、スイッチングトランジスタＱ６が制御回路ＤＲ２からの駆動信号に応じてオン、オフ動作を繰り返し、電流を断続する。トランジスタＱ６を通過したパルス状の電流を、チョークコイルＬ２とダイオードＤ２とコンデンサＣ２によって平滑し、直流に変換する。この時、コンデンサＣ２の端子間に生じた電圧をコンバータ回路１ｃの出力電圧として発光ユニット３と定電流回路２ａに供給する。

【００３３】図２と図５の回路は、それぞれ定電流回路２ａと発光ユニット３の回路構成が同一であるため、定電流回路２ａの動作と作用も同じものとなる。したがって、図５の回路においても発光ユニット３を通過する電流の安定化は定電流回路２ａのカレントミラー動作によって行われる。また、図５のコンバータ回路１ｃのフィードバック制御は、定電流回路２ａの端子間電圧をカレントミラー回路のサチレーション電圧以上の値で安定化するために行われることになる。

【００３４】図６には本発明の点灯回路の第５の実施例の回路図を示した。図２から図６の各回路では、定電流回路をカレントミラー回路を使用して構成していた。これに対して図５の回路では、誤差増幅器ＥＡ３を使用して定電流回路２ｄを構成している。すなわち、発光ユニ

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ット３にＮＰＮ型のトランジスタＱ７のコレクタを接続し、トランジスタＱ７のエミッタを抵抗ＲＤを介してグランドに接続する。誤差増幅器ＥＡ３を設け、誤差増幅器ＥＡ３の出力側をトランジスタＱ７のベースに接続する。誤差増幅器ＥＡ３の２つある入力側のうちの第１の入力側をトランジスタＱ７と抵抗ＲＤの接続点に接続し、第２の入力側を基準電圧源V_{ref2}を介してグランドに接続する。このトランジスタＱ７、抵抗ＲＤ、誤差増幅器ＥＡ３および基準電圧源V_{ref2}により、定電流回路２ｄを構成する。なお、コンバータ回路１ａと発光ユニット３については図２の回路と同じ構成である。

【００３５】このような構成とした図６の回路の場合、定電流回路２ｄの内部では、抵抗ＲＤの端子間電圧がほぼ基準電圧源V_{ref2}の出力電圧と同じになるよう、誤差増幅器ＥＡ３とトランジスタＱ７が動作する。ここで、抵抗ＲＤの端子間電圧がほぼ基準電圧源V_{ref2}の出力電圧と同じ値に一定に保たれれば、抵抗ＲＤおよびトランジスタＱ７の主電流路を通過する電流は一定となる。これにより、抵抗ＲＤ、トランジスタＱ７の主電流路と直列接続の状態にある発光ユニット３を通過する電流も一定となり、各発光ダイオードLED_{11}～LED_{1n}は定電流にて駆動されることになる。なお、コンバータ回路１ａのフィードバック制御は、今までの回路と同様に、定電流回路２ｄの端子間電圧を、定電流回路２ｄが安定した動作を行うことが可能なサチレーション電圧以上の値で安定化するために行われる。

【００３６】以上の実施例の説明では、コンバータ回路に非絶縁型のスイッチングレギュレータを使用した場合を想定した。しかし、コンバータ回路にトランスによる絶縁型のスイッチングレギュレータを使用しても良い。また、各実施例の回路では、コンバータ回路が誤差増幅器を有し、かつ他励式のものとなっている。しかし、誤差増幅器ＥＡ１、ＥＡ２に代えてエラーコンパレータを使用したコンバータ回路、あるいは自励式のコンバータ回路をなど使用しても構わない。図２、３、４、５の回路では、定電流回路を、第１のトランジスタ（Ｑ２、Ｑ４、Ｑ１０）のコレクタ、ベース間を接続した最も基本的なカレントミラー回路によって構成しているが、ウィルソン型、電流増幅型など、他の形態のカレントミラー回路によって構成しても良い。勿論、定電流回路を構成するトランジスタにバイポーラ型以外のトランジスタ、具体的にはＭＯＳＦＥＴ等、を使用しても構わない。

【００３７】図２、３、５において、定電流回路（２ａ、２ｂ）を構成する電流源ＣＳ１の一端は駆動電源供給点（V_D）に接続することとしている。しかし、定電流回路（２ａ、２ｂ）と発光ユニット（３、３ａ）の接続点の電圧に高い安定度が得られる場合、電流源ＣＳ１の一端は前記接続点に接続しても良い。そして図６においては、定電流回路２ｄに誤差増幅器を用いた最も基本的な定電流回路を使用している。しかし、温度特性を補償した形態のものなど、その回路構成が図６と異なった誤差増幅器型の定電流回路を使用しても良い。実施例として示した回路の変形は、本発明の要旨を変更しない範囲であれば、当然、可能である。

【００３８】

【発明の効果】本発明による点灯回路は、少なくとも１つの発光ダイオードからなる発光ユニットに定電流回路を直列接続する。そして、当該発光ユニットと定電流回路の直列回路に対して、コンバータ回路から、定電流回路の端子間電圧が一定になるよう出力電圧を制御しながら直流電力を供給する構成を特徴としている。このような構成によれば、発光ユニットを構成する各発光ダイオードは、定電流回路内の制御動作によって得られる安定度の高い電流によって定電流駆動される。ここでコンバータ回路は、定電流回路の端子間電圧を、その定電流回路が安定して動作することが可能なサチレーション電圧以上の値で安定化し、入力電圧や直列接続された発光ダイオードの順方向電圧の合計値の変化によって定電流回路の動作と各発光ユニットの発光状態が不安定化することを防止する。

【００３９】また、発光ユニットを通過する電流は、抵抗を使用する従来の回路に比べてコンバータ回路の出力電圧のリップルの影響をほとんど受けないものとなる。そして、発光ダイオードを１列当たりｎ個直列接続してそれを並列にｍ列配置して発光ユニットを構成した場合、各発光ダイオードの順方向電圧値にばらつきがあっても、定電流回路を構成する素子の特性値の設定次第で、容易かつ正確に希望する値に設定することが可能となる。また、周囲温度の変化によって各発光ダイオードの特性値が変化しても、フィードバック制御がなされていない第１列目以外の各発光ダイオード列を通過する電流の値が変化するということも無くなる。従って、本発明によれば、発光ダイオードに安定した電流を流すことができ、しかもその電流値を正確かつ容易に設定できる点灯回路が提供できる。

【図面の簡単な説明】

【図１】　本発明の基本概念に基づく点灯回路のブロック図。

【図２】　本発明による点灯回路の第１の実施例の回路図。

【図３】　本発明による点灯回路の第２の実施例の回路図。

【図４】　本発明による点灯回路の第３の実施例の回路図。

【図５】　本発明による点灯回路の第４の実施例の回路図。

【図６】　本発明による点灯回路の第５の実施例の回路図。

【図７】　従来の一例の点灯回路の回路図。

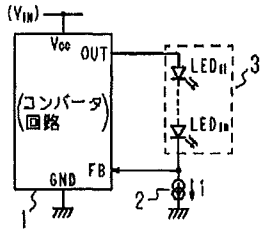
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【図８】　発光ダイオードの数が多い場合における発光ユニットの構成と、発光ユニットと抵抗の接続構成を示す回路図。

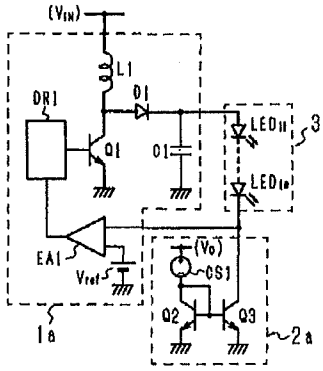
【符号の説明】

１：コンバータ回路　　１ａ～１ｃ：コンバータ回路（具体回路）　　２：定電流回路　　２ａ～２ｄ：＊定電流回路（具体回路）　　３、３ａ：発光ユニット　　ＣＳ１、ＣＳ２：電流源　　Ｑ２、Ｑ１０：トランジスタ（第１のトランジスタ）　　Ｑ３、Ｑ１１～Ｑ１ｍ：トランジスタ（第２のトランジスタ）　　（V_{IN}）：電源供給点　　（V_D）：駆動電圧供給点

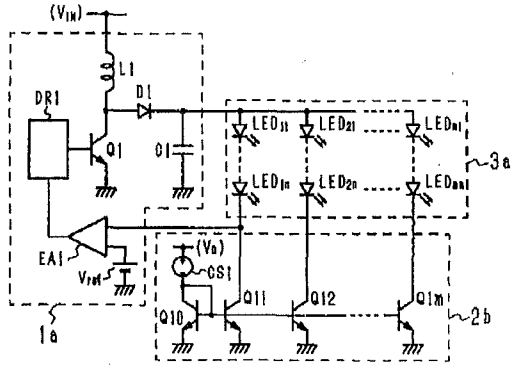
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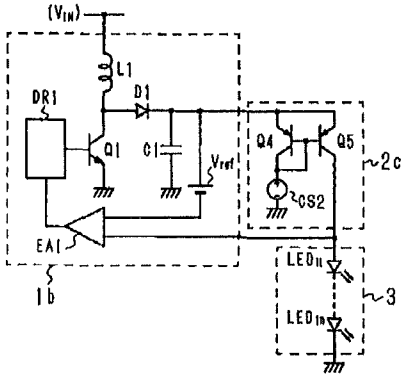
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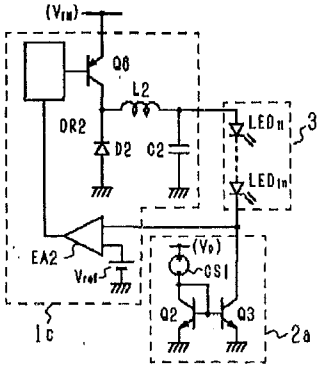
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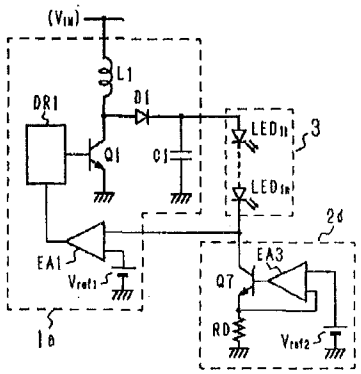
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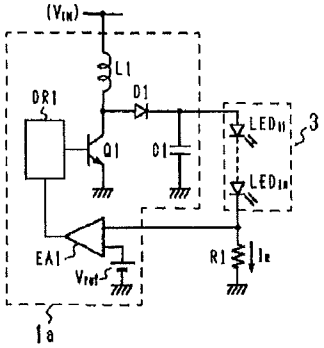
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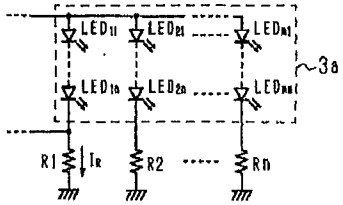
【図６】



【図７】



【図８】



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フロントページの続き

Ｆターム(参考) 3K073 AA12 AA25 AA75 BA09 CG02
CJ17
5C080 AA07 BB03 CC07 DD20 DD30
FF03 FF08 HH14 JJ03 KK52
5F041 BB10 BB23 BB24 BB26 BB32
5H730 AA02 AA14 AS02 BB14 DD02
DD21 DD26 EE18 FD31 FF15
FG01

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Electronic Acknowledgement Receipt

EFS ID:	17349368
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	08-NOV-2013
Filing Date:	17-MAY-2013
Time Stamp:	11:27:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		5308-706TSCT3-Response.pdf	1365581 2c6e18486448dc8338963f4e42ccacd231c4db8d	yes	14

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	14

Warnings:					
Information:					
2		5308-706TSCT3-IDS.pdf	1043228 ee01a4eae95fea34048fb254aade0bbc58cf598b	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2
	Information Disclosure Statement (IDS) Form (SB08)	3	8

Warnings:					
Information:					
3	Foreign Reference	5308-706TSCT3-WO03015476.pdf	2054397 85ef6d505a91dfc20a6c6c00573a16a1f4ea96a7	no	30
Warnings:					
Information:					
4	Foreign Reference	5308-706TSCT3-WO2004100612.pdf	2446517 abce70f439af5e7bf62b52df2502cd292e6411d5	no	26
Warnings:					
Information:					
5	Foreign Reference	5308-703TSCT3-JP2001215913.pdf	1394976 b716851770ad9976eb0b3412a78737138201fb7a	no	11
Warnings:					
Information:					
		Total Files Size (in bytes):	8304699		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/896,977	Filing Date 05/17/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	11/08/2013	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 25	Minus	** 27	=	X $ =	
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/VANESSA BARBER/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

65106 7590 01/13/2014

MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

EXAMINER
A, MINH D

ART UNIT	PAPER NUMBER
2844	

NOTIFICATION DATE	DELIVERY MODE
01/13/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

uspto@myersbigel.com

Office Action Summary	Application No. 13/896,977	Applicant(s) ROBERTS ET AL.	
	Examiner MINH D. A	Art Unit 2844	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *the amendment filed on 11/08/13*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *47-71* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☒ Claim(s) *47-62* is/are allowed.

7)☒ Claim(s) *63-71* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *11/08/13*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

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DETAILED ACTION

This Office Action is a response to Applicant's amendment filed on11/08/13. By virtue of this amendment, claims 1-46 are cancelled and thus, claims 47-71 are currently presented in the instant application.

Double Patenting

1. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of

activities undertaken within the scope of a joint research agreement. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO internet Web site contains terminal disclaimer forms which may be used. Please visit http://www.uspto.gov/forms/. The filing date of the application will determine what form should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

2. Claims 63-71 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 and 15 of U.S. Patent No. 8,203,286. Although the claims at issue are not identical, they are not patentably distinct from each other because the below reasons:

All limitations of claim 63 of instant application are similar all limitations of claims 1 and 15 of Patent application above. The limitations of claim 63 of the instant application are broader or similar to compare with the limitation of claims 1 and 15 of the Patent application above.

Claims 64-71 are also rejected on the ground of nonstatutory double patenting since they are dependent to claim 63.

3. Claims 63-71 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 18-27 of U.S. Patent No. 8,461,776. Although the

claims at issue are not identical, they are not patentably distinct from each other because the below reasons:

All limitations of claim 63 of instant application are similar all limitations of claim 18 of Patent application above. The limitations of claim 63 of the instant application are broader or similar to compare with the limitation of claim 18 of the Patent application above.

Claims 64-71 are also rejected on the ground of nonstatutory double patenting since they are dependent to claim 63.

Claim Rejections - 35 USC § 103

4. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 63-71 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over by Yen (US Patent No: 6,255,786).

Regarding claim 63, Yen discloses light emitting lighting device comprising a PWM logic, a plurality of current drive for each group of LEDs as shown in figure 1.

Yen does not exactly disclose at least first and second strings of solid state lighting devices and at least first and second current supply circuits.

However, a light emitting device of Yen is capable of performing as well, see figure 1, a lighting panel including at least first and second strings of solid state lighting devices (Group 100, 101) that are respectively configured to emit at least a first light and a second light, respectively; at least first and second current supply circuits (current drivers (110 and 111) coupled to the at least first and second strings of solid state lighting devices(100, 111), respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices, a pulse width modulation (PWM) controller(PWM logic(120) that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings. Col.2, lines 1-67 to col.3, lines 1-55.

Regarding claim 64, Yen discloses wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively.

6. Claims 65-71 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over by Yen (US Patent No: 6,255,786) in view of Bruning et al (US Patent No: 6,888,529).

Regarding claims 65-66, Yen does not disclose wherein each of the first and second current supply circuits comprises: **a temperature sensor** that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller and wherein each of the first and second current supply circuits comprises **a sense resistor** that is coupled to an output terminal of the respective one of the first and second current supply circuits and that is coupled to a feedback input to provide the feedback signal to provide closed loop control.

Bruning et al disclose a temperature sensor (28) and a sense resistor (R2-R3) as shown in figure 4.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the light emitting diode lighting device of Yen by employing a sensor temperature and sensor resistor as taught by Bruning et al for the purpose of stabilizing current flow the light emitting didoe, since this configuration for the stated purpose would have been deemed obvious as evidenced by the teaching of Bruning et al.

Regarding claim 67, combination Yen and Bruning et al disclose further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input.

Regarding claim 68, combination Yen and Bruning et al wherein the first string of solid state lighting devices are coated with a wavelength conversion phosphor and are

configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and wherein the second string of solid state lighting devices are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

Regarding claim 69, combination Yen and Bruning et al disclose wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

Regarding claim 70, combination Yen and Bruning et al disclose further comprising a third string of solid state lighting devices that are configured to emit a third light that includes a dominant wavelength corresponding to a red color.

Regarding claim 71, combination Yen and Bruning et al disclose further comprising a third current supply circuit that is configured to supply an on-state drive current to the third string of solid state lighting devices, and wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of current control of the third string of solid state lighting devices provided by the third current supply circuit.

Allowable Subject Matter

7. Claims 47-62 are allowed.

The following is a statement of reasons for the indication of allowable subject matter:

Prior art of record fails to disclose or fairly suggest, alone or in combination, a lighting system, comprising: at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively; at least two current supply circuits coupled to first and second strings of the at least two strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least two strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor and particularly including " a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices" as recited in claim 47 (claims 48-62 would be allowable since they are dependent on claim 47).

Response to Arguments

8. Applicant's arguments filed 11/08/13 have been fully considered but they are not persuasive.

Regarding claims 63-71 are still rejected on the ground of the non-statutory double patenting as being un-patentable over claims 1 and 15 of U.S. Patent No. 8,203,286 and claims 18-27 of U.S. Patent No. 8,461,776.

Conclusion

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Inquiry

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh Dieu A whose telephone number is (571) 272-1817. The examiner can normally be reached on M-F (8:00AM to 5:00PM).
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W Owens can be reached on (571) 272-1662. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published

applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Minh D A/

Primary Examiner

Art Unit 2821

Date 1/7/14

Notice of References Cited	Application/Control No. 13/896,977	Applicant(s)/Patent Under Reexamination ROBERTS ET AL.	
	Examiner MINH D. A	Art Unit 2844	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,255,786	07-2001	Yen, George	315/291
*	B	US-6,888,529	05-2005	Bruning et al.	345/102
	C	US-			
	D	US-			
	E	US-			
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Complete if Known	
				Application Number	13/896,977
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				First Named Inventor	John Roberts
				Art Unit	2821
				Examiner Name	Minh D. A
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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	10	"7872430"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S2	15	"8203286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S3	1	"8461776"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S4	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:50
S5	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S6	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S7	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
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S9	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S10	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:52
S11	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:42
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S13	602	S12 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:44
S14	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
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S16	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2013/08/04 07:45

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S17	34	S13 and S16	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S18	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S19	22	S13 and S18	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S20	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S21	1	S13 and S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S22	859	315/185R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S23	1	S13 and S22	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S24	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S25	1	S13 and S24	US-PGPUB; USPAT; USOCR;	OR	ON	2013/08/04 07:46

			FPRS; EPO; JPO			
S26	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S27	19	S13 and S26	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S28	105675	"315"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S29	165442	"345"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S30	113	S13 and S28	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S31	40	S13 and S29	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S32	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S33	0	S32 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S34	26	S32 and S12	US-PGPUB;	OR	ON	2013/08/04 07:48

			USPAT; USOCR; FPRS; EPO; JPO			
S35	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S36	2386	S35 and (constant near4 (current or voltage) or variable with (boost or buck or bulk))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S37	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S38	26	S37 and S36	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S39	21	S38 and temperature near4 sensor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S40	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:28
S41	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and S40	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:29
S42	32	S41 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:29

S43	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S44	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and S43	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S45	32	S44 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S46	4	S45 and string	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S47	235	(string$1) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
S48	65	S47 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
S49	325	switch$3 near4 regulator same (string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:06
S50	67	switch$3 near4 regulator same (string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting) same inductor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:07
S51	5	S50 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS;	OR	ON	2013/08/04 19:07

			EPO; JPO			
S52	9992	current with circuits same (light with diode$1 or solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3 emitting) and (PWM or pulse)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 09:30
S53	1680	(PWM or pulse with modulation) same current with circuits same (light with diode$1 or solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3 emitting) and (PWM or pulse)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 09:31
S54	1010	(PWM or pulse with modulation) same current near4 circuits same (light with diode$1 or solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3 emitting) and (PWM or pulse)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 09:31
S55	94	S54 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 09:32
S56	43	(PWM or pulse with modulation) same current with circuits same (light with diode$1 or solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3 emitting) same (sensor or detector) same temperature	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:24
S57	12	S56 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:24
S58	90	(group or plurality or array) same current near4 circuit$1 same (solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3 emitting) same (sensor or detector) same temperature	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:47
S59	16	S58 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:48
S60	107	current near4 circuit$1 same (solid near3 state with light$3 or (string$1 or group or plurality)) with (LED$1 or light near3	US-PGPUB; USPAT;	OR	ON	2014/01/07 13:58

		emitting) same (sensor or detector) same temperature	USOCR; FPRS; EPO; JPO			
S61	63	(PWM or pulse with modulation or pulse) and S60	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:59
S62	12	S61 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/01/07 13:59

1/7/2014 4:04:42 PM
C:\Users\ma\Documents\EAST\Workspaces\13896977.wsp

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	Art Unit
	MINH D A	2821

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
315	291, 307, 224, 246, 185R, 200R, 312	8/2/13	MA

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor's name search "East", see serch print out	8/4/13	MA
Test search "East", see search print out	8/2/13	MA
Updated search "East", see search print out	1/7/13	MA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	Art Unit
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013	01/07/2014							
	1	-	-							
	2	-	-							
	3	-	-							
	4	-	-							
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	35	-	-							
	36	-	-							

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013	01/07/2014							
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	68	✓	✓							
	69	✓	✓							
	70	✓	✓							
	71	✓	✓							

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PTO/SB/30 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	13/896,977
Filing Date	May 17, 2013
First Named Inventor	John K. Roberts
Art Unit	2844
Examiner Name	A. Minh D
Attorney Docket Number	5308-706TSCT3

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. ☐ Other _____

   b. ☑ Enclosed

      i. ☑ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☐ Information Disclosure Statement (IDS)

      iv. ☐ Other _____

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 50-0220.

      i. ☑ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other _____

   b. ☐ Check in the amount of $ _____ enclosed

   c. ☐ Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature		Date	June 3, 2014
Name (Print/Type)	Timothy J. Wall	Registration No.	50,743

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the U.S. Patent and Trademark Office on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re: John K. Roberts et al. Confirmation No. 9407
U.S. Serial No. 13/896,977 Examiner: Minh Dieu A
Filing Date: May 17, 2013 Group Art Unit: 2821
For: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Date: June 3, 2014

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT ACCOMPANYING REQUEST FOR CONTINUED EXAMINATION

Sir:

Prior to examination of this application, please enter the following amendment. This amendment accompanies a Request for Continued Examination (RCE) to address the issues raised in the Final Office Action mailed January 13, 2014 regarding the above-referenced patent application. Please amend this application as follows and reconsider the rejections of the claims for at least the reasons presented in the following remarks.

If any extension of time for the accompanying response or submission is required, Applicants request that this be considered a petition therefor. The Commissioner is hereby authorized to charge any additional fee, which may be required, or credit any refund, to our Deposit Account No. 50-0220.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 8 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1-46. (Canceled)

47. (Previously presented) A lighting system, comprising:

at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least two current supply circuits coupled to first and second strings of the at least two strings, respectively, each of the current supply circuits configured to supply an on-state drive current to a respective string of the at least two strings of solid state lighting devices in response to at least one control signal generated in response to a sensor output signal generated by at least one temperature sensor, each of the current supply circuits comprising:

a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and

first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices.

48. (Previously presented) The lighting system according to Claim 47, further comprising a sense resistor coupled to the second output terminal of ones of the current supply circuits.

49. (Previously presented) The lighting system according to Claim 48,

wherein the controller further comprises a feedback input coupled to the sense resistor, and

wherein the controller is configured to activate the second control signal in response to a feedback signal received on the feedback input.

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50. (Previously presented) The lighting system according to Claim 47, wherein the controller comprises a closed loop control system that is configured to generate the first and second PWM control signals in response to the sensor output signals generated by the at least one temperature sensor.

51. (Previously presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

52. (Previously presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a voltage input terminal, and a control input terminal.

53. (Previously presented) The lighting system according to Claim 47, wherein ones of the at least two current supply circuits comprise a charging inductor coupled to the voltage input terminal and an output capacitor coupled to the first output terminal.

54. (Previously presented) The lighting system according to Claim 53, wherein the ones of the at least two current supply circuits are each configured to operate in continuous conduction mode in which current continuously flows through the charging inductor while the on-state drive current is supplied to the first and second strings, respectively.

55. (Previously presented) The lighting system according to Claim 53, wherein each of the current supply circuits comprises:

a rectifier having an anode coupled to the charging inductor and a cathode coupled to the output capacitor; and

a first control transistor coupled to the anode of the rectifier and having a control terminal coupled to the first control output of the controller,

wherein the first control transistor is configured to cause the charging inductor to be energized in response to the first PWM control signal from the controller and to cause energy

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stored in the charging inductor to be discharged through the rectifier and into the output capacitor in response to the first PWM control signal.

56. (Previously presented) The lighting system according to Claim 55, further comprising a second control transistor coupled to the second output terminal of the current supply circuit and having an input coupled to the second control output of the controller;

wherein the second control transistor is configured to cause a voltage stored in the output capacitor to be applied to the first output terminal of the current supply circuit in response to the second PWM control signal from the controller.

57. (Previously presented) The lighting system according to Claim 56, wherein ones of the current supply circuits further comprise:

a low pass filter between the second control output and the second control transistor.

58. (Previously presented) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 50 μH to about 1.3 mH.

59. (Previously presented) The lighting system according to Claim 53, wherein the charging inductor has an inductance of about 680 μH.

60. (Previously presented) The lighting system according to Claim 47, wherein the sensor output signal comprises a first sensor output signal, further comprising a light sensor that generates a second sensor output signal responsive to light output by the lighting system,

wherein the at least one control signal comprises the first sensor output signal and the second output sensor signal.

61. (Previously presented) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 85% of input power into output power.

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62. (Previously presented) The lighting system according to Claim 47, wherein ones of the current supply circuits are configured to convert at least about 90% of input power into output power.

63. (Currently amended) A lighting system, comprising:

a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;

at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices, respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices; and

a pulse width modulation (PWM) controller that is coupled to the first current supply circuit and the second current supply circuit[[s]] and that is configured to generate, for each~~ones~~ of the first current supply circuit and the second current supply circuit[[s]], a first PWM control signal and a second PWM control signal that are supplied to the each of the at least first and second strings.

64. (Previously presented) The lighting system according to Claim 63,

wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode.

65. (Previously presented) The lighting system according to Claim 64, wherein each of the first and second current supply circuits comprises:

a temperature sensor that is configured to generate a sensor output signal that the PWM controller uses to generate the first PWM signal or the second PWM signal, and

a sense resistor that is coupled to an output terminal of the current supply circuit and that is configured to provide a feedback signal to the PWM controller.

66. (Previously presented) The lighting system according to Claim 63, wherein each of the first and second current supply circuits comprises a sense resistor that is coupled

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to an output terminal of the respective one of the first and second current supply circuits and that is coupled to a feedback input to provide the feedback signal to provide closed loop control.

67. (Previously presented) The lighting system according to Claim 66, further comprising a filter coupled to the sense resistor, the filter configured to filter the feedback input.

68. (Previously presented) The lighting system according to Claim 63,

wherein the first string of solid state lighting devices are coated with a wavelength conversion phosphor and are configured to emit the first light that includes a combined light including a dominant wavelength corresponding to a blue color and a dominant wavelength corresponding to a yellow color, and

wherein the second string of solid state lighting devices are configured to emit the second light that includes a dominant wavelength corresponding to a red color.

69. (Previously presented) The lighting system according to Claim 68, wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit.

70. (Previously presented) The lighting system according to Claim 68, further comprising a third string of solid state lighting devices that are configured to emit a third light that includes a dominant wavelength corresponding to a red color.

71. (Previously presented) The lighting system according to Claim 70, further comprising a third current supply circuit that is configured to supply an on-state drive current to the third string of solid state lighting devices, and

wherein the first current supply circuit provides current control of the first string of solid state lighting devices that is independent of current control of the second string of solid state lighting devices provided by the second current supply circuit and that is independent of

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current control of the third string of solid state lighting devices provided by the third current supply circuit.

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REMARKS

Applicants appreciate the detailed examination evidenced by the final Office Action mailed January 13, 2014 (hereinafter "Office Action"). Applicants appreciate the indication that Claims 47-62 are allowed. Claims 47-71 are currently pending. Applicants believe that all claims are patentable over the cited references for the reasons that will be discussed in detail below.

Status of the Claims

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-15 of U.S. Patent No. 8,203,286. (Office Action, page 3.)

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-27 of U.S. Patent No. 8,461,776. (*See* Office Action, pages 3-4.)

Claims 63-71 stand rejected under pre-AIA 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,255,786 to Yen (hereinafter "Yen"). (Office Action, page 4.)

Claims 65-71 stand rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Yen, in view of U.S. Patent No. 6,888,529 to Bruning et al. ("Bruning"). (Office Action, page 5.)

Double Patenting Rejections

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-15 of U.S. Patent No. 8,203,286. (*See* Office Action, page 3.) In response, Applicants submit herewith a Terminal Disclaimer disclaiming additional term over United States Patent No. 8,203,286. Applicants' agreement to provide a Terminal Disclaimer is to expedite issuance of the present case and does not admit that the present invention is not patentably distinct from United States Patent No. 8,203,286. Withdrawal of the double patenting rejection is respectfully requested.

Claims 63-71 stand rejected on the ground of nonstatutory double patenting as being unpatentable over Claims 1-27 of U.S. Patent No. 8,461,776. (*See* Office Action, pages 3-4.) In response, Applicants submit herewith a Terminal Disclaimer disclaiming additional term over United States Patent No. 8,461,776. Applicants' agreement to provide a Terminal Disclaimer is to expedite issuance of the present case and does not admit that the present

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invention is not patentably distinct from United States Patent No. 8,461,776. Withdrawal of the double patenting rejection is respectfully requested.

Independent Claim 63 is Patentable Over Yen

The Office Action rejects Claims 63-71 as being unpatentable over U.S. Patent No. 6,255,786 to Yen ("Yen"). (Office Action, page 4.) Independent Claim 63 has been amended to clarify that each of the first and second current supply circuits is configured to receive a first PWM control signal and a second PWM control signal, which is not disclosed or suggested by Yen. For example, Claim 63, as amended, recites:

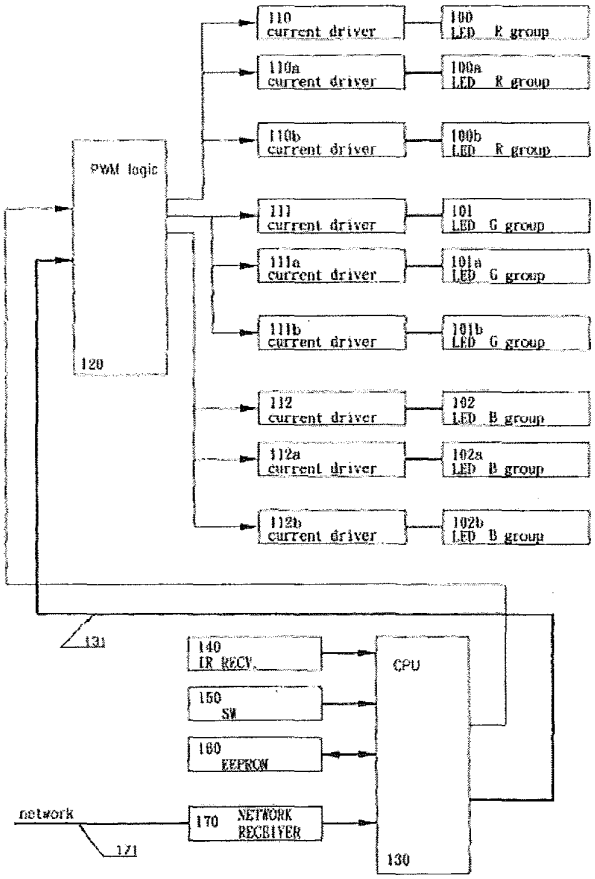
> A lighting system, comprising:
> a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively;
> at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices, respectively, and configured to supply an on-state drive current to a respective one of the first and second strings of solid state lighting devices; and
> a pulse width modulation (PWM) controller that is coupled to the first current supply circuit and the second current supply circuit and that is **configured to generate, for each of the first current supply circuit and the second current supply circuit, a first PWM control signal and a second PWM control signal** that are supplied to the each of the at least first and second strings.

(*Emphasis added.*) Regarding Claim 63, The Office Action concedes that Yen does not disclose at least first and second strings of solid state lighting devices and at least first and second current supply circuit. (Office Action, page 4.) The Office Action alleges that "a light emitting device of Yen is capable of performing as well, see figure 1" and alleges that Yen discloses a pulse width modulation (PWM) controller (PWM logic 120) that is coupled to the current supply circuits (current drivers 110, 111) and that is configured to generate , for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, citing column 2, lines 1-67 to column 3, lines 1-55. (Office Action, page 5.) Applicants respectfully disagree.

As an initial matter, even when positing an inherency-based rejection, the missing claim elements must necessarily be present if not expressly disclosed. In the present case, what Yen is capable of performing appears to be inconsistent with the requirements of art-

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based rejections. As provided above, Claim 63 is amended to clarify that a first PWM control signal and a second PWM control signal is generated for each of the first and second current supply circuits. Applicants respectfully submit that Yen does not disclose or suggest such recitations. Instead, the cited portion of Yen appears to describe a devoted digital logic circuit 120 that generates PWM signals above 30,000 Hz. (Yen, column 3, lines 13-17.) While the PWM logic 120 is coupled to multiple current drivers (110, 111, 112), Yen is wholly silent regarding each of the current drivers receiving a first and a second PWM control signal. Figure 1 of Yen is reproduced below for the Examiner's convenience:



As illustrated above, Yen appears to provide a signal from the WPM logic 120 to each current driver 110, 111, 112. In this regard, Yen appears to describe a first PWM control signal provided to a first current driver 110, a second PWM control signal provided to the second current driver 110a, etc. However, Yen is wholly silent regarding multiple signals (first PWM control signal and second PWM control signal) being provided to a single one of the current drivers. Accordingly, Yen does not disclose or suggest "a pulse width modulation

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(PWM) controller that is coupled to the first current supply circuit and the second current supply circuit and that is configured to generate, for each of the first current supply circuit and the second current supply circuit, a first PWM control signal and a second PWM control signal," as recited in Claim 63, as amended. Accordingly, Claim 63, as amended, is patentable over yen, the allowance of which is respectfully requested.

Dependent Claim 64 is Separately Patentable

Applicants respectfully submit that dependent Claim 64 is patentable at least by virtue of the patentability of independent Claim 63 from which it depends. Additionally, dependent Claim 64 includes separate bases of patentability. Regarding Claim 64, the Office Action alleges that:

> Yen discloses wherein each of the first and second current supply circuits comprises a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode; and a pulse width modulation (PWM) controller that is coupled to the current supply circuits and that is configured to generate, for ones of the first and second current supply circuits, a first PWM control signal and a second PWM control signal that are supplied to the at least first and second strings, respectively. (Office Action, page 5.)

Applicants respectfully disagree. The Office Action does not indicate any portion of Yen that discloses or suggests "a variable voltage boost, constant current power supply circuit configured to operate in continuous current mode," as recited in Claim 64. Instead, Yen appears to be wholly silent regarding the variable voltage boost, constant current power supply recitations of Claim 64. Accordingly, Applicants respectfully submit that Claim 64 is separately patentable over yen, the allowance of which is respectfully requested.

The Remaining Dependent Claims Are Allowable

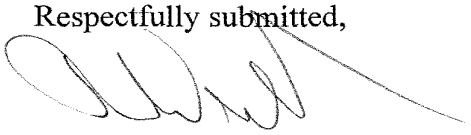
Applicants traverse the rejection of the remaining dependent claims. However, as each of these claims depends from a base claim that is believed to be in condition for allowance, Applicants do not believe that it is necessary to argue the allowability of each dependent claim individually. Applicants do not necessarily concur with the interpretation of these claims, nor with the bases for rejection set forth in the Office Action. Applicants therefore reserve the right to address the patentability of these claims individually as necessary in the future.

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CONCLUSION

As all of the claims are now in condition for allowance, Applicants respectfully request allowance of the claims and passing of the application to issue in due course. Applicants urge the Examiner to contact Applicants' undersigned representative at (919) 854-1400 to resolve any remaining formal issues.

Respectfully submitted,

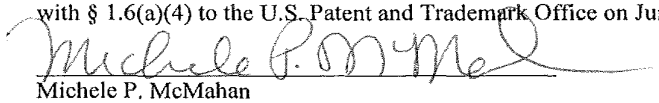


Timothy J. Wall
Registration No. 50,743

Customer Number 65106
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
919-854-1400
919-854-1401 (Fax)

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on June 3, 2014.



Michele P. McMahan

Petitioner Hisense USA Corporation
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Electronic Patent Application Fee Transmittal

Application Number:	13896977
Filing Date:	17-May-2013
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Filer:	Timothy Jennings Wall/Michele McMahan
Attorney Docket Number:	5308-706TSCT3

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 2 months with $0 paid	1252	1	600	600

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for Continued Examination	1801	1	1200	1200
		Total in USD ($)		**1800**

Electronic Acknowledgement Receipt

EFS ID:	19194271
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	03-JUN-2014
Filing Date:	17-MAY-2013
Time Stamp:	12:19:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1800
RAM confirmation Number	11689
Deposit Account	500220
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 249 of 321

1	Request for Continued Examination (RCE)	5308-706TSCT3-RCE.pdf	149766 704321cdfcd100ad6ce7217d38bd98643a8a4da4	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2		5308-706TSCT3-Amendment-with-RCE.pdf	1132880 5f09584265eb569028c85853634bd2417b547ce9	yes	12

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Response After Final Action	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	12

Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	32740 b5cfc5f3da24a9353ecb7ba89e11bbf41620ed42	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	1315386	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/896,977	Filing Date 05/17/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT

06/03/2014	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 25	Minus	** 27	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/RENEE HAWKINS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	**SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCE**

As a below named inventor, I hereby declare that:

This declaration is directed to:
- ☐ The attached application, or
- ☒ United States application or PCT international application number 13/896,977, filed on May 17, 2013,
  - ☒ As amended on May 24, 2013 and June 20, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I am aware of the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

LEGAL NAME OF INVENTOR 1

Signature: John K Roberts Date: 10/20/2013

Legal Name: **John K. Roberts**

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)	
Title of Invention	**SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCE**

As a below named inventor, I hereby declare that:

This declaration is directed to:
- ☐ The attached application, or
- ☒ United States application or PCT international application number 13/896,977, filed on May 17, 2013,
  - ☒ As amended on May 24, 2013 and June 20, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I am aware of the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

LEGAL NAME OF INVENTOR 2

Signature: Keith J. Vadas Date: _____

Legal Name: **Keith J. Vadas**

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)	
Title of Invention	**SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCE**

As a below named inventor, I hereby declare that:

This declaration is directed to:
- ☐ The attached application, or
- ☒ United States application or PCT international application number 13/896,977, filed on May 17, 2013,
  - ☒ As amended on May 24, 2013 and June 20, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I am aware of the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56, including for continuation-in-part applications, material information that became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

LEGAL NAME OF INVENTOR 3

Signature: _____ Date: June 02/2014

Legal Name: **Muhinthan Murugesu**

Application Data Sheet under 37 CFR 1.76 for application filed on or after September 16, 2012	Attorney Docket Number	5308-706TSCT3
	Application Number	13/896,977
Title of Invention	Solid State Lighting Panels with Variable Voltage Boost Current Sources	
Page 1 of 4		

Inventor Information:

Inventor 1					
Legal Name:					
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Address line 2					
City	Grand Rapids	**State/Province**	MI		
Postal Code	49506-6525	**Country**	US		

Inventor 2					
Legal Name:					
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Address line 2					
City	Lake Worth	**State/Province**	FL		
Postal Code	33467	**Country**	US		

Inventor 3					
Legal Name:					
Given Name	Muhinthan	**Middle Name**		**Family Name**	Murugesu
City of Residence	Morrisville	**State/Province of Residence**	NC	**Country of Residence**	US
Mailing Address of Inventor:					
Address line 1	528 Writers Way				
Address line 2					
City	Morrisville	**State/Province**	NC		
Postal Code	27560	**Country**	US		

Correspondence Information:

Customer Number	**65106**

Application Information:

Title of the Invention	Solid State Lighting Panels with Variable Voltage Boost Current Sources				
Attorney Docket Number	5308-706TSCT3				
Application Type	☒ Utility	☐ Plant	☐ Design	☐ Reissue	☐ Provisional
Total Number of Drawing Sheets (if any)	6				
Suggested Drawing Figure for Publication					

☐ **Application discloses any significant part of the subject matter of an application under a secrecy order pursuant to 37 C.F.R. § 5.2.**
[NOTE: any application that does fall under secrecy order may not be filed electronically]

☐ **Request Early Publication (Fee required at time of Request 37 CFR 1.219)**

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

For Plant Application only:

Latin name of genus and species of plant claimed	
Variety Denomination of plant claimed	

Representative Information:

Customer Number	**65106**

Domestic Benefit Information:

This application is a	☐ Non-provisional	☐ National phase	☒ Continuation	☐ Divisional	☐ Continuation-in-part
of Application No.	13/469188				
Filed	05/11/2012				
Status	Pending				

WHICH IS A

This application is a	☐ Non-provisional	☐ National phase	☒ Continuation	☐ Divisional	☐ Continuation-in-part
of Application No.	12/977422				
Filed	12/23/2010				
Status	Pending				

WHICH IS A

Application Data Sheet under 37 CFR 1.76 for application filed on or after September 16, 2012	Attorney Docket Number	5308-706TSCT3
	Application Number	13/896,977
Title of Invention	Solid State Lighting Panels with Variable Voltage Boost Current Sources	
Page 3 of 4		

This application is a	☐ Non-provisional	☐ National phase	☒ Continuation	☐ Divisional	☐ Continuation-in-part
of Application No.	11/601504				
Filed	11/17/2006				
Status	Pending				

WHICH IS A

This application is a	☒ Non-provisional	☐ National phase	☐ Continuation	☐ Divisional	☐ Continuation-in-part
of Application No.	60/738305				
Filed	11/18/2005				
Status	Expired				

which are hereby incorporated by reference in its / their entirety.

Foreign Priority Information:

Application No.	Country	Filing Date	Access Code

which is / are hereby incorporated by reference in its / their entirety.

Statement Under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2012 and (2) also contains or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to be granted access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this

Application Data Sheet under 37 CFR 1.76 for application filed on or after September 16, 2012		Attorney Docket Number	5308-706TSCT3
		Application Number	13/896,977
Title of Invention	Solid State Lighting Panels with Variable Voltage Boost Current Sources		
Page 4 of 4			

Authorization.

Applicant Information:

Applicant 1:			
Name of Applicant	Cree, Inc.		
Mailing Address Information:			
Address line 1	4600 Silicon Drive		
Address line 2			
City	Durham	**State/Province**	NC
Country **US**		**Postal Code**	27703

[NOTE: If the assignee/obligated assignee is NOT the Applicant, leave the above section blank.]

Non-Applicant Assignee Information:

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or persons who otherwise show sufficient proprietary interest), as the patent application publication will include the name(s) of the applicant(s).

Assignee 1:			
Name of Assignee			
Mailing Address Information:			
Address line 1			
Address line 2			
City		**State/Province**	
Country		**Postal Code**	

Signature under 37 C.F.R. § 1.76(e):

Signature		Date	07/11/2014
Typed Name	Timothy J. Wall	Registration Number	50,743

Electronic Acknowledgement Receipt

EFS ID:	19555996
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Michele McMahan
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	11-JUL-2014
Filing Date:	17-MAY-2013
Time Stamp:	13:57:45
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	5308-706TSCT3-Declaration.pdf	332551 6409e9a4ec0031f805b7048dd8872450289f7470	no	3

Warnings:	
Information:	

2	Application Data Sheet	5308-706TSCT3-Supp-ADS.pdf	421113 638b1b9f6a2b70e53c0f6ce51c8606ab4c7b9279	no	4

Warnings:	
Information:	
This is not an USPTO supplied ADS fillable form	
Total Files Size (in bytes):	753664

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

65106 7590 08/13/2014
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

EXAMINER	
A, MINH D	
ART UNIT	PAPER NUMBER
2844	

DATE MAILED: 08/13/2014

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

TITLE OF INVENTION: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	11/13/2014

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

Petitioner Hisense USA Corporation
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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

65106 7590 08/13/2014
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

TITLE OF INVENTION: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	11/13/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
A, MINH D	2844	315-308000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29
  NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27
  NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status.
  NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

Petitioner Hisense USA Corporation
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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Address: COMMISSIONER FOR PATENTS
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

65106 7590 08/13/2014

MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

EXAMINER	
A, MINH D	

ART UNIT	PAPER NUMBER
2844	

DATE MAILED: 08/13/2014

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 263 of 321

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 13/896,977	Applicant(s) ROBERTS ET AL.	
	Examiner MINH D. A	Art Unit 2844	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *RCE filed on 1/07/14*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *47-71*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/MINH D A/

Primary Examiner, Art Unit 2844

Date 8/6/14

Allowable Subject Matter

1. Claims 47-71 are allowed.

2. The following is an examiner's statement of reasons for allowance:

Prior art of record fails to disclose or fairly suggest, alone or in combination, a lighting system, comprising: at least two strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively; at least two current supply circuits coupled to first and second strings of the at least two strings, respectively and particularly including "a controller having a control input, a first control output configured to provide a first PWM control signal, and a second control output configured to provide a second PWM control signal; and first and second output terminals coupled to the respective string of the at least two strings of solid state lighting devices", in combination with the remaining claimed limitations as recited in claim 47 (claims 48-62 are allowed, since they are dependent on claim 47).

Prior art of record fails to disclose or fairly suggest, alone or in combination, a lighting system, comprising: a lighting panel including at least first and second strings of solid state lighting devices that are respectively configured to emit at least a first light and a second light, respectively; at least first and second current supply circuits coupled to the at least first and second strings of solid state lighting devices and particularly including "a pulse width modulation (PWM) controller that is coupled to the first current supply circuit and the second current supply circuit[[s]] and that is configured to generate, for each of the first current supply circuit and the second current supply circuit, a first PWM control signal and a second PWM control signal that are supplied to

the each of the at least first and second strings", in combination with the remaining claimed limitations as recited in claim 63 (claims 64-71 are allowed, since they are dependent on claim 63).

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Inquiry

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Minh Dieu A whose telephone number is (571) 272-1817. The examiner can normally be reached on M-F (8:00AM to 5:00PM).
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W Owens can be reached on (571) 272-1662. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Minh D A/

Primary Examiner

Art Unit 2844

Date 8/6/14

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	Art Unit
	MINH D A	2821

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
315	291, 307, 224, 246, 185R, 200R, 312	8/2/13	MA
315	308	8/6/14	MA

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor's name search "East", see serch print out	8/4/13	MA
Test search "East", see search print out	8/2/13	MA
Updated search "East", see search print out	1/7/13	MA
Updated Inventor's name search "East", see serch print out	8/6/14	MA
Updated Test search "East", see search print out	8/6/14	MA
Reference text search "East", see search print out	8/6/14	MA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
315	308	8/6/14	MA

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2844

CPC							
Symbol						**Type**	**Version**
H05B		33	/	0809		F	2013-01-01
H05B		33	/	0863		I	2013-01-01
G09G		2320	/	0653		A	2013-01-01
G09G		3	/	3406		I	2013-01-01
H05B		33	/	0872		I	2013-01-01
H05B		33	/	0821		I	2013-01-01
G09G		2360	/	145		A	2013-01-01
H05B		33	/	0869		I	2013-01-01
G09G		2320	/	064		A	2013-01-01
H05B		33	/	0803		I	2013-01-01
G09G		3	/	3413		I	2013-01-01
			/				
			/				
			/				
			/				

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/MINH D A/ Primary Examiner.Art Unit 2844	8/6/14	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	47	8&9

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2844

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
315	308	G 0 5 F 1 / 00 (2006.0)	

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/MINH D A/ Primary Examiner.Art Unit 2844	8/6/14	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	47	8&9

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2844

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	47	17	63												
2	48	18	64												
3	49	19	65												
4	50	20	66												
5	51	21	67												
6	52	22	68												
7	53	23	69												
8	54	24	70												
9	55	25	71												
10	56														
11	57														
12	58														
13	59														
14	60														
15	61														
16	62														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 25	
/MINH D A/ Primary Examiner.Art Unit 2844 (Primary Examiner)	8/6/14 (Date)	O.G. Print Claim(s) 47	O.G. Print Figure 8&9

Petitioner Hisense USA Corporation
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013	01/07/2014	08/06/2014						
	1	-	-	-						
	2	-	-	-						
	3	-	-	-						
	4	-	-	-						
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	10	-	-	-						
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	29	-	-	-						
	30	-	-	-						
	31	-	-	-						
	32	-	-	-						
	33	-	-	-						
	34	-	-	-						
	35	-	-	-						
	36	-	-	-						

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 273 of 321

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13896977	ROBERTS ET AL.
	Examiner	**Art Unit**
	MINH D A	2821

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/04/2013	01/07/2014	08/06/2014						
	37	-	-	-						
	38	-	-	-						
	39	-	-	-						
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	41	-	-	-						
	42	-	-	-						
	43	-	-	-						
	44	-	-	-						
	45	-	-	-						
	46	-	-	-						
1	47	✓	=	=						
2	48	✓	=	=						
3	49	✓	=	=						
4	50	✓	=	=						
5	51	✓	=	=						
6	52	✓	=	=						
7	53	✓	=	=						
8	54	✓	=	=						
9	55	✓	=	=						
10	56	✓	=	=						
11	57	✓	=	=						
12	58	✓	=	=						
13	59	✓	=	=						
14	60	✓	=	=						
15	61	✓	=	=						
16	62	✓	=	=						
17	63	✓	✓	=						
18	64	✓	✓	=						
19	65	✓	✓	=						
20	66	✓	✓	=						
21	67	✓	✓	=						
22	68	✓	✓	=						
23	69	✓	✓	=						
24	70	✓	✓	=						
25	71	✓	✓	=						

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	((string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and temperature near4 (sensor or detector) and (first and second) near4 PWM).clm.	US-PGPUB	OR	ON	2014/08/06 19:39
L2	4	((string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and PWM near4 controller and panel and (first and second) near4 PWM).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 19:40

8/6/2014 7:41:20 PM

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 9407

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/896,977	05/17/2013 RULE	315	2844	5308-706TSCT3

APPLICANTS

Cree, Inc., Durham, NC, Assignee (with 37 CFR 1.172 Interest);

INVENTORS

John K. Roberts, Grand Rapids, MI;
Keith J. Vadas, Lake Worth, FL;

**** CONTINUING DATA ***************************

This application is a CON of 13/469,188 05/11/2012 PAT 8461776
which is a CON of 12/977,422 12/23/2010 PAT 8203286
which is a CON of 11/601,504 11/17/2006 PAT 7872430
which claims benefit of 60/738,305 11/18/2005

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

06/12/2013

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	☐ Yes ☑ No	/MINH D A/ Examiner's Signature	☐ Initials	MI	6	27	3

ADDRESS

MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627
UNITED STATES

TITLE

SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
2300	No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	35328	(Cree with Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 17:47
L2	42	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and L1	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 17:47
L3	24	L2 and control near4 input and PWM	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 17:47
L4	7333	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:19
L5	5207	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:20
L6	1569	315/308.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:20
L7	3791	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:20
L8	1699	315/246.ccls.	US-	OR	ON	2014/08/06

			PGPUB; USPAT; USOCR; FPRS; EPO; JPO			18:20
L9	1864	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (first and second) near4 current	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:22
L10	350	l9 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:23
L11	6600	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and current	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:24
L12	1525	l11 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:25
L13	85	l12 and l4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:25
L14	42	l12 and l5	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:25
L15	13	l12 and l6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:25
L16	27	l12 and l7	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2014/08/06 18:26

			JPO			
L17	3	l12 and l8	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 18:26
S1	10	"7872430"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S2	15	"8203286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S3	1	"8461776"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:09
S4	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:50
S5	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S6	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S7	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S8	859	315/185R.ccls.	US-PGPUB; USPAT; USOCR;	OR	ON	2013/08/02 19:51

			FPRS; EPO; JPO			
S9	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:51
S10	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/02 19:52
S11	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:42
S12	2386	S11 and (constant near4 (current or voltage) or variable with (boost or buck or bulk))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:44
S13	602	S12 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:44
S14	6651	315/291.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S15	49	S13 and S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S16	4559	315/307.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S17	34	S13 and S16	US-PGPUB;	OR	ON	2013/08/04 07:45

			USPAT; USOCR; FPRS; EPO; JPO			
S18	3501	315/224.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S19	22	S13 and S18	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S20	1612	315/246.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S21	1	S13 and S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:45
S22	859	315/185R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S23	1	S13 and S22	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S24	1252	315/200R.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S25	1	S13 and S24	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46

S26	1864	315/312.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S27	19	S13 and S26	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S28	105675	"315"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S29	165442	"345"/$7.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S30	113	S13 and S28	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S31	40	S13 and S29	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:46
S32	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S33	0	S32 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 07:48
S34	26	S32 and S12	US-PGPUB; USPAT; USOCR; FPRS;	OR	ON	2013/08/04 07:48

			EPO; JPO			
S35	6163	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S36	2386	S35 and (constant near4 (current or voltage) or variable with (boost or buck or bulk))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S37	13047	(Cree nwith Durham or John with Roberts or Keith with Vadas).inv.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S38	26	S37 and S36	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S39	21	S38 and temperature near4 sensor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:02
S40	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:28
S41	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and S40	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:29
S42	32	S41 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 11:29
S43	1187	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or	US-PGPUB; USPAT;	OR	ON	2013/08/04 18:03

		load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	USOCR; FPRS; EPO; JPO			
S44	203	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) same (temperature near4 (sensor or detector)) and S43	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S45	32	S44 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S46	4	S45 and string	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:03
S47	235	(string$1) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and (temperature near4 (sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
S48	65	S47 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 18:06
S49	325	switch$3 near4 regulator same (string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:06
S50	67	switch$3 near4 regulator same (string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting) same inductor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:07
S51	5	S50 and @pd<="20051118"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2013/08/04 19:07
S52	35328	(Cree with Durham or John with Roberts or	US-	OR	ON	2014/08/06

		Keith with Vadas).inv.	PGPUB; USPAT; USOCR; FPRS; EPO; JPO			15:06
S53	42	(string$1 or array or group or solid near4 state) same (light near4 source$1 or LED$1 or light near4 emitting or lamps or load$1) and ((first and second) or (plurality or group or each)) same (PWM or pulse near4 width near4 modulat$3) and S52	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	OR	ON	2014/08/06 15:06

8/6/2014 7:28:01 PM
C:\Users\ma\Documents\EAST\Workspaces\13896977.wsp

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

IMPROPER CFR REQUEST



Date Mailed: 09/26/2014

RESPONSE TO REQUEST FOR CORRECTED FILING RECEIPT

Power of Attorney, Claims, Fees, System Limitations, and Miscellaneous

In response to your request for a corrected Filing Receipt, the Office is unable to comply with your request because:

- The request to correct inventorship or inventor name(s) under 37 CFR 1.48 is deficient because the fee set forth in 37 CFR 1.17(i) (for a nonprovisional application) or 37 CFR 1.17(q) (for a provisional application) has not been submitted.
- The request to correct inventorship under 37 CFR 1.48(a), which was filed after the first Office action on the merits, is deficient because it was not accompanied by the fee set forth in 37 CFR 1.17(d) or a statement that the request to correct or change inventorship was due solely to the cancelation of claims in the application. See 37 CFR 1.48(c).

/ttran/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Attorney Docket No.: 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: John K .Roberts et al.
Serial No.: 13/896,977
Filing Date: May 17, 2013
Examiner Name: A, Minh D.
Group Art Unit: 2844
Confirmation No.: 9407
For: **SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES**

Date: October 10, 2014

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PETITION TO CORRECT INVENTORSHIP AND REQUEST FOR CORRECTED FILING RECEIPT

Dear Sir:

Further to the Declaration and Supplemental Application Data Sheet filed July 11, 2014, Applicants respectfully request that a Corrected Filing Receipt be issued to include the 3rd Inventor. The 3rd Inventor's name was inadvertently left off of the original Application Data Sheet filed with this Application. Applicants respectfully request -- **Muhinthan Murugesu, Morrisville, NC;**-- be added to the Filing Receipt.

The Director is hereby authorized to charge the $140.00 petition fee set forth in 37 C.F.R. § 1.17(i) and any additional fees believed to be due in connection with this matter to our Deposit Account No. 50-0220.

Respectfully submitted,

Timothy J. Wall
Registration No. 50,743
Attorney for Applicants

Customer Number 65106
Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, NC 27627
919-854-1400
919-854-1401 (Fax)

CERTIFICATION OF TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on October 10, 2014.

Jessica Blischok

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/896,977	05/17/2013	2821	2300	5308-706TSCT3	27	3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

FILING RECEIPT

OC00000006190998O

Date Mailed: 06/19/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

John K. Roberts, Grand Rapids, MI;
Keith J. Vadas, Lake Worth, FL;

Applicant(s) --Muhinthan Murugesu, Morrisville, NC; --
Cree, Inc., Durham, NC

Assignment For Published Patent Application

Cree, Inc., Durham, NC

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/469,188 05/11/2012 PAT 8461776
which is a CON of 12/977,422 12/23/2010 PAT 8203286
which is a CON of 11/601,504 11/17/2006 PAT 7872430
which claims benefit of 60/738,305 11/18/2005

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 06/12/2013

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 288 of 321

Electronic Patent Application Fee Transmittal

Application Number:	13896977
Filing Date:	17-May-2013
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Filer:	Timothy Jennings Wall/Jessica Blischok
Attorney Docket Number:	5308-706TSCT3

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Petition fee- 37 CFR 1.17(h) (Group III)	1464	1	140	140
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**140**

Electronic Acknowledgement Receipt

EFS ID:	20385990
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Jessica Blischok
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	10-OCT-2014
Filing Date:	17-MAY-2013
Time Stamp:	14:02:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$140
RAM confirmation Number	242
Deposit Account	500220
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part/.zip	Pages (if appl.)

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 291 of 321

1		5308-706TSCT3_Petition_and_Request_for_Corrected_Filing_Receipt.pdf	207259 b8c38fa465a24142fac143785dae5f22ee8d6532	yes	2

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Petition for review by the Office of Petitions.	1	1
Request for Corrected Filing Receipt	2	2

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30882 cc1f833a8906d4bf0230447908396493a9eff50f	no	2

Warnings:

Information:

Total Files Size (in bytes):	238141

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 10/16/2014

VVAN11	SALE	#00000045	Mailroom Dt:	10/10/2014		500220	13896977
		01	FC : 1830	140.00	DA		
		02	FC : 1819	600.00	DA		

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 10/16/2014

VVAN11 ADJ #00000004 Mailroom Dt: 10/10/2014
Seq No: 242 Sales Acctg Dt: 10/14/2014 500220 13896977
01 FC : 1464 140.00 CR

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/896,977	05/17/2013	2844	2300	5308-706TSCT3	27	3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

CORRECTED FILING RECEIPT

OC000000071397253

Date Mailed: 10/17/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

John K. Roberts, Grand Rapids, MI;
Keith J. Vadas, Lake Worth, FL;
Muhinthan Murugesu, Morrisville, NC;

Applicant(s)

Cree, Inc., Durham, NC

Assignment For Published Patent Application

Cree, Inc., Durham, NC

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/469,188 05/11/2012 PAT 8461776
which is a CON of 12/977,422 12/23/2010 PAT 8203286
which is a CON of 11/601,504 11/17/2006 PAT 7872430
which claims benefit of 60/738,305 11/18/2005

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 06/12/2013

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 295 of 321

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/896,977**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

Title

SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Preliminary Class

315

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 296 of 321

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒ Practitioners associated with Customer Number: 65106

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☐ The address associated with Customer Number:

OR

☐

Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address: Cree, Inc.
4600 Silicon Drive
Durham, NC 27703

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	10/21/14
Name	Julio Garceran	Telephone	919-854-1400
Title	Chief Intellectual Property Counsel - Cree, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Cree, Inc.

Application No./Patent No.: 13/896,977 Filed/Issue Date: 05-17-2013

Titled: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

Cree, Inc., a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose one of options 1, 2, 3 or 4 below):

1. [✓] The assignee of the entire right, title, and interest.

2. [ ] An assignee of less than the entire right, title, and interest (check applicable box):

   [ ] The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   [ ] There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. [ ] The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. [ ] The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose one of options A or B below):

A. [✓] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 018763, Frame 0543, or for which a copy thereof is attached.

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature	Date: 10/21/14
Julio Garceran	Chief IP Counsel
Printed or Typed Name	Title or Registration Number

Electronic Acknowledgement Receipt

EFS ID:	20477600
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Jessica Blischok
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	21-OCT-2014
Filing Date:	17-MAY-2013
Time Stamp:	16:48:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		5308-706TSCT3_POA.pdf	922373 abf1d10f213c5f226fe97226b010cecf990799b6	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Power of Attorney	1	1
	Assignee showing of ownership per 37 CFR 3.73.	2	3
Warnings:			
Information:			
	Total Files Size (in bytes):	922373	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3

CONFIRMATION NO. 9407

65106
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

POA ACCEPTANCE LETTER

OC000000071490483

Date Mailed: 10/24/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/21/2014.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/ttkim/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

65106 7590 08/13/2014
MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	05/17/2013	John K. Roberts	5308-706TSCT3	9407

TITLE OF INVENTION: SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	11/13/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
A, MINH D	2844	315-308000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Myers Bigel Sibley
2 & Sajovec, P.A.
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Cree, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Durham, NC

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-0220 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date 11-12-2014
Typed or printed name Timothy J. Wall Registration No. 50,743

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Petitioner Hisense USA Corporation
Exhibit 1002 - Page 304 of 321

Electronic Patent Application Fee Transmittal

Application Number:	13896977
Filing Date:	17-May-2013
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Filer:	Timothy Jennings Wall/Kirsten Carlos
Attorney Docket Number:	5308-706TSCT3

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	960	960
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt

EFS ID:	20685053
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Kirsten Carlos
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	13-NOV-2014
Filing Date:	17-MAY-2013
Time Stamp:	12:23:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$960
RAM confirmation Number	8574
Deposit Account	500220
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	5308_706TSCT3IssueFeePayment.pdf	137932 0d43252768e70f2d34bc89691caaf662bbe75629	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30670 7280c48113cc3831f4044e59167d1f00f97c8fea	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	168602		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (use as many sheets as necessary)				Complete if Known	
				Application Number	13/896,977
				Filing Date	May 17, 2013
				First Named Inventor	John Roberts
				Art Unit	2821
				Examiner Name	Minh D. A
Sheet	A4	of	A6	Attorney Docket Number	5308-706TSCT3

/MA/	122	US	6,411,046		06/2002	Muthu	
/MA/	123	US	6,507,159		01/2003	Muthu	
/MA/	124	US	7,122,971		10/2006	Yeh et al.	
/MA/	125	US	6,894,436		05/2005	Togashi et al.	
/MA/	126	US	6,441,558		08/2002	Muthu et al.	
/MA/	127	US	6,864,641		03/2005	Dygert, Gregory J.	
/MA/	128	US	7,236,148		06/2007	Yoshida et al.	
/MA/	129	US	7,569,996		08/2009	Holmes et al.	
/MA/	130	US	7,122,971		10/2006	Yeh et al.	
/MA/	131	US	6,507,159		01/2003	Muthu	
/MA/	132	US	6,411,046		06/2002	Muthu	
/MA/	133	US	~~6,181,079~~	B1	01/30/2001	Chang et al.	6,181,079
/MA/	134	US	6,864,641		03/2005	Dygert, Gregory J.	
/MA/	135	US	6,495,964		12/2002	Muthu et al.	
/MA/	136	US	6,510,955		01/2003	Pellegrino, John B.	
/MA/	137	US	5,949,222		09/1999	Buono, Robert N.	
/MA/	138	US	6,940,189		09/2005	Gizara, Andrew R.	
/MA/	139	US	6,870,328		03/2005	Tanabe et al.	
/MA/	140	US	6,018,220		01/2000	Nerone, Louis R.	
/MA/	141	US	5,877,595		03/1999	Nerone, Louis R.	
/MA/	142	US	7,872,430		01/2011	Roberts et al.	
/MA/	143	US	2005/0207196	A1	09/22/2005	Holmes et al.	
/MA/	144	US	2003/0137475	A1	07/24/2003	Yoshida et al.	
/MA/	145	US	6,441,558	B1	08/27/2002	Muthu et al.	
/MA/	146	US	6,621,235		~~09/2203~~	Chang, Chin	315/216 September 16, 2003
/MA/	147	US	6,909,249		06/2005	Otake, Tetsushi	315.281
/MA/	148	US	~~6,441,556~~		08/2002	Muthu et al.	315/149 6,441,558
/MA/	149	US	6,510,995		01/2003	Muthu et al.	235/454
/MA/	150	US	6,870,328		03/2005	Tanabe et al.	315/291
/MA/	151	US	8,203,286		06/2012	Roberts eta l.	315/307
/MA/	152	US	5,877,595		03/1999	Nerone, Louis R.	315/209R
/MA/	153	US	6,940,189		09/2005	Gizara, Andrew Roman	307/151

Change(s) applied to document, /S.J.W./ 10/2/2014

Change(s) applied to document, /K.M./ 10/3/2014

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.	Foreign Patent Document Country Code, Number, Kind Code (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
/MA/	154	GB 2 249 840	05-20-1992	Alfreza Ghazi Hessami (UK)		T
/MA/	155	JP 10-233669	09-02-1998	Matsushita Electric Works, Ltd.		T

Examiner Signature	/Minh A/	Date Considered	01/07/2014

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/896,977	01/27/2015	8941331	5308-706TSCT3	9407

65106 7590 01/07/2015

MYERS BIGEL SIBLEY & SAJOVEC, P.A.
P.O. BOX 37428
RALEIGH, NC 27627

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Cree, Inc., Durham, NC, Assignee (with 37 CFR 1.172 Interest);
John K. Roberts, Grand Rapids, MI;
Keith J. Vadas, Lake Worth, FL;
Muhinthan Murugesu, Morrisville, NC;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Attorney Docket No. 5308-706TSCT3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: Roberts et al.
Application No.: 13/896,977
Filed: May 17, 2013
Title: *SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES*

U.S. Patent No.: 8,941,331
Issued: January 27, 2015
Confirmation No: 9407

February 24, 2015

Commissioner for Patents
Attn: Certificate of Correction Branch
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR ENTRY OF CERTIFICATE OF CORRECTION UNDER 35 U.S.C. §254 AND 37 C.F.R. §1.322

Sir:

The Applicants of record for the above-referenced patent hereby request, pursuant to 35 U.S.C. §254 and 37 C.F.R. §1.322, that a Certificate of Correction be issued. This request is made in order to correct the mistakes incurred through the fault of the U.S. Patent and Trademark Office. The mistakes appearing in the patent are set forth with corrections on the Certificate of Correction attached herewith.

No fee is believed due. However, the Commissioner is authorized to charge any deficiency or credit any overpayment to Deposit Account No. 50-0220.

Respectfully submitted,

Timothy J. Wall
Registration No.: 50,743

Customer No.: 65106
Myers Bigel Sibley & Sajovec, P.A.
P. O. Box 37428, Raleigh, NC 27627
Telephone: (919) 854-1400
Facsimile: (919) 854-1401

CERTIFICATION OF ELECTRONIC TRANSMISSION

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with § 1.6(a)(4) to the U.S. Patent and Trademark Office on February 24, 2015.

Cathy J. Leonard

PTO/SB/44 (09-07) Approved for use through 08/31/2010. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. (Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.:	8,941,331
APPLICATION NO.:	13/896,977
ISSUE DATE:	January 27, 2015
INVENTOR(S):	Roberts et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 17, Claim 13, Line 2: Please correct "of about 680 pH."
to read -- of about 680 μH. --

MAILING ADDRESS OF SENDER:
Myers, Bigel, Sibley & Sajovec
P.O. Box 37428
Raleigh, NC 27627

Electronic Acknowledgement Receipt

EFS ID:	21578916
Application Number:	13896977
International Application Number:	
Confirmation Number:	9407
Title of Invention:	SOLID STATE LIGHTING PANELS WITH VARIABLE VOLTAGE BOOST CURRENT SOURCES
First Named Inventor/Applicant Name:	John K. Roberts
Customer Number:	65106
Filer:	Timothy Jennings Wall/Cathy Leonard
Filer Authorized By:	Timothy Jennings Wall
Attorney Docket Number:	5308-706TSCT3
Receipt Date:	24-FEB-2015
Filing Date:	17-MAY-2013
Time Stamp:	09:45:05
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Certificate of Correction	5308-706TSCT3_Request_for_COC.pdf	144856 59071fc4826a9401b467ee3063f08be4d2df1c34	no	2

Warnings:	
Information:	

Total Files Size (in bytes):	144856

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,941,331 B2
APPLICATION NO. : 13/896977
DATED : January 27, 2015
INVENTOR(S) : Roberts et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 17, Claim 13, Line 2: Please correct "of about 680 pH."
to read -- of about 680 μH. --

Signed and Sealed this
Nineteenth Day of May, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas - Marshall Divison on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:22-cv-00170	5/24/2022	Eastern District of Texas - Marshall Divison

PLAINTIFF	DEFENDANT
BRIGHTPLUS VENTURES LLC	LG ELECTRONICS, INC. and LG ELECTRONICS U.S.A., INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,960,812	4/6/2010	Brightplus Ventures LLC
2	7,872,705	1/18/2011	Brightplus Ventures LLC
3	8,177,382	5/15/2012	Brightplus Ventures LLC
4	8,294,075	10/23/2012	Brightplus Ventures LLC
5	8,330,710	12/11/2012	Brightplus Ventures LLC

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
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3		
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5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas - Marshall Divison on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:22-cv-00170	5/24/2022	Eastern District of Texas - Marshall Divison

PLAINTIFF	DEFENDANT
BRIGHTPLUS VENTURES LLC	LG ELECTRONICS, INC. and LG ELECTRONICS U.S.A., INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,941,331	1/27/2015	Brightplus Ventures LLC
2	9,605,835	3/28/2017	Brightplus Ventures LLC
3	RE42,598	8/9/2011	Brightplus Ventures LLC
4	RE45,796	11/10/2015	Brightplus Ventures LLC
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas - Marshall Divison on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:22-cv-00194	6/7/2022	Eastern District of Texas - Marshall Divison

PLAINTIFF	DEFENDANT
BRIGHTPLUS VENTURES LLC	TCL ELECTRONICS HOLDINGS LTD. et al.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,960,812	4/6/2010	Brightplus Ventures LLC
2	8,941,331	1/27/2015	Brightplus Ventures LLC
3	8,177,382	5/15/2012	Brightplus Ventures LLC
4	8,294,075	10/23/2012	Brightplus Ventures LLC
5	8,330,710	12/11/2012	Brightplus Ventures LLC

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas - Marshall Divison on the following

☑ Trademarks or ☐ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:22-cv-00194	6/7/2022	Eastern District of Texas - Marshall Divison

PLAINTIFF	DEFENDANT
BRIGHTPLUS VENTURES LLC	TCL ELECTRONICS HOLDINGS LTD. et al.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	9,605,835	3/28/2017	Brightplus Ventures LLC
2	RE45,796	11/10/2015	Brightplus Ventures LLC
3	RE42,598	8/9/2011	Brightplus Ventures LLC
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Northern District of Georgia on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:22-cv-02774-TCB	7/14/2022	for the Northern District of Georgia

PLAINTIFF	DEFENDANT
Hisense USA Corporation	Brightplus Ventures LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	See Attachment A		
2			
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
KEVIN P. WEIMER	s/ A. Edwards	7/15/2022

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

Print Save As...

Attachment A to Form AO 120

Patent No.	Date of Patent	Holder of Patent
7,690,812	4/6/2010	Brightplus Ventures LLC
7,872,705	1/18/2011	Brightplus Ventures LLC
8,177,382	5/15/2012	Brightplus Ventures LLC
8,294,075	10/23/2012	Brightplus Ventures LLC
8,330,710	12/11/2012	Brightplus Ventures LLC
8,941,331	1/27/2015	Brightplus Ventures LLC
9,605,835	5/28/2017	Brightplus Ventures LLC
RE42,598	8/9/2011	Brightplus Ventures LLC
RE45,796	11/10/2015	Brightplus Ventures LLC