The disclosure also concerns the optimisation of system power factor (PF) values and the minimisation of system total harmonic distortion (THD) via use of the systems as described herein.

BACKGROUND

Light-emitting diode (LED) lighting technology is known for delivery of increased power efficiency with associated reductions in cost particularly in commercial applications, such as for example in street lighting where previously inefficient / high cost HID sodium lamps were utilised.

From a commercial perspective, and particularly from the viewpoint of potential implementation of LED arrays in large-scale commercial applications, such as for example in industrial applications or in large retail applications, it would clearly be of considerable benefit if such LED array(s) could be operated on a more energy efficient basis, and in a cost-efficient manner whilst providing the capacity for remote control of their wavelength, radiant intensities and photoperiods.

Commercially available LED lights are powered with DC current that means that they are typically placed in close proximity to an AC/DC inverter, typically 230v AC – 24v DC. At low voltage DC there is a significant voltage drop over short distances which mean that for system efficiency the AC/DC invertor must be placed at a distances from the LED lights of less than 5m, and typically about 2m.

A particular disadvantage of using LED-based lighting for the provision of lighting for large-scale commercial or industrial applications, or high intensity lighting systems which require high numbers of LED lights, is that the necessary spacing between either the individual LED lights or between groups of the LED lights means that the distance between the AC/DC inverters needs to increase because such arrangements typically mean that the risk of DC voltage drop is increased. The Applicant has recognised that such risk of DC voltage drop is applicable to any DC-powered lighting device.

To date efforts to resolve this voltage drop issue for commercial applications have provided modified lighting systems which utilise LED lights, and particularly strips of LED lights, also known as strip lighting in association with an increased number of AC/DC inverters which are smaller in size. In addition to the LED costs indicated hereinbefore, and the additional inverter costs, such modified systems require far higher quantities of high voltage AC wiring, to connect to multiple inverters, than would be required if using a single large AC/DC inverter. This is particularly expensive in large-scale commercial systems, such as systems for use in large-scale industrial applications or complex commercial applications where all wiring and inverters must be IP rated. In addition, the complexity of such systems means that the measures required for controlling the LED lighting within such modified systems, as well as the measurement of wavelength, intensity and photoperiod generated becomes impractical as well as potentially hazardous should any fault occur.

At present, the industry standard AC/DC inverters for use with LED lights have power factors (PF) typically in the range 0.7 to 0.9. There would be however a considerable financial benefit to increasing the power factor to close to 1.0.

Total harmonic distortions (THDs) of 20% or less, are considered acceptable in the provision of LED lighting. It would be of considerable benefit to provide a system that could reduce or eliminate THD

because any THD is both potentially damaging to animal and human health and interferes with other electronic systems.

Thus, there is a need to provide a system for the provision of power and lighting to lighting devices which are adapted to be powered by DC, and especially to LED-based lighting systems containing one or more LED-lighting devices, such as LED arrays which overcomes the voltage-drop restrictions of current systems and is capable of delivering radiant power distribution in a uniform manner, with improved power conversion versus the presently available conventional compact or strip-style LED lighting arrays and which is provided improved (increased) PF and/or reduced or no THD.

One of the desirable features of LED fixtures is the ability to control each wavelength independently and to vary the intensities and the photoperiods according to the specific needs of the customised commercial or domestic system.

It is technically possible using LEDs to adjust the photoperiods from milliseconds to hours. LED lighting manufacturers have designed compact LED lighting arrays using conventional printed circuit boards (PCBs**)** often incorporating 100's of high powered LEDs. These are IP rated and supplied by high voltage, typically 240v AC.

As over 50% of the power supplied to such LED arrays is typically converted to heat rather than radiant power, these compact LED lighting arrays are often air cooled with fans. Given the ever-increasing awareness of both domestic and commercial consumers of the environmental cost associated with wasted energy consumption, the relative inefficiency of the power conversion provided by commercially available LED arrays can be a deterrent to their use in some circumstances.

Thus, there is a need to provide a power system for such LED lighting arrays which converting more than 50% of the power supplied to radiant power rather than heat energy.

SUMMARY

In a first aspect, the present disclosure provides a power and lighting system comprising one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device, wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply, wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification, and wherein the 3-phase AC power supplied to the system is distributed by tubular conductors.

In a second aspect, the present disclosure provides a method for the provision of controllable power and lighting, or use of a controllable power and lighting system, in applications independently selected from: (i) applications relating to growth including horticulture, agriculture, and aquaculture; (ii) as applications relating to the provision of power and lighting in settings where animals are held including in animal husbandry; (iii) applications relating to the deployment of power and lighting systems in large-scale settings having a demand for dynamic, responsive LED lighting; and (iv) applications where LED-lighting and power are in close proximity to humans, wherein the method, or use, comprises a power and lighting system comprising one or more power consuming devices, wherein at least one of the power consuming

devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply and wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification, and wherein the 3-phase AC power supplied to the system is distributed by tubular conductors.

The present disclosure comprises a novel and improved power and lighting system suitable for use in applications having one or more DC powered LED-containing lighting devices. The disclosure particularly relates to a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply and wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification.

The present disclosure provides a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply, wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification and wherein the 3-phase AC power supplied to each LED-containing lighting device is reduced by a step-down device.

The present disclosure provides a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply, wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification and wherein the 3-phase AC power supplied to each LED-containing lighting device is reduced by a main AC step-down transformer.

The present disclosure additionally relates to a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply, wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification and wherein the 3-phase AC power supplied to the system is less than or equal to 50V AC RMS.

The present disclosure also relates to a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply , wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification and wherein the 3-phase AC power supplied to the system is distributed by conductive bus bars.

The present disclosure also relates to a controllable system for the provision of power and lighting for applications, wherein the system comprises one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply, wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification and wherein the system includes means for automatic control of each device.

For the avoidance of doubt each of the above embodiments relating to power step-down, <= 50V AC RMS, bus bars and/or automatic control may be combined within the present system. These and additional embodiments are detailed hereinafter.

According to a particular embodiment there are disclosed controllable power and lighting systems wherein the 3-phase AC voltage power is low voltage 3-phase AC power, and especially 3-phase AC extra-low voltage power of less than or equal to 50V AC RMS is distributed on bus bars.

The present disclosure additionally provides a controllable power and lighting system as defined hereinbefore wherein the at least one LED-containing lighting devices is any suitable LED-containing lighting device, including an LED, a light fitting including at least one LED, a luminaire containing at least one LED, a group of LEDs, a group of light fittings each containing at least one LED, a group of luminaires each containing at least one LED, or one or more arrays of LEDs.

The present disclosure additionally provides a controllable power and lighting system as detailed hereinbefore wherein the one or more LED-containing lighting devices, or group of one or more LED-containing lighting devices, or one or more arrays of LEDs are linked to an AC main transformer.

The present disclosure provides a controllable power and lighting system as detailed hereinbefore wherein the 3-phase AC power is distributed by conductive bus bars. In addition the present disclosure additionally provides a controllable power and lighting system as detailed hereinbefore wherein the 3-phase AC power is distributed by conductive bus bars, particularly wherein the bus bars are conductive hollow bus bars, or conductive tubular or substantially tubular bus bars.

There is also provided a controllable power and lighting system for use in applications comprising one or more LED-containing lighting devices wherein the one or more lighting devices is adapted to be powered by a 3-phase AC power supply wherein the 3-phase AC power supplied to each lighting device, or group of lighting devices is converted to DC power via 3-phase AC/DC rectification and wherein means for communications are located on the AC-side i.e. communications are extracted from the AC waveform at each lighting device or group of lighting devices i.e. at each load connected to the system via power line technology in combination with communications and registration means within the devices, and wherein the system can be monitored and controlled remotely.

According to an embodiment there is provided a controllable power and lighting system wherein the LED-lighting comprises one or more LED-containing lighting devices, or group of one or more LED-lighting devices, or an LED array comprising LED lights wherein the devices or lights are adapted to be powered by a 3-phase AC power supply wherein

(i) the 3-phase AC power distributed to the LED-lighting is linked to an AC main transformer that may be positioned externally or internally;

(ii) the 3-phase AC power is distributed by conductive bus bars;

(iii) the 3-phase AC power supplied to each lighting device, or group of lighting devices is converted to low voltage or extra-low voltage DC via 3-phase AC/DC rectification of the power supplied to each connected load, and particularly via an AC/DC rectifier associated with each lighting LED-containing lighting device, or group of LED-containing lighting devices; and

(iv) the system includes means for automatic control of the output of the lighting as a whole, or individual LED-containing lighting devices, or groups of LED-containing lighting devices within the system.

According to a further embodiment in the above controllable power and lighting system where the 3-phase AC power supplied to each LED-containing lighting device, or group of LED-containing lighting devices is converted to low voltage or extra-low voltage DC via 3-phase AC/DC rectification of the power supplied to each connected load the rectification is via an AC/DC rectifier associated with each LED-containing lighting device, or group of LED-containing lighting devices.

According to a yet further embodiment, in either of the systems directly about the bus bars tubular or substantially tubular and are adapted to power one or more optional non-lighting based devices where present within the system, and wherein the system additionally comprises power line technology in combination with communications, and registration means within the array, and the non-LED based devices and wherein the system can be monitored and controlled remotely.

According to another embodiment the present disclosure provides a novel power and lighting system as defined herein wherein power line technology provided via the bus bars provides a control system for the lighting system, wherein the control system communicates with each individual lighting device, or groups of one or more lighting devices, or one or more arrays of lighting devices via use of one or more lighting device-specific registration chips to provide a remote controlled and monitored system, and wherein automatic correction of voltage drop within the system is managed by local inverters associated with each lighting device, or group of lighting devices, or individual lighting devices or groups of lighting devices, including strips of lighting devices within each array, and particularly wherein the lighting devices are LEDs.

A further embodiment provides a novel power and lighting system as defined hereinbefore having web-based remote-control features and means for the provision of power source blending between peak and off peak main power supplies, and between a main power supply and alternative, renewable power supplies such as for example solar power.

According to yet further embodiments the present disclosure provides a novel power and lighting system as defined hereinbefore wherein the system additionally comprises one or more of the following independent features, and any combination thereof: the lighting devices comprises LED strips; the lighting devices comprises LED spot lights; the lighting devices comprises LED floodlights; the lighting devices comprises a combination of LED spot lights, LED floodlights and/or LED strips; the combined power line and array registration enables wireless remote control and monitoring of the system; the system includes a feedback loop in the control system to enable real-time LED adjustment within buildings.

According to a still further embodiment the present disclosure provides a novel power and lighting system as defined hereinbefore wherein each individual power consuming device within the system, including individual lighting devices, and/or non-lighting devices, or group of lighting devices and/or group of non-lighting devices, or array of lighting devices within the power and lighting system can be individually registered for control ultimately via the internet with all data collected via cloud internet with such control enabled by a power line communications chip.

According to another embodiment the present disclosure provides an improved LED array for use as the lighting device with the present power and lighting systems for use in growth systems wherein the LED array comprises a series of aluminium strips arranged in parallel wherein individual LED lights can be spaced at any distance along the length of each individual strip, wherein each individual strip is spaced at a similar distance from each individual adjacent strip and wherein the overall LED pattern provided by the LED array approximates to a uniform grid and wherein the LED strips are adapted to be powered by an AC low voltage 3-phase power supply.

(i) the 3-phase AC power supplied to each lighting device, or group of lighting devices is converted to DC power via 3-phase AC/DC rectification of the power supplied to each connected load; and

(ii) the system includes means for automatic control of the output of the lighting as a whole, or individual lighting devices, or groups of lighting devices; and optionally

(iii) the bus bars are optionally adapted to power one or more non-lighting devices within the system.

According to a further embodiment the present disclosure provides a controllable power and lighting system wherein the lighting comprises one or more LED arrays, wherein each LED array comprises one or more strips wherein one or more individual LED lights are spaced at any distance along the length of each individual strip, wherein the LED-containing strips are adapted to be powered by a 3-phase AC low voltage power supply wherein

(i) the low voltage, 3-phase, AC power distributed to the array is linked to a main transformer;

(ii) the low voltage, 3-phase, AC power is distributed by tubular bus bars;

(iii) the low voltage, 3-phase, AC supplied to each LED light, or group of LED lights is converted to low voltage DC via 3-phase AC/DC rectification of the power supplied to each connected LED light, or group of LED lights;

(iv) the system includes means for automatic control of the output of the LED array as a whole, or individual LED lights, or groups of LED lights within the array; and optionally

(v) the bus bars are adapted to power one or more non-LED devices within the system.

According to another embodiment the present disclosure provides a novel power and lighting system for use in growth systems wherein the lighting comprises one or more LED arrays, wherein each LED array comprises one or more strips wherein one or more individual LED lights are spaced at any distance along the length of each individual strip, wherein the LED containing strips are powered by a 3 phase AC low voltage power supply and

(i) wherein the low voltage 3 phase, AC power distributed to the array is linked to an external transformer;

(ii) wherein the low voltage 3-phase AC power is distributed by tubular bus bars;

(iii) wherein the low voltage or 3 phase AC supplied to each strip is converted to low voltage DC via AC/DC rectification of the power supplied to each connected load; and

(iv) wherein the system includes means for automatic control of the output of the LED array as a whole or individual LED lights, or groups of LED lights within the array.

The above embodiments and yet further embodiments of the invention are described hereinafter.

DESCRIPTION

Traditionally lighting systems are powered by single phase voltage. It is well-known in the lighting industry that low power loading lighting systems, such as low voltage DC-powered LED lights are not considered suitable for powering via 3-phase power.

To date it has not been possible to provide a lighting system employing lights that require DC power, such as LEDs, using a 3-phase power supply. Surprisingly, not only has the Applicant provided the first 3-phase power supply based controllable power and lighting system suitable for use with LED-containing lights which are adapted to be powered by 3-phase DC, the Applicant has also found that use of a 3-phase voltage power supply, and particularly a 3-phase low voltage AC power supply, in the controllable power and lighting systems described herein the rectification of this 3-phase voltage into DC is much more efficient than traditional single phase rectification.

The Applicant has additionally found that use of a 3-phase AC supply in the present controllable power and lighting systems not only delivers desirable efficiency benefits versus traditional lighting systems but also enables the use of far smaller capacitors for smoothing the DC voltage, than those required by an equivalent single phase system. These efficiency and capacitor-related benefits have been demonstrated across voltage levels i.e. at high and low levels of 3-phase AC power supply. In particular the Applicant has found that these advantages are especially useful where a low or extra low voltage 3-phase power supply is utilised in the present power and lighting systems. The ability to use far smaller capacitors has great advantages to cost, size, efficiency and reliability of the rectification and associated hardware components. The Applicant has found that capacitors suitable for use in the present power and lighting systems having 3-phase rectification are up to and including 90% smaller than the corresponding capacitors needed for systems employing low voltage AC with single phase rectification. Furthermore, the Applicant has demonstrated that in the controllable power and lighting systems as detailed herein the capacitor can be eliminated completely provided the output voltage from the transformer is tuned to the exact application.

Without wishing to be bound to any particular theory, it is thought that one of the reasons that the present system employing a 3-phase supply is more efficient than a corresponding system having a single phase supply is due to the voltage ripple effect, whereby the voltage ripple frequency of a 3-phase AC supply is 3-fold greater than that for a single phase AC supply. For example, a 3-phase 50Hz becomes AC becomes 300Hz DC ripple and 3-phase 60Hz becomes 360Hz DC ripple.

The Applicant has additionally demonstrated that use of the present system provides increased power factor (PF) values versus the current industry standards of 0.7-0.9. In particular PV values of 0.95 or above, more particularly 0.97 or above, and especially 0.99 or above have been demonstrated via use of the present system.

The Applicant has also demonstrated that use of the present system provides significant reductions in the level of total harmonic distortions (THDs) versus the presently accepted levels of 20% or less. In particular, THD values of 10%, less, more particularly 5%, or less, especially 1% or less and more especially 0.5% of less have been demonstrated via use of the present system.

CLAIMS

1. A controllable power and lighting system comprising one or more power consuming devices,

wherein at least one of the power consuming devices is an LED-containing lighting device,

wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply,

wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification, and

wherein the 3-phase AC power supplied to the system is distributed by tubular conductors.

2. The system according to claim 1, wherein the 3-phase AC power supplied to each LED-containing lighting device is reduced by a step-down device.

3. The system according to claim 1, wherein the 3-phase AC power supplied to each LED-containing lighting device is reduced by a main AC step-down transformer.

4. The system according to claim 1, wherein the 3-phase AC power supplied to the system is less than or equal to 50V AC RMS, preferably wherein the 3-phase AC power supplied to the system is extra low voltage power of between 12v and 50v AC RMS.

5. The system according to claim 1, wherein the 3-phase AC/DC rectification is local rectification.

6. The system according to claim 1, wherein the system includes automatic controllers of each device.

7. The system according to claim 1, wherein the LED-lighting comprises one or more LED-containing lighting devices, or group of one or more LED-lighting devices, or an LED array comprising LED lights wherein the devices or lights are adapted to be powered by a 3-phase AC power supply wherein

(i) the 3-phase AC power distributed to the LED-lighting is linked to an AC main transformer that may be positioned externally or internally;

(ii) the 3-phase AC power is distributed by tubular conductors;

(iii) the 3-phase AC power supplied to each lighting device, or group of lighting devices is converted to low voltage or extra-low voltage DC via 3-phase AC/DC rectification of the power supplied to each connected load, and particularly via an AC/DC rectifier associated with each lighting LED-containing lighting device, or group of LED-containing lighting devices; and

(iv) the system includes means for automatic control of the output of the lighting as a whole, or individual LED-containing lighting devices, or groups of LED-containing lighting devices within the system.

8. The system according to claim 1 additionally comprising one or more non-lighting power consuming devices wherein each non-lighting power consuming device is adapted to be powered by a 3-phase AC power supply.

9. The system according to claim 1, wherein the power supplied to each lighting device is low voltage or extra low voltage 3-phase AC that is converted to low voltage DC power via a 3-phase AC/DC rectifier associated with each lighting device.

10. The system according to claim 1 wherein 3-phase AC power supplied to each LED-containing lighting device is reduced by a step-down device or a main AC transformer located externally or internally to the location of the system.

11. The system according to claim 1, wherein the conductors are present as an assembly having main, secondary and optionally tertiary conductors.

12. The system according to claim 11,

wherein the main, secondary and tertiary conductors, where present, independently comprise aluminum or copper conductors.

13. The system according to claim 1, wherein the system includes three line positive tubular conductors and optionally one neutral tubular conductor.

14. The system according to claim 6, wherein the automatic controllers use powerline technology or a wireless link to a local PC or via the internet remotely or uses a combination of powerline and wireless technologies according the needs of the particular system to be controlled.

15. The system according to claim 1, wherein the at least one LED-containing lighting device is an LED light, an LED array comprising one or more LED lights, or groups of LED lights including: one or more LED spotlights; one or more LED floodlights; one or more light fittings including at least one LED; one or more luminaires containing at least one LED; one or more LED strip lights; or one or strips containing LED lights; or any combination of LED spotlights, LED floodlights, light fittings, luminaires, LED strip lights, or arrays or strips containing LEDs.

16. The system according to claim 1, wherein the one or more power consuming devices comprises one or more lighting devices, wherein the one or more lighting devices are LED-containing lighting devices, LEDs, wherein the one or more lighting devices is powered by a 3 phase AC power supply and wherein the 3 phase AC power supplied to each lighting device is converted to DC power via 3-phase AC/DC rectification.

17. The system according to claim 16, wherein the 3 phase AC power is linked to a main transformer, wherein the 3 phase AC power supplied to each lighting device is between 12 -50v AC RMS, and wherein the 3 phase AC power is distributed by tubular conductors.

18. Use of the system according to claim 1 for provision of power and lighting in applications independently selected from:

(i) applications relating to growth including horticulture, agriculture, and aquaculture;

(ii) as applications relating to the provision of power and lighting in settings where animals are held including in animal husbandry;

(iii) applications relating to the deployment of power and lighting systems in large-scale settings having a demand for dynamic, responsive LED lighting; and

(iv) applications where LED-lighting and power are in close proximity to humans.

19. A method for the provision of controllable power and lighting, or use of a controllable power and lighting system, in applications independently selected from:

(i) applications relating to growth including horticulture, agriculture, and aquaculture;

(ii) as applications relating to the provision of power and lighting in settings where animals are held including in animal husbandry;

(iii) applications relating to the deployment of power and lighting systems in large-scale settings having a demand for dynamic, responsive LED lighting; and

(iv) applications where LED-lighting and power are in close proximity to humans

wherein the method, or use, comprises a power and lighting system comprising one or more power consuming devices, wherein at least one of the power consuming devices is an LED-containing lighting device, wherein the LED-containing lighting device is adapted to be powered by a 3-phase AC power supply and wherein the 3-phase AC power supplied to the system is converted to DC power via 3-phase AC/DC rectification, and wherein the 3-phase AC power supplied to the system is distributed by tubular conductors.