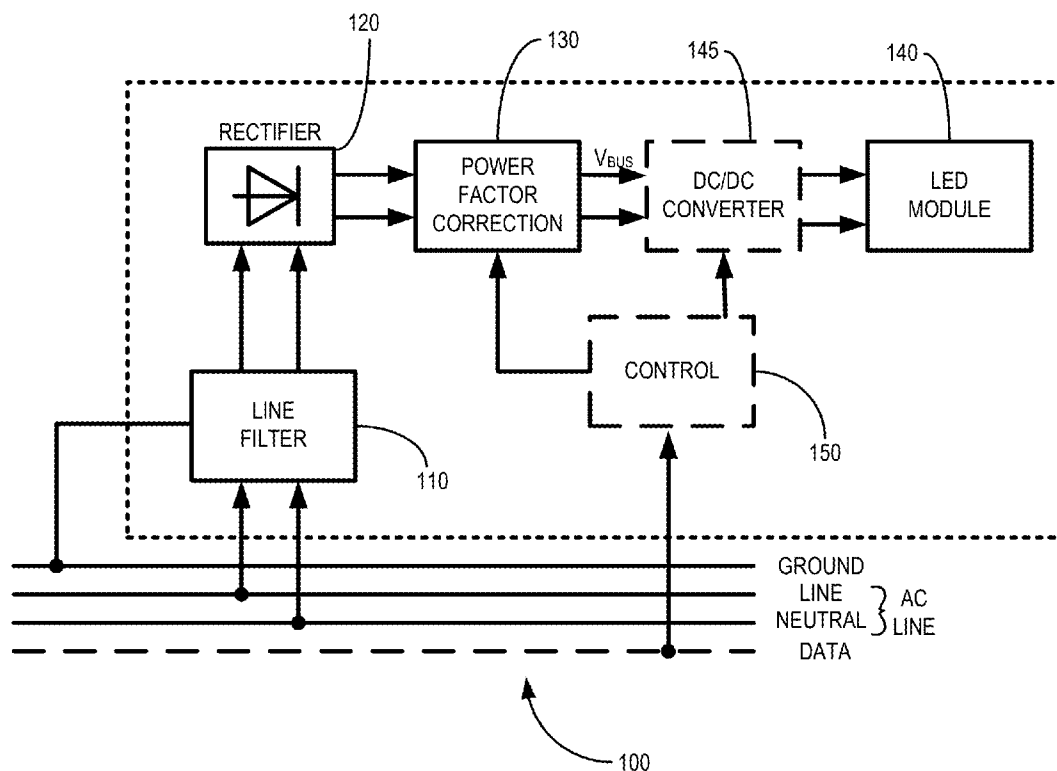


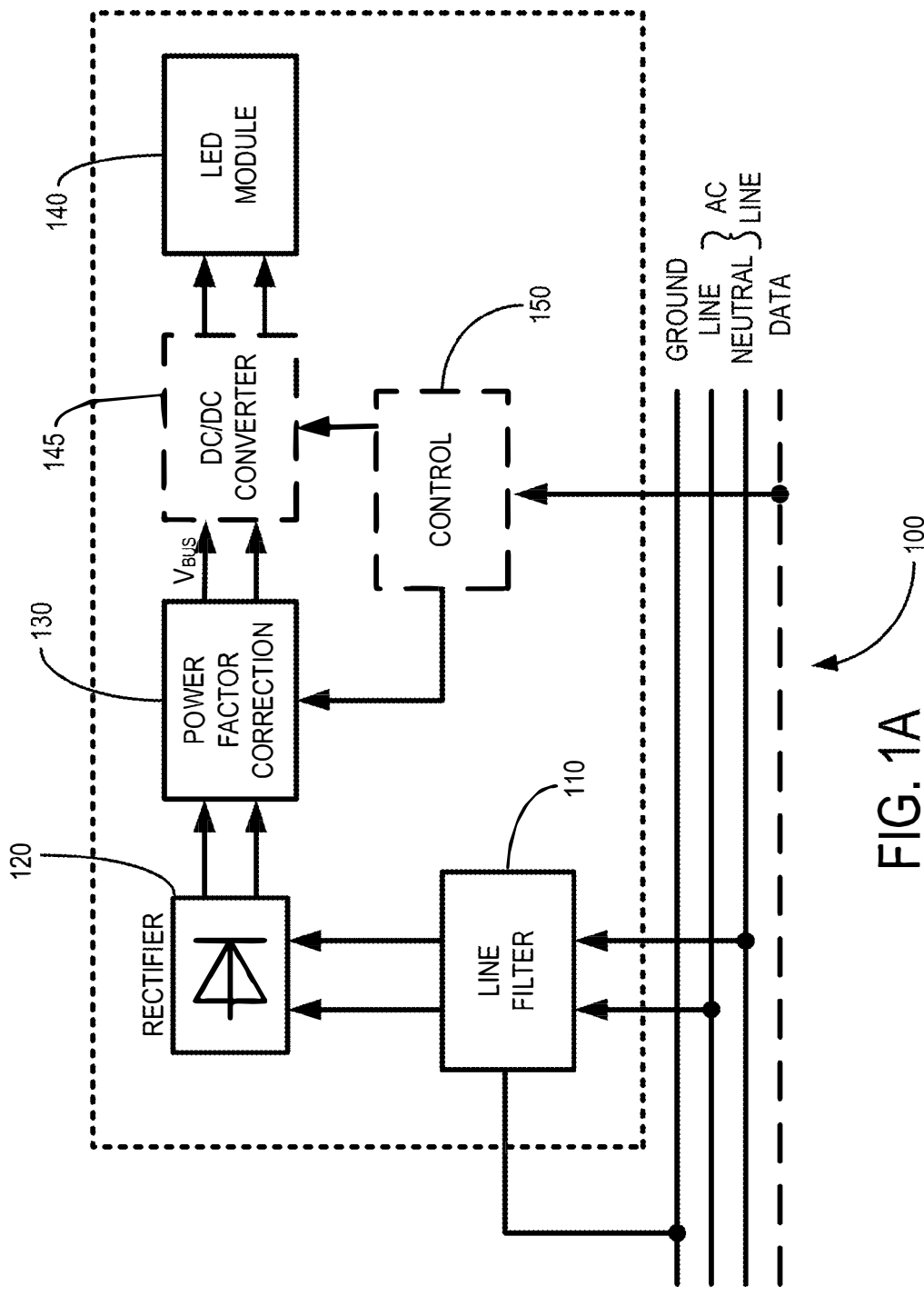


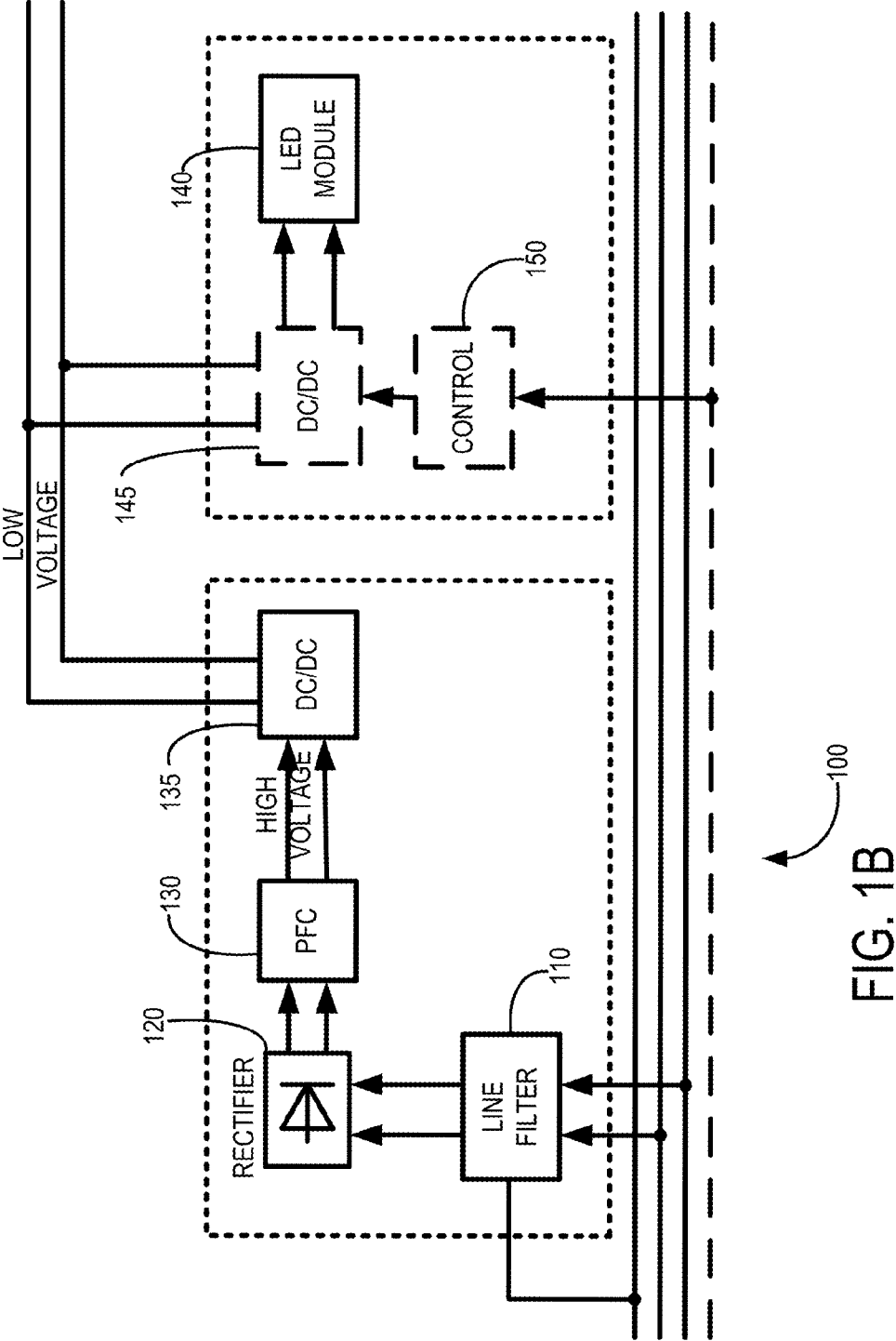
US 20140103804A1

(19) **United States**(12) **Patent Application Publication**
Zhdanau et al.(10) **Pub. No.: US 2014/0103804 A1**(43) **Pub. Date: Apr. 17, 2014**(54) **POWER DISTRIBUTION SYSTEM AND
METHOD FOR LED LIGHTING****Publication Classification**(71) Applicants: **Siarhei Zhdanau**, Mississauga (CA);
Vladimir Grigorik, Mississauga (CA)(51) **Int. Cl.**
H05B 33/08 (2006.01)(72) Inventors: **Siarhei Zhdanau**, Mississauga (CA);
Vladimir Grigorik, Mississauga (CA)(52) **U.S. Cl.**
CPC **H05B 33/0812** (2013.01)
USPC **315/85**(21) Appl. No.: **13/840,494**(22) Filed: **Mar. 15, 2013****Related U.S. Application Data**(60) Provisional application No. 61/612,741, filed on Mar.
19, 2012.(57) **ABSTRACT**

There is disclosed an improved LED lighting system and method which limits current and employs a voltage significantly greater than line voltage in order to allow lighting circuits to be built with up to thousands of Watts fed from a single power/data source. The present system and method allows exceptionally long lengths of LED lighting of 200 meters or more for large scale LED lighting applications such as the architectural delineation of skyscrapers and bridges.







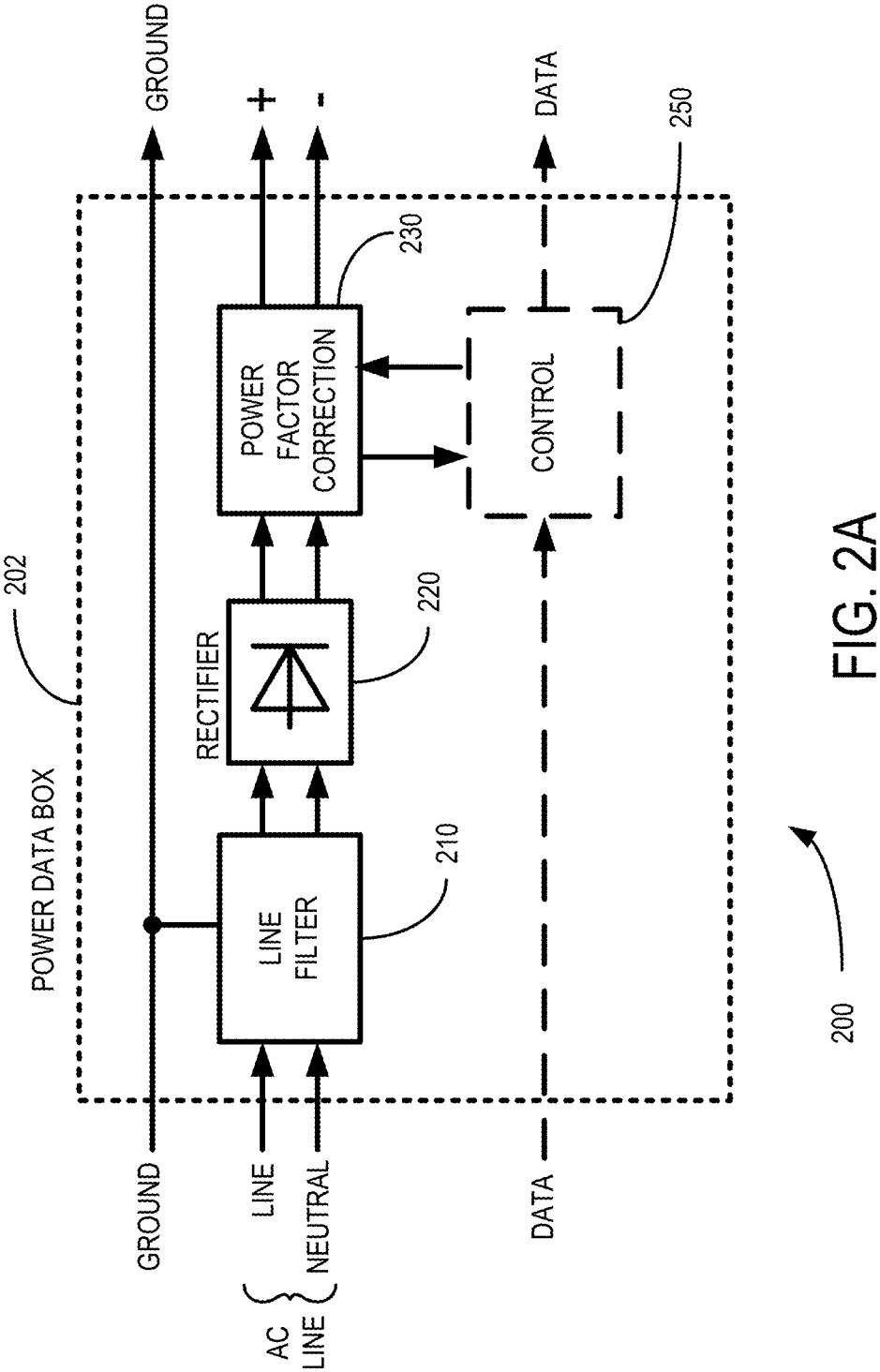


FIG. 2A

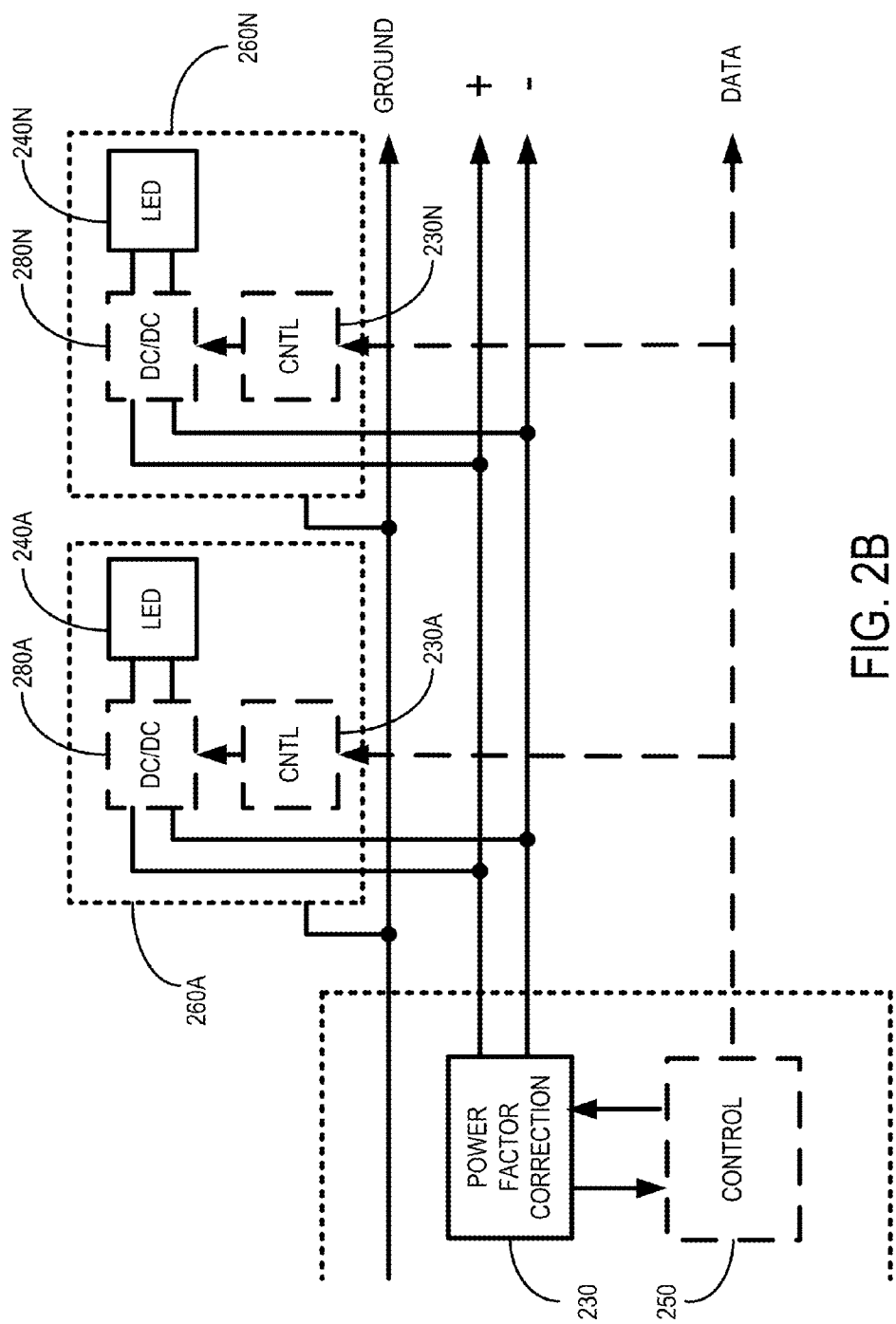


FIG. 2B

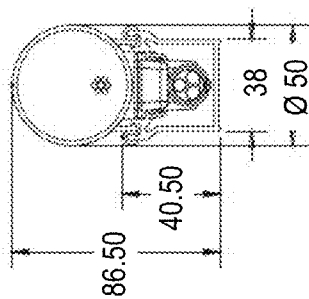
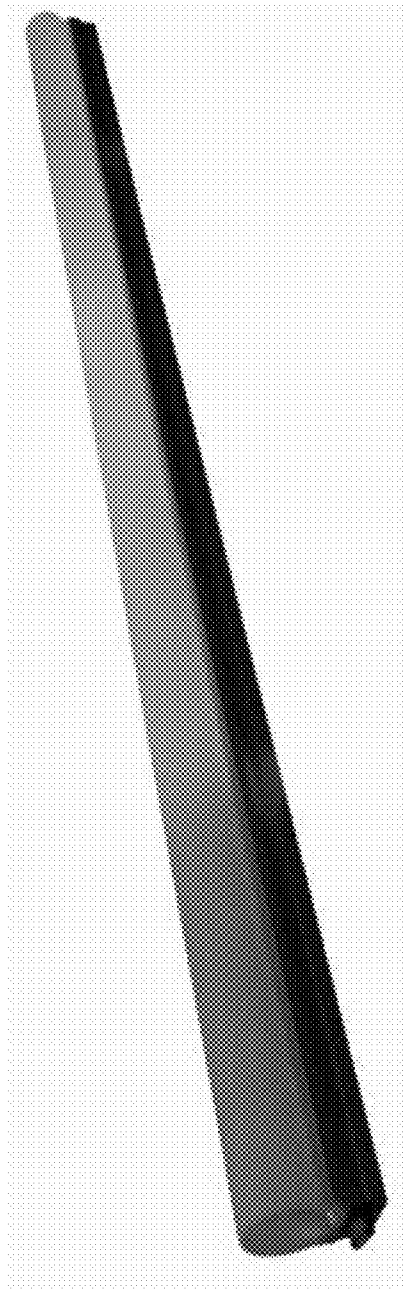


FIG. 3A

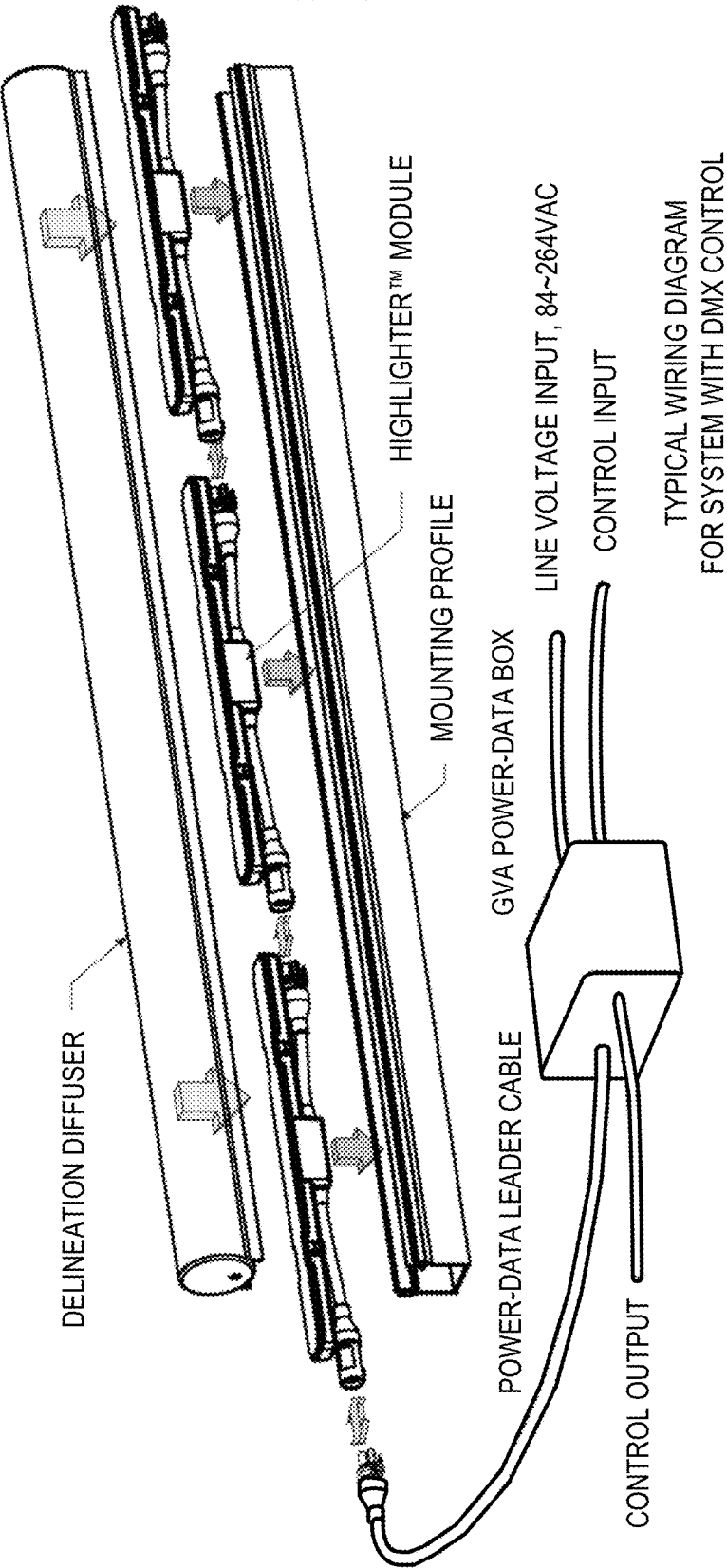


FIG. 3B

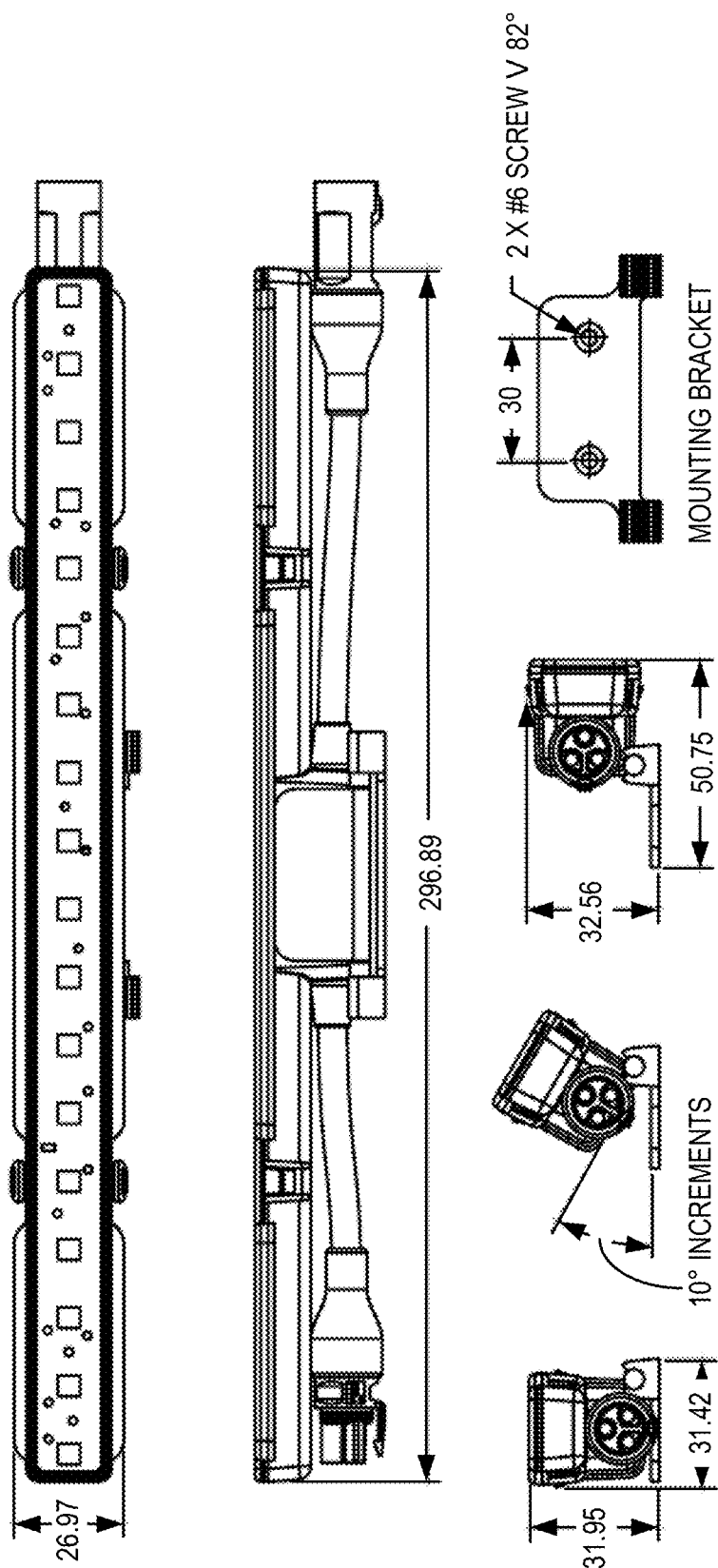


FIG. 4A

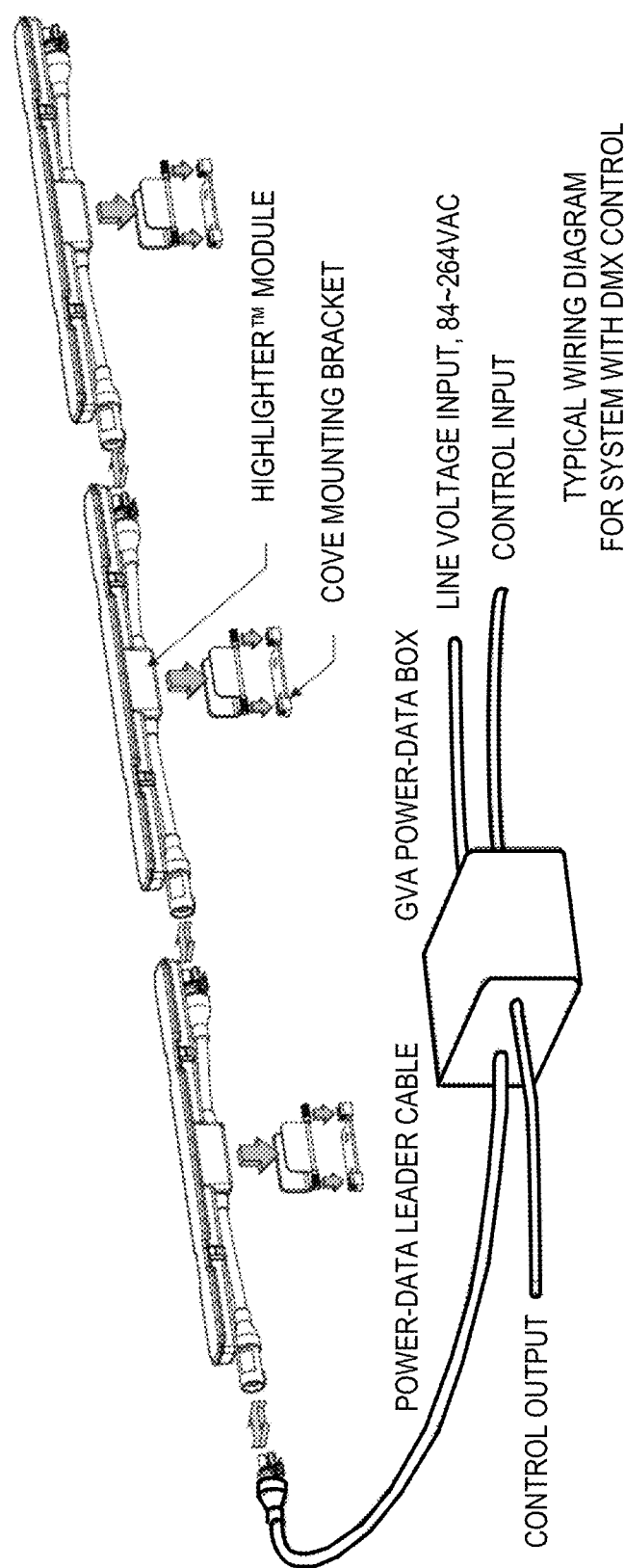


FIG. 4B

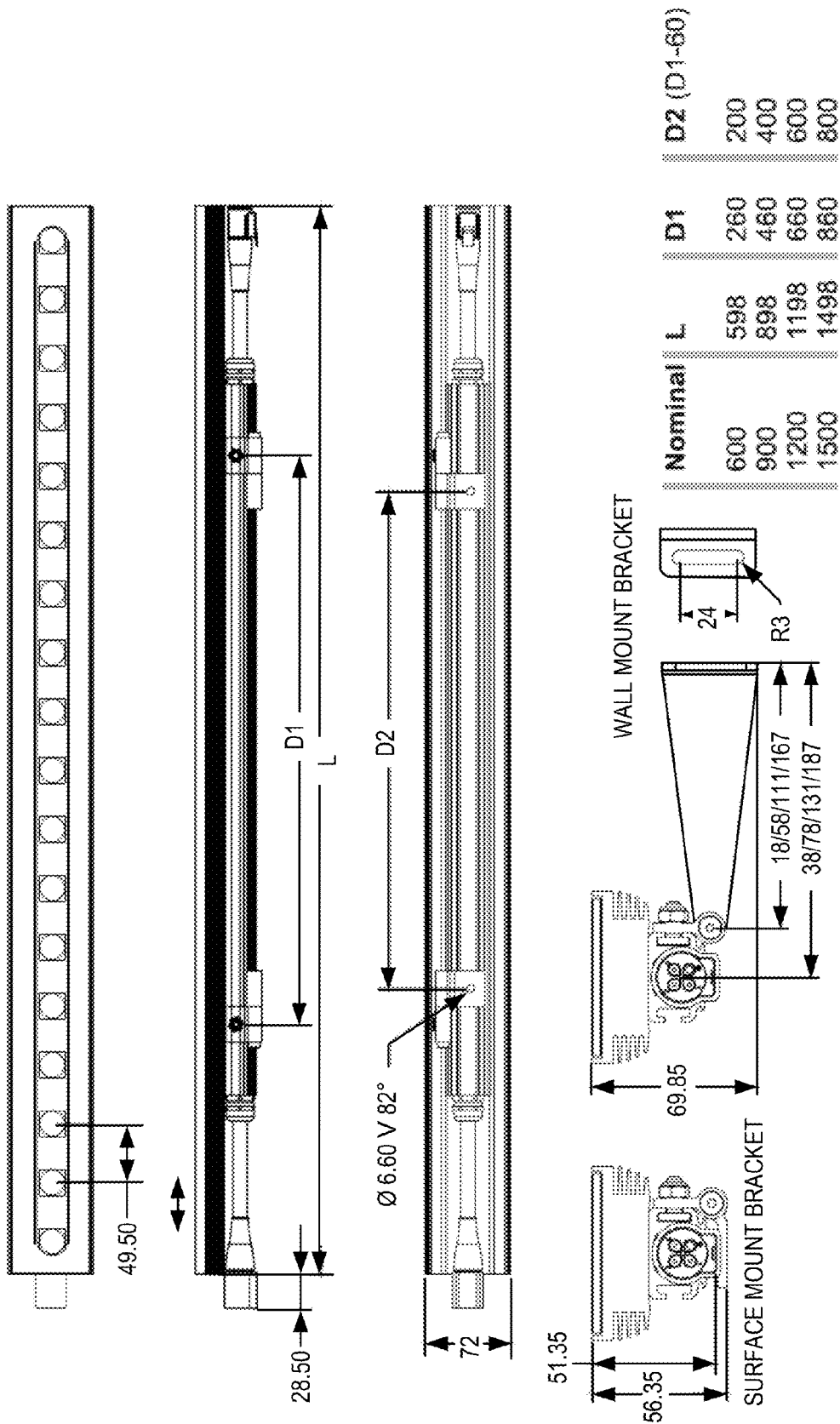


FIG. 5A

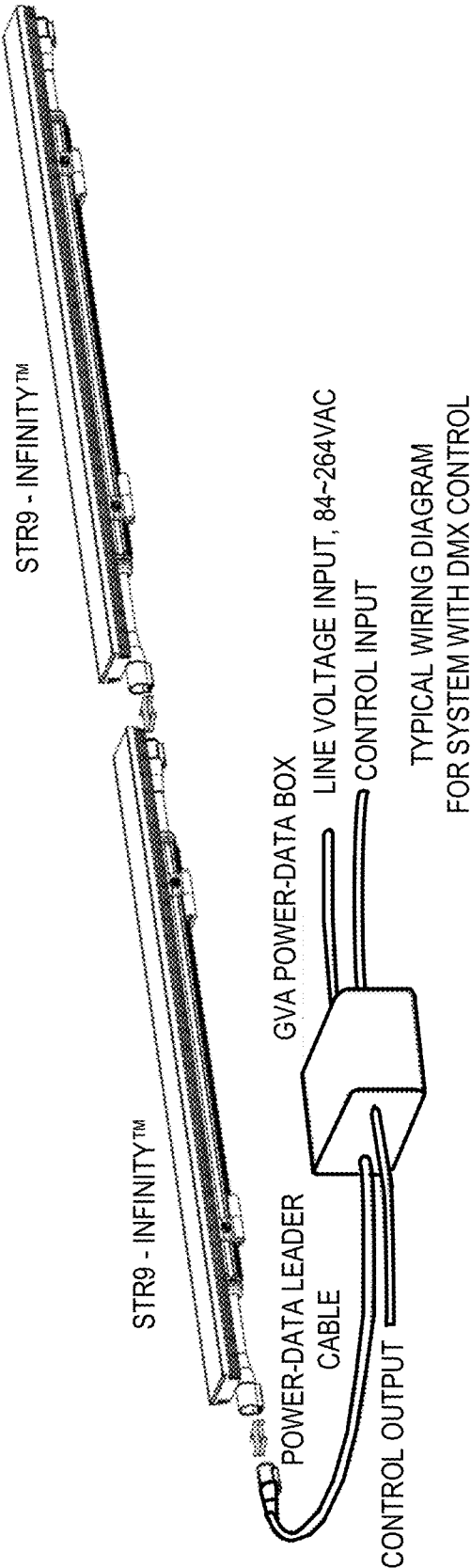


FIG. 5B

POWER DISTRIBUTION SYSTEM AND METHOD FOR LED LIGHTING

FIELD

[0001] This present disclosure relates generally to a power distribution system and method for light emitting diode (LED) lighting.

BACKGROUND

[0002] Large scale controllable LED lighting applications such as lighting for architectural delineation for skyscrapers, bridges, airports and shopping malls and other mission critical applications require high system reliability, and long service life. Additionally, such applications desire small luminaire size and long luminaire run length from single power connection point.

[0003] However, existing power distribution systems for LED lighting suffer from limitations including limited life, larger luminaire dimensions, limited lighting length and limited system life.

[0004] What is needed is an improved power system and method for LED lighting which overcomes at least some of these limitations.

SUMMARY

[0005] This present disclosure relates generally to an improved AC line supplied LED lighting power distribution system and method, in which the required power conversion components, specifically electromagnetic interference (EMI) filter, rectifier, and power factor corrector (PFC), are located remotely from luminaires, enabling smaller luminaire size, and keeping the advantages of the high voltage power distribution system.

[0006] Additionally, the disclosed power distribution current is limited to reasonable ranges in order to maintain desirably small physical dimensions. The disclosed power distribution system delivers sufficient total power by significantly increasing the system voltage above the peak input line voltage (e.g. 110 VAC in North America).

[0007] In an illustrative embodiment, which is not meant to be limiting, a system is designed around AWG 18 conductors with current limited to 10 A, and voltage at around 380 VDC to allow lighting circuits to be built with up to 3,800 W fed from a single power/data source.

[0008] With the present system and method, LED lighting lengths of 200 meters or more may be configured providing exceptionally long runs of LED lighting for large scale LED lighting applications such as the architectural delineation for skyscrapers and bridges.

[0009] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1A shows a schematic block diagram of a conventional AC LED lighting system with inboard power distribution

[0011] FIG. 1B shows a schematic block diagram of a conventional AC LED lighting system with low-voltage power distribution.

[0012] FIGS. 2A and 2B show an illustrative schematic block diagram of the disclosed power distribution system for LED lighting utilizing a power-data box in accordance with an embodiment.

[0013] FIGS. 3A and 3B show illustrative perspective views of one possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B.

[0014] FIGS. 4A and 4B show illustrative plan views and perspective views of another possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B.

[0015] FIGS. 5A and 5B show illustrative plan views and perspective views of yet another possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B.

[0016] In the drawings, embodiments of the invention are illustrated by way of example. It is to be expressly understood that the description and drawings are only for the purpose of illustration and as an aid to understanding, and are not intended as a definition of the limits of the invention.

DETAILED DESCRIPTION

[0017] As noted above, the present disclosure relates generally to an improved power distribution system and method for LED lighting, especially for large scale LED lighting applications such as lighting for architectural delineation for skyscrapers, bridges, airports and shopping malls and the like.

[0018] Prior art technologies are based on two common approaches to power distribution:

[0019] 1. Low-voltage DC power distribution—power supply converting AC to low voltage DC is located remotely from luminaire. Each luminaire is powered by low voltage DC power.

[0020] 2. Inboard luminaire power integration—power supply is integrated with luminaire, enabling high voltage distribution but large luminaire dimensions.

[0021] A low voltage DC distribution system is not suitable for lighting significant lengths due to electric current limitations, as specified by Class 2 electrical code. The LED lighting lengths, for example at 5 Watts/foot (1 foot=0.3048 meters) can be extended only 20 feet or so assuming 5 W/ft power consumption to stay within Class 2 specifications.

[0022] An inboard luminaire power system, where the AC/DC power supplies are integrated with LED luminaires, enables extended run lengths (e.g. 50-60 ft at 110 VAC, and 100 ft at 220 VAC), however the physical dimensions of luminaires are increased due to the presence of EMI, rectified and PFC power conversion components within the luminaire. Additionally, the overall system reliability is dictated by the shortest lifespan of inboard components. Typical embodiments of this approach rely on electrolytic capacitors which have an order of magnitude shorter lifespan than other components of the system. Also, the lighting run lengths remain capped because they are based on fixed input AC line voltage (110 VAC or 220 VAC depending on the geographical region).

[0023] The present system and method was developed by the inventors to address the issues of component size, while

maintaining sufficient brightness over long lighting lengths. More particularly, the inventors proposed a power distribution system in which the required power conversion components, specifically EMI filter, rectifier, and PFC, are located remotely from luminaires, enabling smaller luminaire size, and keeping the advantages of the high voltage power distribution system.

[0024] Additionally, the inventors made a decision to limit the current to a suitable level in order to be able to use sufficiently small gauges of conductive wires, and by significantly increasing voltage over conventional household line voltages (e.g. 110 VAC in North America, and 220 VAC in Europe and other regions) to allow for adequate power.

[0025] As an illustrative example, which is not meant to be limiting, a system is designed around AWG 18 conductors with current limited to 10 Amps, and voltage at around 380 VDC to allow lighting circuits to be built with up to 3,800 W fed from a single power/data source. With the present system and method, LED lighting lengths of 200 meters or more may be configured providing exceptionally long runs of LED lighting for large scale LED lighting applications such as the architectural delineation for skyscrapers and bridges. To generate the high voltages necessary, the present system and method utilizes a power-data box comprising a filter, bridge and a PFC as a power source, replacing multiple PFC modules in each lighting module with a single PFC provided in the power-data box.

[0026] Various illustrative embodiments are described with respect to the figures.

[0027] Referring to FIG. 1A, shown is a schematic block diagram of a conventional AC LED lighting system with inboard power distribution **100** including a line filter **110** connected to ground and to an AC line including line and neutral. The AC line provides a typical AC line voltage (e.g. 110 VAC in North America, 220 VAC in Europe and in other regions). The AC line voltage can also be supplied from 2 or 3 phase power systems. As shown, line filter **110** is operatively connected to a rectifier **120**, which in turn is connected to a power factor correction ("PFC") module **130**. The rectifier **120** converts an input AC line voltage source to a DC voltage at value $V_{ac} \cdot \sqrt{2}$, where V_{ac} is the root mean square value of the AC line voltage. PFC **130** provides power factor on the AC line close to 1.0 and its output voltage (for a boost type of PFC) is at least a few volts higher than DC voltage from the rectifier **130** (180 VDC at AC line voltage 110 VAC; 260 VDC at AC line voltage 220 VAC and 430 VDC at universal AC line voltage 70 VAC to 305 VAC). Notably, using any step-down type of PFC (for example buck, buck-boost, etc.) is a problem for red green blue (RGB) color changing types of LED luminaires for various reasons. A bus voltage V_{bus} from PFC **130** supplies LED module **140**. An optional DC/DC driver **145** may be provided between PFC **130** and LED module **140** to down convert to a voltage suitable to the LED module **140**. A control **150** is adapted to receive a data signal from the data line to control DC/DC driver **145** and/or PFC **130**.

[0028] Referring to FIG. 1B, shown is a schematic block diagram of another conventional AC LED lighting system with low-voltage power distribution. As shown, line filter **110**, rectifier **120** and PFC **130** supply a high voltage to a DC/DC converter **135** in a conventional power box. DC/DC converter **135** provides low voltage power to one or more luminaires, including a DC/DC driver **145**, control **150**, and an LED **140**. The low voltage power provided to the one or

more luminaires necessitates a correspondingly high current in order to drive the one or more luminaires at sufficient brightness. To handle the higher current, a thicker gauge wire is required in order to extend the length of the wires providing the low voltage power.

[0029] Now referring to FIGS. 2A and 2B, shown is an illustrative schematic block diagram of a DC LED lighting system **200** utilizing a power-data box in accordance with an embodiment. As shown in FIG. 2A, in an embodiment, the DC LED lighting system **200** includes a power-data box **202**, which includes a line filter **210** connected to ground and to line and neutral of an AC line. Power data box **202** further includes a rectifier **220**, a PFC module **230**, and a control unit **250**.

[0030] FIG. 2B shows PFC **230** and control **150** from FIG. 2A, and further shows ground, + and - lines from PFC **130**, and data lines extending from power-data box **202**. As shown in FIG. 2B, one or more luminaires **260A** . . . **260N** are connected to ground, the + and - lines of PFC **130**, and to the data line. More particularly, each LED module **260A** . . . **260N** includes individual LEDs **240A** . . . **240N** and an LED module control **230A** . . . **230N** adapted to receive data from main control unit **250**. Each of the LED module controls **230A** . . . **230N** may be used to control the current and brightness of individual LEDs **240A** . . . **240N**, and may be collectively controlled via the main control unit **250** to generate various lighting patterns.

[0031] As shown in FIG. 2B, LED luminaires **260A** . . . **260N** need not contain individual PFCs **130** as in FIG. 1, as the LEDs **240A** . . . **240N** are connected to PFC module **230** in the main power data box **202**. This significantly decreases the number of components required in LED modules **240A** . . . **250N**. Optional LED module controls **230A** . . . **230N** connected to optional DC/DC drivers **280A** . . . **280N** may be addressable to individually receive data from main control unit **250** or to receive data broadcast to all LED module controls **230A** . . . **230N**.

[0032] In an embodiment, the gauge or cross-section area of the conducting wires used to connect LED luminaires **260A** . . . **260N** may be selected much less than for conventional AC LED lighting system **100** (FIG. 1) due to the limited current, and output voltage from PFC **230** being significantly higher than AC line voltage used in conventional AC LED lighting system **100**.

[0033] More preferably, the gauge of the conducting wires used to connect LED luminaires **260A** . . . **260N** may be selected to be between American Wire Gauge (AWG) AWG 24 and AWG 14, and the current may be limited between 5 and 30 Amps, such that the size of the LED luminaires **260A** . . . **260N** can be limited to desirably small dimensions.

[0034] Most preferably, the gauge of the conducting wires used to connect LED luminaires **260A** . . . **260N** may be selected to AWG 18, and the current may be limited to 10 Amps, such that the size of the Luminaires **260A** . . . **260N** can be limited for use in illustrative examples as shown in FIGS. 3-5 as described further below.

[0035] In an embodiment, power-data box **202** is adapted to supply a DC voltage significantly higher than conventional line voltage, in an operable range up to 430 VDC.

[0036] More preferably, power-data box **202** is adapted to supply a DC voltage between a range of 100 and 400 VDC, such that power-data box **202** can generate a sufficiently high level of power to supply power to individual LEDs **240A** . . . **240N** for significant lengths.

[0037] Most preferably, power-data box **202** is adapted to supply a DC voltage between a range of about 200 and 380 VDC, such that power-data box **202** can generate up to 3,800 Watts, which can be used to supply power to individual LEDs **240A . . . 240N** rated at between about 1 and 100 Watts, connected at appropriate intervals depending on the Wattage of the LEDs **240A . . . 240N**, over lengths of conductive wires extending 200 meters or more.

[0038] In an embodiment, Table 1 below shows possible lighting lengths in meters achievable when the power-data box **202** is capable of generating 2,000 Watts and 3,800 Watts and 5,000 Watts of power utilizing 110 VAC or 220-240 VAC input line voltages.

TABLE 1

POWER-DATA-BOX	INPUT VOLTAGE	STR9-INF			
		HL-DL	HL-COVE	25 Watts/meter	50 Watts/meter
PDB-2000	90-199 VAC	110	110	39	20
PDB-2000	200-264 VAC	60	60	73	36
PDB-3800*	90-264 VAC	201**	201**	142	72
PDB-5000*	90-264 VAC	201**	201**	182	93

**For the color mixing version requiring three control channels to independently control three colors (for example red, green, and blue) version, the maximum length is 341 feet for 1 foot addressability (limited by DMX control universe, which can only address 241 three color pixels), full length for three channel control requires two DMX control universes.

[0039] Now referring to FIGS. 3A and 3B, shown are illustrative perspective views of one possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B. FIG. 3A illustrates a length of lighting which may include a number of lighting unit modules connected in series. As shown in FIG. 3B, three lighting unit modules are connected in series and covered by a delineation diffuser, which may be acrylic for example. A mounting profile, which may be aluminium for example, receives the three lighting unit modules and together with the delineation diffuser provides a protective, fully sealed IP66 300 millimeters (nominally 1 foot) luminaire with 18 LEDs. In use, each lighting unit module snaps into place in the aluminium profile, which is securely fastened to a mounting surface. The three lighting unit modules are connected end-to-end within the profile to create linear runs. The acrylic diffuse, with specialized light diffusing and UV stabilizing additives, installs to the profile, over the LED light modules. The diffuser conceals all mounting provisions, and provides a clean, uniform illuminated surface.

[0040] Still referring to FIG. 3B, a first end of the first lighting unit module is connected by a power-data leader cable to a power-data box shown in the foreground. The power-data box include a line voltage input, which may be between about 84-347 VAC. The power-data box also receives a control input line, and a control output leads out of the power-data box to be connected to the lighting unit modules in order to control the individual LED modules.

[0041] As shown in Table 2, below, this illustrative embodiment shown in FIGS. 3A and 3B allows exceptionally long runs of up to 201 meters with a single power and data feed from the power-data box.

TABLE 2

Specification Logic				
FAMILY	MOUNTING PROFILE COLOUR	LED COLOR	CONTROL	RUN LENGTH (IN METERS OR FEET)*
HL-DL	CM—Clear	RGB	ND—No Dimming	XXX
	Matts	2700K	DMX—DMX	
	CUSTOM	3000K	Control	
		3500K	DALI—DALI	
		4000K	Control	
		5000K	ARTNET—	
		6500K	ARTNET	
		RD—Red	Control	
		GR—Green	0-10 V - 0-10 V	
		BL—Blue	Dimming	

* Length should be in 1 ft or 0.3 m increments

Sample Logic: HL-DL-CM-RGB-DMX-102M

[0042] Now referring to FIGS. 4A and 4B, shown are illustrative plan views and perspective views of another possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B.

[0043] As shown in FIG. 4A, this illustrative embodiment comprises a long-run modular LED lighting system designed for cove lighting applications where it is impractical to have numerous power feed points. Typical applications include architectural cove lighting and delineation where long runs are necessary and limited power feeds are available. Exceptionally long runs of up to 201 meters are achievable with appropriate power-data-box.

[0044] In the present embodiment, the system consists of LED modules and corresponding mounting profiles. Each LED module is a fully sealed, IP66, 300 mm (1 foot) linear luminaire with 10 LEDs. Each module snaps into the mounting profile, which is securely fastened to the mounting surface. Modules are installed and connected end-to-end to create linear runs. Table 3, below, provides some illustrative LED lighting color and control specifications.

TABLE 3

Specification Logic			
FAMILY	LED COLOR	CONTROL	RUN LENGTH (IN METERS OR FEET)*
HL-COVE	RGB	ND—No Dimming	XXX
	2700K	DMX—DMX Control	
	3000K	DALI—DALI Control	
	3500K	ARTNET—ARTNET Control	
	4000K	0-10 V - 0-10 V Dimming	
	5000K		
	6500K		
	RD—Red		
	GR—Green		
	BL—Blue		

* Length should be in 1 ft or 0.3 m increments

Sample Logic: HL-COVE-RGB-DMX-300FT

[0045] Now referring to FIGS. 5A and 5B, shown are illustrative plan views and perspective views of yet another possible physical embodiment of the DC LED lighting system of FIGS. 2A and 2B.

[0046] This illustrative embodiment is a high-power, long-run, linear LED luminaire designed for wall “washing”, wall

“grazing” and cove lighting. Typical applications include “Architainment”, facade, bridge, airport, and shopping malls, particularly in large installations requiring long runs where multiple feeding points are not desirable or allowed. The system allows the LED modules to be connected end-to-end in exceptionally long runs (e.g. 182 meters at 25 Watt/meter consumption is achievable with a 5,000 W power-data-box. In an embodiment, IP68 rated connectors may be used to provide sealing even when unmated.

[0047] The LED modules are sealed to provide IP66 rated weatherproofing, and provides compact size, making it virtually invisible on the structure to which it is installed. The thermal design is effective in hot and humid climates as well as severe northern winters. Table 4, below, shows

3. The power distribution system of claim 2, wherein the conductor wires are between American Wire Gauge (AWG) 24 and AWG 14.

4. The power distribution system of claim 2, wherein the line filter, rectifier, and PFC are configured to generate a DC voltage between higher than peak AC line input and 750 VDC.

5. The power distribution system of claim 1, wherein the conductor wire is American Wire Gauge (AWG) 18 suitable for direct current up to about 10 A.

6. The power distribution system of claim 5, wherein the line filter, rectifier, and PFC are configured to generate a DC voltage between about 200 VDC and 380 VDC.

TABLE 4

Specification Logic									
FAMILY	NOMINAL LENGTH	BODY COLOR	LED QTY. PER 300 MM/ 1 FT.	LED POWER	LED COLOR	OPTICS	CONTROL	VOLT-AGE	MOUNTING
STR9-INF	600	CM—Clear Matte	6	1 W	2700K	TD—Tight Beam (8° FWHM)	ND—No Dimming, On/Off	380 VDC	SM—Surface Mount Adjustable
	900	BM—Black Matte		2.3 W	3000K	NB—Narrow Beam (12° FWHM)	ZH—GVA Protocol ZH	24 VDC	W35—Wall Mount Adjustable 38 mm
	1200				3500K	MB—Medium Beam (20° FWHM)		48 VDC	W78—Wall Mount Adjustable 78 mm
	1300				4000K	WB—Wide Beam (54° FWHM)			W121—Wall Mount Adjustable 131 mm
	1800				5000K	FB—Flood Beam (70° FWHM)			W187—Wall Mount Adjustable 187 mm
	2100				6300K	EB—Elliptical Beam (12° × 46° FWHM)	Sample Logic: STR9-INF-1500-CM-6-2WT-3000K-NB-ZH-380VDC		
	2400				RD—Red	AN—Asymmetrical Narrow			
					RO—Red-Orange	AE—Asymmetrical Elliptical			
					AM—Amber				
					GR—Green				
					BL—Blue				
					RB—Royal Blue				

[0048] While various illustrative embodiments have been described, it will be appreciated that various modifications and changes may be made without departing from the scope of the invention.

1. A power distribution system for light emitting diode (LED) lighting, comprising:

- a line filter configured to receive an alternating current (AC) line voltage;
- a rectifier for converting the AC line voltage into a direct current (DC) voltage; and
- a power factor corrector (PFC) configured to output a DC voltage greater than peak AC line voltage, and wherein the PFC configured to supply the DC voltage directly to a plurality of LED luminaires remotely connected to the PFC by conductor wires.

2. The power distribution system of claim 1, wherein the conductor wires are selected to have a cross-sectional area between about 2 mm² and 0.1 mm² suitable for direct current in a range of about 5 Amperes and 30 Amperes.

7. The power distribution system of claim 6, wherein the line filter, rectifier, and PFC are configured to supply up to about 3800 Watts of power over an extended conductor length of over 30 meters.

8. The power distribution system of claim 1, further comprising a control module for controlling the plurality of LED luminaires:

9. The power distribution system of claim 8, further comprising a data line for connecting the control module to a control unit in each remote LED luminaire.

10. The power distribution system of claim 9, further comprising a DC/DC driver in each LED luminaire configured to be controlled by the control unit in each remote LED luminaire.

11. A power distribution method for light emitting diode (LED) lighting, comprising:

- providing a line filter configured to receive an AC line voltage;
- providing a rectifier for converting the AC line voltage into a DC voltage; and

a configuring a power factor corrector (PFC) to output a DC voltage greater than peak AC line voltage, and wherein the PFC configured to supply the DC voltage directly to a plurality of LED luminaires remotely connected to the PFC by conductor wires.

12. The power distribution method of claim **11**, further comprising selecting the conductor wires to have a cross-sectional area between about 2 mm² and 0.2mm² suitable for direct current in a range of about 5 A and 30 A.

13. The power distribution method of claim **12**, wherein the conductor wires are between American Wire Gauge (AWG) 24 and AWG 14.

14. The power distribution method of claim **12**, wherein the line filter, rectifier, and PFC are configured to generate a DC voltage between higher than peak AC line input and 750 VDC.

15. The power distribution method of claim **12**, wherein the conductor wire is American Wire Gauge (AWG) 18 suitable for direct current up to about 10 A.

16. The power distribution method of claim **15**, wherein the line filter, rectifier, and PFC are configured to generate a DC voltage between about 200 VDC and 380 VDC.

17. The power distribution method of claim **16**, wherein the line filter, rectifier, and PFC are configured to supply up to about 3800 Watts of power over an extended conductor length of over 30 meters.

18. The power distribution method of claim **11**, further comprising providing a control module for controlling the plurality of LED luminaires:

19. The power distribution method of claim **18**, further comprising providing a data line for connecting the control module to a control unit in each remote LED luminaire.

20. The power distribution method of claim **19**, further comprising a DC/DC driver in each LED luminaire configured to be controlled by the control unit in each remote LED luminaire.

* * * * *