Title: A SYSTEM AND METHOD FOR ACTIVE POWER FACTOR CORRECTION AND CURRENT REGULATION IN LED CIRCUIT

Abstract: The present invention discloses a method and system for active power factor correction and current regulation in LED circuit. The system (100) used in the LED driver circuit performs active PFC and current regulation through the dynamic input current wave shaping by limiting peak currents. The dynamic wave shaping scheme is realized through hardware and firmware and is used to strike an optimal balance between current accuracy, Power factor, THD and peak inductor currents. The system (100) is versatile enough to improve PF and current accuracy in LED circuits and indimmers circuits.
Designated States (unless otherwise indicated, for every field of regional protection available):

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- GM, KE, LR, LS, MW, MZ, NA, RW, SE, SL, ET, SZ,
- TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RO,
- T1, TH), European (AL, AT, BE, BG, CH, CY, CZ, DE,
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TITLE OF THE INVENTION

A system and method for active power factor correction and current regulation in led circuit

[0001] Technical field of the invention

[0002] The present invention relates to a system and method to achieve optimal balance between current accuracy, inductor size, PF (Power Factor), THD (Total Harmonics Distortion) and peak inductor currents using the active PFC (Power Factor Correction) without the use of external components therein. More particularly, the present system achieves PFC through customized wave shaping profile by using the intelligent current control and peak current limit control.

[0003] Background of the invention

[0004] LEDs (Light Emitting Diode) are used in a variety of applications as indicator lamps and in different types of lighting environments, for example in aviation lighting, digital microscopes, automotive lighting, backlighting, advertising, general lighting, and traffic signals. The LEDs have significant advantages such as high efficiency, good directionality, color stability, high reliability, long life time, small size, and environmental safety. The LED systems having efficient power factor leads to various factors such as less thermal runaway issues, less chances of flicker and less fault scenarios. Power factor is defined as the ratio of real power to apparent power. Power factor correction (PFC) is the process of adjusting the characteristics of electric loads that create a power factor less than 1. Power factor correction is used to improve the stability and efficiency of the transmission network. The power factor correction intern reduces the costs in the transmission networks by reducing the losses. A high power factor (i.e., close to unity, or "1") is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load.
Various types of conventional LED circuits that are used for active power factor correction are known in the prior art. The US Patent document 7952293 B2 describes the power factor correction and driver circuits. The claimed circuit defines about the power factor correction and driver circuits. Driver circuits configured for electrical loads such as series arrangements of light emitting diodes are also described. An exemplary embodiment of a driver circuit can implement a comparator and/or a voltage regulator to allow for improved output current uniformity for high-voltage applications and loads, such as series configurations of LEDs. Embodiments of PFC stages and driver stages can be combined for use as a power supply, and may be configured on a common circuit board. Power factor correction and driver circuits can be combined with one or more lighting elements as lighting.

The US Patent document 7295452 B1 describes an active power factor correction circuit and control method thereof. The method comprises the following steps. Drive the power switch of the circuit so that the average inductor current waveform follows the rectified input voltage waveform. Suspend the operation of the power switch at a first moment in a first line cycle of the rectified input voltage and then resume the operation of the power switch at a second moment in a second line cycle of the rectified input voltage. The first moment is when the phase angle of the rectified input voltage exceeds a predetermined angle and the switching frequency of the power switch exceeds a predetermined frequency. The time span from the first moment to the end of the first line cycle is substantially as long as the time span from the beginning of the second line cycle to the second moment.

However, the claimed driver circuits and methods use analog and digital implementations. The analog implementations use external elements such as capacitors to estimate the average current and to achieve low loop band width for PFC. The driver circuit uses external components to detect accurate switching cycle by cycle power for open loop LED driver application. The digital implementations use expensive filter implementations and/or complicated high
speed sampling schemes. These implementations does not provide enough flexibility to detect switching cycle by cycle power, loop band width adjustability, error detection etc.

[0008] Typically, the Switching Mode Power Supply (SMPS) does not receive continuous power from input supply, which leads to Low Power Factor(LPF) and THD. The passive PF scheme minimises the THD and improves the PF by drawing continues power from the input supply. However, the passive scheme leads to increased component count, cost, lower efficiency and board space requirements.

[0009] Typically, in convention PFC the wave shaping implies to higher currents at higher AC Supply and lower currents at lower supply, which leads in higher peak (inductor) currents and lower efficiency. The approach requires higher current rated inductors, which results in increased cost.

[0010] Hence, there is need for a system and method to achieve optimal balance between current accuracy, PF, THD and peak inductor currents using the active PFC without the use of external components therein. Further, the system achieves PFC through customized wave shaping profile by using the intelligent current control and peak current limit control, customizable through a firmware.

[0011] **Summary of the invention:**

[0012] The present invention overcomes the drawbacks in the prior art and provides a system and method for active power factor correction and current regulation in led circuit. The system comprises of an input module, a computing module, a subtractor module, a gain module, an accumulator module, an analog to digital module, a multiplier module, a digital to analog module, a Pulse Width Modulation (PWM) module, the power and current estimator module and a firmware control module (micro controller). The input module allows the user (s) to enter the reference set point as per the requirement through a reference block. The computing module is configured to compute the average power/current from a supply line cycle to generate the average feedback signal using a filter average.
The subtractor module is configured to receive the reference set point signal and the average feedback signal from the input module and computing module. The reference set point signal and average feedback signal is calculated by calculating the difference therein to produce an error signal using a subtractor. The gain module receives the difference error signal from the subtractor module and boost up the loop response and speed of correction in the error signal by adding the gain signal. The accumulator module is configured to accumulate the error signal from the gain module and determines the level of effective set point signal to ensure the average feedback signal equaling to the reference set point signal using an accumulator. In the preferred embodiment, the analog to digital module is configured to sense and convert the input line signal to the digital signal using an Analog to Digital Converter (ADC). The multiplier module is configured to multiply the output of the analog to digital module and the accumulator module using a multiplier. The multiplier module contains information of the input line signal and level of error signal. The digital to analog module receives and converts the digital signal from the multiplier module to the analog signal using a Digital to Analog Converter (DAC). The DAC establishes the set point to the inductor current level of the analog signal to perform active power factor correction and current regulation. Further, the system includes the control module which is configured to control the peak currents through inductor from input power supply using a switch. The controlled inductor peak currents are allowed to flow through a sense resistor to generate a voltage. The generated voltage is in form of saw tooth waveform. The saw tooth waveform determines the turn ON time and turns OFF time of the switch to achieve the active power factor correction and regulates the average LED current using the reference set point, wherein the average LED current tracks the reference set point in the LED circuit.

[0013] In a preferred embodiment of the invention, the system further comprises of a Pulse Width Modulation (PWM) module to turn ON the switch when the output of the DAC is larger than the voltage from the sense resistor using a PWM converter.
In a preferred embodiment of the invention, the system further comprises of a power and current estimator module configured to determine the cycle by cycle power/current based on various factors such as the DAC set point, turn ON time of the switch and switching period of the switch.

In a preferred embodiment of the invention, the system further comprises of a dim block, a thermal block and an input block. The dim block estimates the dimming duty cycle i.e. ON time and OFF time in the saw tooth waveform and in supply line frequency. The thermal block gives the thermal information of the outside electronic components such as LEDs and chips. The input block gives additional inputs such as error correction or any other desired information as per the applications in the LED circuits.

In a preferred embodiment of the invention, the system further detects and classifies the faults state when the average switching cycle by cycle power/current exceeds a specified tolerance band.

According to another embodiment of the invention, the system comprises of a firmware module which controls each block to generate the response for one or more events and transmit the response via the event based module to operate at-least one of the block selected from the list of the input module, the computing module, the subtractor module, the gain module, the accumulator module, the analog to digital module, the multiplier module, the digital to analog module and the control module for LED applications.

According to another embodiment of the invention, the invention provides method for active power factor correction and current regulation in led circuit. In most preferred embodiment, the method includes the step of entering the reference set point signal by the user(s) as per the requirement through a reference block. After entering the reference set point signal, the average power/current is computed from a supply line cycle to produce the average feedback signal. The difference between the reference set point signal and average feedback signal is calculated to produce an error signal using a subtractor. After calculating the error
signal, the gain signal is added to the error signal to boost up the loop response and speed of correction in the error signal. The error signal accumulated and the level of effective set point signal is determined to ensure the average feedback signal equalling to the reference set point signal using an accumulator. In the preferred embodiment, the input line signal sensed and converted to the digital signal using an ADC. After obtaining the digital signal, the digital signal multiplied with the error signal using a multiplier. The multiplier module contains information of the input line signal and level of error signal. After multiplying, the digital signal is to the analog signal using a DAC. The reference set point to the peak inductor current level of the analog signal is established using the DAC. Finally, the current through inductor from input power supply is controlled using a switch. The controlled inductor current is allowed to flow through a sense resistor to generate a voltage. The generated voltage is in form of saw tooth waveform which will determine the turn ON time and turn OFF time of the switch to achieve the active power factor correction and regulates the average LED current using the reference set point, wherein the average LED current tracks the reference set point in the LED circuit.

[0019] In a preferred embodiment of the invention, the method further provides the switching operations for the saw tooth waveform to compute cycle by cycle power/current to activate the plurality of events such as triggering a bleeder circuitry in dimming applications using the firmware.

[0020] In a preferred embodiment of the invention, the method further realizes the desired low loop band width for controlling the average currents using the firmware.

[0021] The prior arts use the external components to determine the switching cycle by cycle power/current through peak sense voltage or current setting. The present invention accurately detects the switching cycle by cycle power/current through peak sense voltage or current setting without using the external components. The invented method uses the firmware to accurately realize the average currents from single to multiple supply cycles. The invented system
provides post processing delay errors through a combination of hardware and firmware in LED driver applications.

[0022] The present invention provides a system and method which is simple, time saving, resource efficient, and cost effective. The invention may be used in variety of applications as indicator lamps and in different types of lighting environments which uses LED's.

[0023] It is to be understood that both the foregoing general description and the following details description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

[0024] **Brief description of the drawings:**

[0025] The foregoing and other features of embodiments will become more apparent from the following detailed description of embodiments when read in conjunction with the accompanying drawings. In the drawings, like reference numerals refer to like elements.

[0026] **Figure 1** illustrates a system for active power factor correction and current regulation in the led circuit, according to one embodiment of the invention.

[0027] **Figure 2** illustrates the method flow involved in implementing the active power factor correction and current regulation in the led circuit, according to one embodiment of the invention.

[0028] **Figure 3** shows the wave shaping profile for active power factor correction and current regulation in the led circuit, according to one embodiment of the invention.

[0029] **Figure 4** shows the saw tooth wave of active power factor correction and current regulation in the led circuit, according to one embodiment of the invention.

[0030] **Figure 5** shows the dimmer waveform shaping profile of the LED circuits, according to one embodiment of the invention.
Detailed description of the invention:

Reference will now be made in detail to the description of the present subject matter, one or more examples of which are shown in figures. Each embodiment is provided to explain the subject matter and not a limitation. These embodiments are described in sufficient detail to enable a person skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, physical, and other changes may be made within the scope of the embodiments. The following detailed description is, therefore, not be taken as limiting the scope of the invention, but instead the invention is to be defined by the appended claims.

The present invention discloses a system and method for active power factor correction and current regulation in led circuit. The system used in the LED driver circuit performs active PFC through the dynamic input current wave shaping while limiting peak currents. The dynamic wave shaping scheme is realized through hardware and firmware and is used to strike an optimal balance between current accuracy, Power factor, THD and peak inductor currents. The system is versatile enough to improve PF and current accuracy in LED circuits and dimmers circuits.

Figure 1 illustrates a system for active power factor correction and current regulation in led circuit, according to one embodiment of the invention. The system (100) comprises of an input module (101), a computing module (102), a subtractor module (103), a gain module (104), an accumulator module (105), an analog to digital module (106), a multiplier module (107), a digital to analog module (108), a Pulse Width Modulation (PWM) module (110), the power and current estimator module (109), a firmware module (118) and a control module. The input module (101) allows the user(s) to enter the reference set point as per the requirement through a reference block (114). The computing module (102) is configured to compute the average power or current from a supply line cycle to generate the average feedback signal using a filter average. The subtractor module (103) is configured to receive the reference set point signal and the average...
feedback signal from the input module (101) and computing module (102). The reference set point signal and average feedback signal is calculated by calculating the difference therein to produce an error signal using a subtractor. The gain module (104) receives the difference error signal from the subtractor module (103) and boost up the loop response and speed of correction in the error signal by adding the gain signal. The accumulator module (105) is configured to accumulate the error signal from the gain module and determines the level of effective reference set point signal to ensure the average feedback signal equaling to the reference set point signal using an accumulator.

[0035] In the preferred embodiment, the analog to digital converter module (106) is configured to sense and convert the input line signal to the digital signal using an Analog to Digital Converter (ADC). The multiplier module (107) is configured to multiply the output of the analog to digital module and the accumulator module using a multiplier. The multiplier module (107) contains information of the input line signal and level of error signal. The digital to analog module (108) receives and converts the digital signal from the multiplier module (107) to the analog signal using a Digital to Analog Converter (DAC). The DAC establishes the set point to the inductor current level of the analog signal to perform active power factor correction and regulates the average current. Further, the system (100) includes the control module which is configured to control the peak currents through inductor (112) from input power supply using a switch (111). The controlled inductor peak currents are allowed to flow through a sense resistor (113) to generate a voltage. The generated voltage is in form of saw tooth waveform. The saw tooth waveform determines the turn ON time and turns OFF time of the switch to achieve the active power factor correction and regulates the average LED current using the reference set point, wherein the average LED current tracks the reference set point in the LED circuit.

[0036] In the preferred embodiment, the firmware module (118) is configured to operate for each module. The firmware module (118) provides flexible operations for each module. The connection between each block in the system is done
through the firmware module (118). The firmware module (118) provides wireless connection between each block in the system. The operation of each block remains same even though the position of each block is interchanged using the firmware module (118).

[0037] In the preferred embodiment, the Pulse Width Modulation (PWM) module (110) is configured to turn ON the switch when the output of the DAC is larger than the voltage from the sense resistor using a PWM converter. The system (100) further includes the power and current estimator module (109) which is configured to determine the cycle by cycle power or current based on various factors such as the DAC set point, turn ON time of the switch and switching period of the switch.

[0038] The system (100) further comprises of a dim block, a thermal block and an input block. The dim block (115), the thermal block (116) and the input block (117) updates and alerts the system (100) by inputting the various information. The dim block (115) estimates the dimming duty cycle i.e. ON time and OFF time in the saw tooth waveform and in the supply line frequency. The thermal block (116) gives the thermal information of the outside electronic components such as LEDs and chips. The input block (117) gives additional inputs to the system such as error correction or any other desired information as per the applications in the LED circuits.

[0039] In the preferred embodiment, the system (100) comprising a firmware module (118) which is configured to work for each block to generate the response for one or more events and transmit the response via the event based module to operate at-least one of the block selected from the list of the input module (101), the computing module (102), the subtractor module (103), the gain module (104), the accumulator module (105), the analog to digital module (106), the multiplier module (107), the digital to analog module (107) and the control module for LED applications.

[0040] In the preferred embodiment, the system (100) further calculates the error signal over a supply cycle and provides automatic averaging/filtering, wherein the
calculated error signal produces wave shaping profile, wherein the wave shaping profile may be further customized through the firmware module (118).

[0041] Figure 2 illustrates the method flow (200) involved in implementing the active power factor correction and current regulation in led circuit, according to one embodiment of the invention. At step (201), user (s) enters the reference set point signal in a reference block (s) as per the requirement. After entering the reference set point signal, at step (202), the average power or current from a supply line cycle or cycles is computed to produce the average feedback signal. At step (203), the difference is calculated between the reference set point signal and average feedback signal to produce an error signal. After calculating the error signal, at step (204), the gain signal is added to the error signal to boost up the loop response and speed of correction in the error signal. At step (205), the error signal is accumulated and the level of reference effective set point signal is determined to ensure that the average feedback signal equalling to the reference set point signal. At step (206), the input line signal is sensed and converted to the digital signal using an ADC. After converting the analog signal to digital signal, at step (207), the digital signal is multiplied the error signal using a multiplier. The multiplier module contains information of the input line signal and level of error signal. At step (208), the digital signal converted to the analog signal using a DAC. After receiving the analog signal, at step (209), the set point to the peak inductor current level of the analog signal is established using the DAC. Finally, at step (210), the current through inductor from input power supply is controlled using a switch. The controlled inductor current is allowed to flow through a sense resistor to generate a voltage. The generated voltage is in form of saw tooth waveform which will determine the turn ON time and turn OFF time of the switch to achieve the active power factor correction and and regulates the average LED current using the reference set point, wherein the average LED current tracks the reference set point in the LED circuit.

[0042] In the preferred embodiment, the method provides the switching operations for the saw tooth waveform to compute cycle by cycle power or
current to activate the plurality of events such as triggering a bleeder circuitry in
dimming applications using the firmware. Further, the method realizes the desired
low loop band width for controlling the average LED currents using the firmware.

[0043] Figure 3 shows the wave shaping profile of active power factor correction
and current regulation in the led circuit, according to one embodiment of the
invention. In the preferred embodiment, the top waveform indicates the
Alternating Current (AC) line. The middle waveform indicates limited peak
inductor current using DAC. The bottom waveform indicates the input line
current.

[0044] Figure 4 shows the saw tooth wave of active power factor correction and
current regulation in the led circuit, according to one embodiment of the invention.
In the preferred embodiment, the saw tooth waveform indicates the cycle by cycle
current limit and regulation details. The saw tooth waveform is used to calculate
the average LED current. The average LED current for each cycle is calculated
using the below equation:

\[
\text{Average LED current} = \frac{(A_1 + A_2 + A_3 + A_4 + \ldots + A_n)}{(T_1 + T_2 + \ldots + T_n)}
\]

\[
A_x = \frac{I_{\text{peak}x}}{2} = \frac{V_{\text{ref}}x}{2}
\]

[0045] Figure 5 shows the dimmer waveform shaping profile of the LED circuits,
according to one embodiment of the invention. In the preferred, the current may
be modified by either directly reducing the direct current level to the LEDs or by
reducing the average current through duty cycle modulation through the LED
circuits.

[0046] The present invention discloses a system and method for active power
factor correction and current regulation in led circuit. The system used in the LED
driver circuit performs active PFC through the dynamic input current wave
shaping while limiting peak currents. The dynamic wave shaping scheme is
realized through hardware and firmware and is used to strike an optimal balance
between current accuracy, Power factor, THD and peak inductor currents. The system is versatile enough to improve PF and current accuracy in LED circuits and dimmers circuits.

[0047] The prior arts use the external components to determine the switching cycle by cycle power/current through peak sense voltage or current setting. The present invention accurately detects the switching cycle by cycle power/current through peak sense voltage or current setting without using the external components. The invented method uses the firmware to accurately realize the average currents from single to multiple supply cycles. The invented system provides post processing delay errors through a combination of hardware and firmware in LED driver applications.

[0048] The present invention provides a system and method which is simple, time saving, resource efficient, and cost effective. The invention may be used in variety of applications as indicator lamps and in different types of lighting environments which uses LED’s.

[0049] It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only. Changes may be made in the details, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.
We claim:

1. A system for active power factor correction and current regulation in led circuit, the system comprises of:

   a) an input module (101) allows the user (s) to enter the reference set point as per the requirement through a reference block (114);

   b) a computing module (102) configured to compute the average power/current from a supply line cycle (s) to generate the average feedback signal using a filter average;

   c) a subtractor module (103) receives the reference set point signal and the average feedback signal from the input module and filter module, wherein the reference set point signal and average feedback signal is calculated by calculating the difference therein to produce an error signal using a subtractor;

   d) a gain module (104) receives the difference error signal from the subtractor module and boost up the loop response and speed of correction in the error signal by adding the gain signal;

   e) an accumulator module (105) configured to accumulate the error signal from the gain module (104) and determines the level of effective set point signal to ensure the average feedback signal equalling to the reference set point signal using an accumulator;

   f) an analog to digital module (106) configured to sense and convert the input line signal to the digital signal using an Analog to Digital Converter (ADC);

   g) a multiplier module (107) multiplies the output of the analog to digital module and the accumulator module using a multiplier, wherein the multiplier module contains information of the input line signal and level of error signal;

   h) a digital to analog module (108) receives and converts the digital signal from the multiplier module to the analog signal using a
Digital to Analog Converter (DAC), wherein the DAC establishes
the reference set point to the inductor current level of the analog
signal to perform active power factor correction and regulates the
average current; and

i) a control module configured to control the peak currents through
inductor (112) from input power supply using a switch (111),
wherein the controlled inductor peak currents is allowed to flow
through a sense resistor (113) to generate a voltage, wherein the
generated voltage is in form of saw tooth waveform, wherein the
saw tooth waveform determines the turn ON time and turn OFF
time of the switch to achieve the active power factor correction
and regulates the average LED current using the reference set point,
wherein the average LED current tracks the reference set point in
the LED circuit.

2. The system as claimed in claim 1, wherein the system (100) further comprises
of a Pulse Width Modulation (PWM) module (110) to turn ON the switch
when the output of the DAC is larger than the voltage from the sense resistor
(113) using a PWM converter.

3. The system as claimed in claim 1, wherein the system (100) further comprises
of a power and current estimator module (109) configured to determine the
cycle by cycle power/current based on various factors such as the DAC set
point, turn ON time of the switch and switching period of the switch.

4. The system as claimed in claim 1, wherein the system (100) further comprises
of a dim block (115), a thermal block (116) and an input block (117), wherein
the dim block (115) estimates the dimming duty cycle i.e. ON time and OFF
time in the saw tooth waveform and supply line frequency, wherein the
thermal block (116) gives the thermal information of the outside electronic
components such as LEDs and chips, wherein the input block (117) gives
additional inputs such as error correction or any other desired information as per the applications in the LED circuits.

5. The system as claimed in claim 1, wherein the system (100) further detects and classifies the faults state when the average switching cycle by cycle power/current exceeds a specified tolerance band.

6. The system as claimed in claim 1, wherein the system (100) further calculates the error signal over a supply cycle and provides automatic averaging/filtering, wherein the calculated error signal produces wave shaping profile, wherein the wave shaping profile may be further customized through the firmware module (118).

7. A system for active power factor correction and current regulation in led circuit, the system (100) comprises of:
   a. a firmware module (118) configured to work for each block to generate the response for one or more events and transmit the response via the event based module to operate at-least one of the block selected from the list of the input module (101), the computing module (102), the subtractor module (103), the gain module (104), the accumulator module (105), the analog to digital module (106), the multiplier module (107), the digital to analog module (108) and the control module for LED applications.

8. A method for active power factor correction and current regulation in led circuit, the method (200) comprising the steps of:
   a. entering the reference set point signal by the user(s) as per the requirement through a reference block (201);
   b. computing the average power/current from a supply line cycle to produce the average feedback signal (202);
c. calculating the difference between the reference set point signal and average feedback signal to produce an error signal using a subtractor (203);
d. adding the gain signal to the error signal to boost up the loop response and speed of correction in the error signal (204);
e. accumulating the error signal and determining the level of effective reference set point signal to ensure the average feedback signal equalling to the reference set point signal using an accumulator (205);
f. sensing and converting the input line signal to the digital signal using an ADC (206);
g. multiplying the error signal with the digital signal using a multiplier, wherein the multiplier module contains information of the input line signal and level of error signal (207);
h. converting the digital signal to the analog signal using a DAC (208);
i. establishing the reference set point to the peak inductor current level of the analog signal using the DAC (209); and
j. controlling the current through inductor from input power supply using a switch, wherein the controlled inductor current is allowed to flow through a sense resistor to generate a voltage, wherein the generated voltage is in form of saw tooth waveform, wherein the saw tooth waveform determines the turn ON time and turn OFF time of the switch to achieve the active power factor correction and regulates the average LED current using the reference set point, wherein the average LED current tracks the reference set point in the LED circuit (210).

9. The method as claimed as claimed 8, wherein the method (200) further comprises the steps of:
a. switching the cycle by cycle power/current information of the saw tooth waveform to activate the plurality of events such as triggering a bleeder circuitry in dimming applications using the firmware.

10. The method as claimed in claim 8, wherein the method (200) further comprises the steps of:

a. realizing the desired low loop band width for controlling the average currents using the firmware.
FIGURE 1
Entering the reference set point signal by the user(s) as per the requirement through a reference block.

Computing the average power or current from a supply line cycle or cycles to produce the average feedback signal.

Calculating the difference between the reference set point signal and average feedback signal to produce an error signal using a subtractor.

Adding the gain signal to the error signal to boost up the loop response and speed of correction in the error signal.

Accumulating the error signal and determining the level of effective reference set point signal to ensure the average feedback signal equaling to the reference set point signal using an accumulator.

Sensing and converting the input line signal to the digital signal using an ADC.

Multiplying the error signal with the digital signal using a multiplier, wherein the multiplier module contains information of the input line signal and level of error signal.

Converting the digital signal to the analog signal using a DAC.

Establishing the set point to the peak inductor current level of the analog signal using the DAC.
Controlling the current through inductor from input power supply using a switch, wherein the controlled inductor current is allowed to flow through a sense resistor to generate a voltage, wherein the generated voltage is in form of saw tooth waveform, wherein the saw tooth waveform determines the turn ON time and turn OFF time of the switch to achieve the active power factor correction and regulates the average LED current using the reference set point in the LED circuit.

FIGURE 2

FIGURE 3
International application No. PCT/IB 15/59190

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G05F 1/00 (2016.01)
CPC - H02M 3/1588

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 (8) - G05F 1/00 (2016.01)
CPC - H02M 3/1588

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - Y02B 70/1466; H02M 3/1586 (See Keywords Below)
USPC - 323/271, 323/285, 323/225, 315/297, 315/312

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Thomsoninnovation.com; Patbase; Google Scholar; Google Patents; Gogole.com; Freepatentsonline; ProQuest Dialog
Search Terms: Active power factor correction, error, difference, current, input, subtractor, multiplier, accumulator, average, feedback, boost, gain, resistor, flipflop, LED, driver, firmware, software, program, event, etc.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>US 201 1/0215736 A1 (HORBST et al.), 08 September 201 (08.09.201 1), entire document, especially Abstract; Para [0040]-[0041], [0049], [0055]-[0057]</td>
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<td>Y</td>
<td>US 201 1/0066713 A1 (HOOGZAAD), 24 March 201 (24.03.201 1), entire document, especially Abstract; Para [0055]-[0056], [0139], [0162], [0231], [0240]-[0244]</td>
<td>1-6 and 8-10</td>
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<td>US 5,949,229 A (CHOI et al.), 07 September 1999 (07.09.1999), entire document, especially Abstract; col 2, in 1-25</td>
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<td>US 7,733,678 B1 (NOTOHAMIPRODJO et al.), 08 June 2010 (08.06.2010), entire document</td>
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