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• **Technolabs S.p.A.**
20040 Cornate d'Adda (MI) (IT)

(72) Inventors:
• **Pignatelli, Eugenio**
00136 Roma (RM) (IT)
• **Pignatelli, Giovanni Battista**
00161 Roma (IT)

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(71) Applicants:
• **Pignatelli, Eugenio**
00136 Roma (RM) (IT)
• **Pignatelli, Giovanni Battista**
00161 Roma (IT)

(74) Representative: **Iannone, Carlo Luigi et al**
Barzanò & Zanardo Roma S.p.A.
Via Piemonte 26
00187 Roma (IT)

(54) **Unit, system and method for adjusting and controlling the ignition and adjustment of a discharge lamp**

(57) The present invention concerns an adjustment and control unit (6) of a discharge lamp (5) supplied by a power supply network (2), **characterized in that** it comprises a power stage (9) connected with said power supply line (2) and with said discharge lamp (5), capable of supplying said discharge lamp (5), and processing means (8), connected with said power stage (9), said

processing means (8) being suitable to adjust the operation of said power stage (9) by a control signal modulated in Pulse Frequency Modulation (PFM), so as to select a desired operating power level, that can be set beforehand, of said discharge lamp (5).

The present invention also relates to a system and method for controlling ignition and adjustment of a plurality of discharge lamps (5).

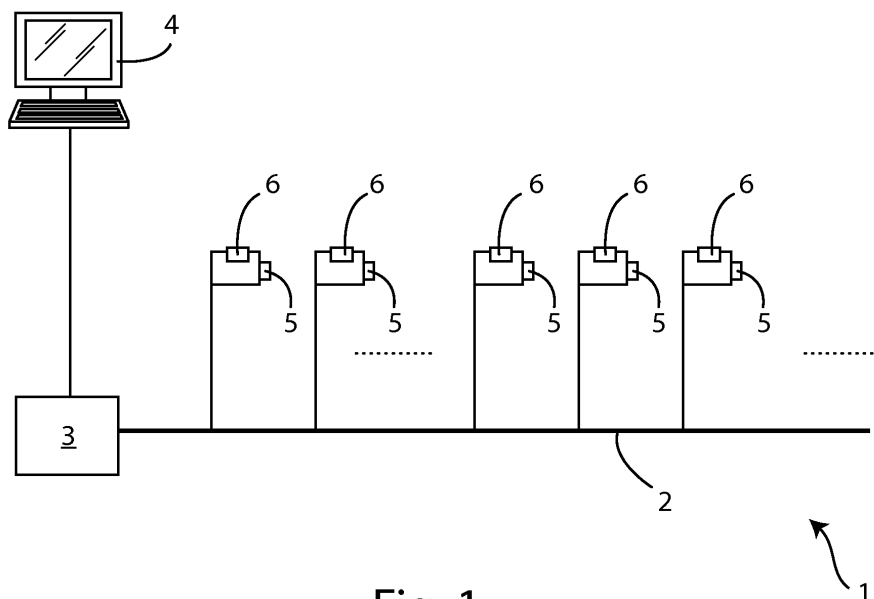


Fig. 1

Description

[0001] The present invention relates to a unit, system and method for adjusting and controlling the ignition and adjustment of a discharge lamp.

[0002] More specifically, the invention concerns a unit and a method for adjustment of a discharge lamp supplied by a network, through which conveyed waves are transmitted, particularly studied and realised to permit high adjustment flexibility without generating noise through the supply network and in signals transmitted by the same.

[0003] As it is well known, electric power costs are presently growing fast. This event pushed electric power Authorities to modify their politics for managing lighting of public roads, in order to reduce costs and consumption.

[0004] For example, highway lighting is designed in order to permit an optimum view under the worse conditions, i.e. when the traffic is utmost busy. Such a condition can only occur for a short time period during the highest peak of traffic.

[0005] At present, control systems are spreading for reducing light intensity on the basis of the real need. Furthermore, many technologies are being developed and spread for remote controlling and analysing public lighting. Particularly, it is known "point to point" remote control, by which it is possible:

- saving maintenance costs, thanks to the possibility of carrying out interventions where the failure is located;
- saving materials thanks to the immediate individuation of really damaged components;
- planning maintenance.

[0006] At present, systems are known that can control, monitor and manage road lighting from a remote position, permitting remarkable power savings. However, said systems has the limit due to the fact that, in order to control and adjust lamps of a network it is employed the well known conveyed network communication technology, substantially concerning juxtaposition of low frequency continua or alternate supply electric current, of a higher frequency signal, modulated by an information to be transmitted.

[0007] For example, in order to adjust luminosity of a lamp of a conveyed wave controlled supply network lamp, they are at present used switch systems, not permitting a fine tuning, but only with few adjustment levels, in order to prevent noise along supply line, which would disturb the transmitted signal.

[0008] In view of the above, it is therefore object of the present invention that of suggesting an adjustment and control unit and the relevant ignition and adjustment method for a discharge lamp, particularly a high pressure sodium (HPS) lamp, supplied by supply lines through which conveyed waves are conveyed, that cannot interfere with said conveyed wave signals along said electric

supply network.

[0009] A further object of the present invention is that the above control filters noise generated and can realise a high number of adjustment levels.

[0010] It is therefore specific object of the present invention an adjustment and control unit of a discharge lamp supplied by a power supply network, **characterized in that** it comprises a power stage connected with said power supply line and with said discharge lamp, capable of supplying said discharge lamp, and processing means, connected with said power stage, said processing means being suitable to adjust the operation of said power stage by a control signal modulated in Pulse Frequency Modulation (PFM), so as to select a desired operating power level, that can be set beforehand, of said discharge lamp.

[0011] Always according to the invention, said unit can comprise a demodulator/modulator of conveyed waves connected with said power supply line and with said processing means, suitable to permit the reception and the transmission of data in conveyed waves transmitted on said power supply line, said data concerning the ignition and the operating of said discharge lamp.

[0012] Still according to the invention, said unit can comprise a filtering module, capable to select a band around an operating base frequency, so as to reduce the noise along said supply line) on which said conveyed waves are transmitted.

[0013] Furthermore, according to the invention, said filtering module can comprise functions for varying the frequency around a basic value for attenuating the noise re-injected on said power supply line by said pulse frequency modulated signal.

[0014] Advantageously according to the invention said power stage can comprise said filtering module, the latter preferably including an electromagnetic interference filter.

[0015] Still according to the invention said power stage can comprises a rectifier, a radio-frequency calibrating module and an inverter block and resonant circuit connected with said adjustment and control unit and apt to be controlled by the same by means of said control signal.

[0016] It is further object of the present invention a control system for igniting and adjusting a plurality of discharge lamps, **characterized in that** it comprises an adjustment and control unit, as defined in the above, connected with each one of said discharge lamps, a remote central unit provided with main data transceiving means, preferably in GPRS/UMTS, capable of transmit ranges of ignition and work values of said discharge lamp, at least one concentrator, connected with said power supply line, and comprising further data transceiving means, preferably in GPRS/UMTS mode for connection with said remote central unit, and a modulator/demodulator for conveyed waves, for transmitting and receiving data to/from said adjustment and control units, for controlling said lamps connected with them on the basis of said ranges of ignition and work values received from said remote central unit.

[0017] It is also object of the present invention an ignition and adjustment method of a discharge lamp, supplied by a power supply network and connected with an adjustment and control unit for operation of a plurality of operating power levels set beforehand, said method comprising: a setting step, wherein, for each one of said one or more operating parameters of said discharge lamp, said adjustment and control unit acquires a range of ignition values that can be programmed, for regulating the power supply at one of said operating power levels set beforehand; a step of actuation of said discharge lamp, wherein said adjustment and control unit brings the value of each one of said operating parameters at the respective range of ignition values acquired during said setting step, for allowing the passage of said discharge lamp to a warm up mode; an operative step, wherein said adjustment and control unit acquires a range of working values set beforehand for each one of said one or more operative parameters, and sets each one of said operative parameters at the respective range of working values, for allowing the passage of said discharge lamp to a state corresponding to one of said operating power levels set beforehand.

[0018] Always according to the invention said setting step can further comprise the following steps:

- waiting for a first discharge lamp cooling time interval (Dt1);
and
- enabling the generation of a control signal modulated in pulse frequency modulation for driving the supply of said discharge lamp, the frequency of said control signal being function of said ignition or working values.

[0019] Still according to the invention said step of actuation can further comprise the following steps:

- comparing the value of the supply voltage (Vlamp) of said discharge lamp with a maximum supply voltage threshold (Max_Inition_Vlamp), and, if said value of the supply voltage is less than or equal to said threshold, then go to the next step;
- comparing the value of the supply current frequency (Flamp) of said discharge lamp with a maximum frequency threshold (Ignition_Max_Flamp), and if said supply current frequency (Flamp) is less than or equal to said threshold, then increase the value of said supply current frequency (Flamp) of a first frequency range, preferably equal to about 10MHz for any second time interval (Dt2), preferably equal to about 1 millisecond, or otherwise said setting step is carried out again;
- detecting if values of each one of said operating parameters is included within the relevant range of ignition values acquired in said setting step, and, if at least one of said operating parameters has the relevant value not included in the relevant range, then

said adjustment and control unit transmits an error signal, otherwise go to said operating step; and

- generating said control signal corresponding to said ranges of ignition value received.

[0020] Furthermore according to the invention said operative step can comprise the following further steps:

- cyclically detecting the supply operating frequency of said discharge lamp (5) for any third time interval (Dt3), preferably equal to about 250 milliseconds;
- detecting, after a fourth time interval (Dt4), if the values of each one of said operative parameters is included within the relevant range of working values set during said setting step, so that, if at least one of said parameters has the value not included within the relevant operating range, then said adjustment and control unit transmits an error signal;
- comparing the supply voltage value (Vlamp) of said discharge lamp with a maximum operating threshold (Max_WarmUp_Vlamp), and, if said supply voltage value (Vlamp) is greater than or equal to said threshold then go to next step, otherwise go back to warm up state; and
- generating said control signal corresponding to said ranges of working values received.

[0021] Advantageously, according to the invention, said method can comprise, after said operative step, a step of detection of said values of said parameters, and a step of calculation of a power factor by said values of said parameters.

[0022] Always according to the invention said parameters can comprise the supply voltage (Vlamp) across the terminals of said discharge lamp and/or the supply current frequency (Flamp) of said discharge lamp and/or the frequency of the wave of said control signal pulse frequency modulated, the supply current of said discharge lamp and/or the power factor and/or the temperature of the discharge lamp.

[0023] The present invention will be now described for illustrative but not limitative purposes, according to its preferred embodiments, with particular reference to the enclosed drawings, wherein:

figure 1 shows a scheme of the control system of a lighting network;
figure 2 shows the block diagram within a concentrator;
figure 3 shows the block diagram within an adjustment and control unit for supplying of a lamp; and
figures 4a, 4b and 4c show a flowchart of a supply adjustment method.

[0024] In the various figures, similar parts will indicated by the same references.

[0025] Making reference to figure 1, it is observed an adjustment and control system 1 of an electric supply

network or line 2. Particularly, it is observed a concentrator 3 connected to said electric supply line and a remote central unit 4 connected with said concentrator 3.

[0026] A plurality of discharge lamps 5 is connected to said electric supply line 2. An adjustment and control unit is interposed between said electric line 2 and each discharge lamp 5, suitable to control operation of the discharge lamp 5, as will be better described in the following.

[0027] Concentrator 3 and adjustment and control unit 6 communicate each other by a PLC (Power Line Communication - conveyed waves system. Conveyed waves modulated signal is transmitted along said electric supply line 2.

[0028] Particularly, said concentrator 3 and said adjustment and control unit 6 can communicate by both *Cenelec* A and C bands, according to the needing.

[0029] When adjustment and control system 1 is configured for electric lighting applications, said concentrator 3 and said adjustment and control units 6 communicate through the band A; while in the industrial, civil or commercial applications, they communicate through band C.

[0030] Each adjustment and control unit 6, is particularly seen as a knot of the electric supply line 2.

[0031] Concentrator 3 can control adjustment and control units 6, which control ignition of discharge lamp 5, adjusting its intensity by a modulated control signal according to a PFM (Pulse Frequency Modulation) pulse frequency modulation. Said concentrator 3 configures each adjustment and control unit 6, transmitting value of adjustment parameters for ignition and adjustment of light intensity. Furthermore, each one of said adjustment and control units 6 can detect each failure of the relevant discharge lamp 5, communicating the same to said concentrator 3, always by a conveyed wave signal. Then, said concentrator 3 can transmit said information to said remote central unit 4. Said remote central unit 4 and said concentrator 3 are connected by suitable transceiving means, for example of the GSM/GPRS type.

[0032] As already said, discharge lamps 5 are of the High Pressure Sodium (HPS) type or of the metal Halide (MH) type, with a supply power usually between 70 and 100 Watts or between 150 and 250 Watts, as well as of the halogen type. Supply tension can reach 4.5 Volts and operation frequency can be higher than 37 kHz. As it is well known, their ignition must be suitable carried out so as to limit wear of the same discharge lamp 5.

Figure 2 shows block diagram of concentrator 3, mainly comprising a microcontroller 3, for processing data received from said remote central unit 4, and from said adjustment and control units 6, and a conveyed wave modulator/demodulator 32.

Figure 3 shows block diagram of adjustment and control unit 6, comprising a conveyed wave modulator/demodulator 7, for communication with said concentrator 3.

is connected with electric supply line 2 by a coupling circuit 7' and an amplifier 7". Further, said adjustment and control unit 6 also comprises a microprocessor 8, connected with said modulator/demodulator 7 and with a temperature sensor 8' and an EEPROM memory 8".

[0034] Said adjustment and control unit 6 also comprises a power unit 9, including, in the present embodiment, a filtering module 91, the function of which will be better described in the following, a rectifier 92, a radio-frequency calibration module 93 and an inverter and resonant circuit block 94.

[0035] Said adjustment and control unit 6 is completed by a timer 10 and a power unit 11 for supplying different circuits.

[0036] Said microprocessor 8, following information about parameters for ignition and adjustment of said discharge lamp 5, generates a PFM (Pulse Frequency Modulation) pulse frequency modulated control signal, piloting, i.e. adjusting, said inverter and resonant circuit block 94, varying operation frequency of discharge lamp 5 and consequently light emission.

[0037] Pulse frequency modulation control and duty cycle fixed at 50% reduces generated noise with respect to known controls. In any case, switching modulation frequency modulation too can cause noise which, by a function carried out by filtering module 91, makes a selection of a suitable band about an operative base signal frequency, reducing noise effects on communication performances along conveyed waves.

[0038] Filtering module 91 comprises common mode and differential mode filters to attenuate noise readmitted along electric line 2 by said frequency modulation signal, thus reducing harmonics caused by power stage.

[0039] Said microprocessor 8 can switch on and adjust said discharge lamp 5 by a specific procedure, so as not to disturb conveyed waves along said electric supply line 2.

[0040] Figures 4a, 4b and 4c show the above procedure. From figure 4a, it is observed discharge lamp 5 in a switched off mode, during which it remains for a first cooling time interval Dt1, to pass then to a waiting mode.

[0041] Then (figure 4b), has a first cycle during which it is checked that said first cooling time interval Dt1 is finished. Meanwhile, adjustment and control unit 6 can receive a pre-programmable ignition value range for one or more operative parameters of the discharge lamp 5. Said operation parameters are transmitted from said concentrator 3 and can be set by a remote central unit 4.

[0042] Then, a step during which it is checked if supply tension of said discharge lamp 5 Vlamp is lower or equal to an ignition tension constant value for said lamp Max_Ignition_Vlamp. If the above test is true, it is then checked if frequency of the discharge lamp 5 Flamp supply current is lower or equal to an ignition tension constant value for said lamp Max_Ignition_Flamp. In the negative, a failed ignition attempt of said discharge lamp 5 occurred, being it necessary cooling again said lamp 5 (i.e. let inactive for said first cooling time interval Dt1), otherwise, an in-

[0033] Said conveyed wave modulator/demodulator 7

crement of Flamp is made of a first frequency interval, preferably about 10 MHz, for a time interval corresponding to a second cooling time interval Dt2. Preferably of about 1 millisecond.

[0043] Then, it is checked if value of each one of said operative parameters of said discharge lamp 5 is included within the ignition range value set during said preparation step. In the negative, it has an operation error, which is transmitted by adjustment and control unit 6 to said concentrator 3 as an error message. Otherwise, discharge lamp 5 is brought to the quick warm-up state and passes to a monitoring step of said discharge lamp 5, during which it is made:

- a constant control of operation frequency of discharge lamp 5 Flamp every third time interval Dt3, preferably set at about 250 microseconds; and
- after a set fourth time interval Dt4, a reconfiguration of said parameters occurs, during which said adjustment and control unit 6 acquires an interval of working values for each one or for a plurality of operation parameters of said discharge lamp 5 from said concentrator 3.

Then, said adjustment and control unit 6 brings each one of said operation parameters to the relevant operative value interval, piloting said power unit 9, acting on the control signal modulated according to a pulse amplitude modulation mode.

[0044] Then, a constant control (figure 4c) of parameters occurs, so that said operation values are included within the above working intervals.

[0045] It must be considered that each one of said working interval assembly of the operative parameters of said discharge lamps 5 corresponds to one of the preset levels of the operation power, so that said halogen lamp 5 can work at a minimum value, even of 30% of nominal power, thus permitting an even precise adjustment, e.g. of five lighting levels. Further, thanks to the control type by control signal modulated according to a pulse frequency modulation (PFM) mode, a reduced noise generation occurs, that can limit disturbs all along electric supply line 2. This is also particularly due to the fact that in the present system a physical distinction occurs between the components controlling the discharge lamp 5 and components supplying the same.

[0046] During said operative step, it is also controlled if supply tension of said discharge lamp 5 Vlamp is higher or equal to a supply tension maximum threshold of the same Max_WarmUp_Vlamp under a quick warming condition. If said condition is not satisfied, discharge lamp 5 is brought back to the quick warm-up state; otherwise, said discharge lamp 5 is in the wished lighting condition or state, i.e. at one of the operation power levels, during which all operation parameters are monitored and power factor is calculated in real time by said microprocessor.

[0047] Finally, it must be considered that operation parameters of said discharge lamp 5 can comprise Vlamp

at the ends of said discharge lamp 5 and/or frequency of Flamp current of said discharge lamp 5 and/or frequency of said pulse amplitude modulated control signal, supply current of said discharge lamp 5, power factor, discharge lamp 5 temperature.

[0048] Present invention has been described, for illustrative, but not limitative purposes, but it is to be understood that variations and/or modifications can be introduced by those skilled in the art without departing from the relevant scope, as defined in the enclosed claims.

Claims

1. Adjustment and control unit (6) of a discharge lamp (5) supplied by a power supply network (2), **characterized in that** it comprises a power stage (9) connected with said power supply line (2) and with said discharge lamp (5), capable of supplying said discharge lamp (5), and processing means (8), connected with said power stage (9), said processing means (8) being suitable to adjust the operation of said power stage (9) by a control signal modulated in Pulse Frequency Modulation (PFM), so as to select a desired operating power level, that can be set beforehand, of said discharge lamp (5).
2. Unit (6) according to claim 1, **characterized in that** it comprises a demodulator/modulator of conveyed waves (7) connected with said power supply line (2) and with said processing means (8), suitable to permit the reception and the transmission of data in conveyed waves transmitted on said power supply line (2), said data concerning the ignition and the operating of said discharge lamp (5).
3. Unit (6) according to claim 2, **characterized in that** it comprises a filtering module (91), capable to select a band around an operating base frequency, so as to reduce the noise along said supply line (2) on which said conveyed waves are transmitted.
4. Unit (6) according to claim 3, **characterized in that** said filtering module (91) comprises functions for varying the frequency around a basic value for attenuating the noise re-injected on said power supply line (2) by said pulse frequency modulated signal.
5. Unit (6) according to anyone of claims 3 or 4, **characterized in that** said power stage (9) comprises said filtering module (91), the latter preferably including an electromagnetic interference filter.
6. Unit (6) according to anyone of the preceding claims, **characterized in that** said power stage (9) comprises a rectifier (92), a radio-frequency calibrating module (93) and an inverter block and resonant circuit

(94) connected with said adjustment and control unit (6) and apt to be controlled by the same by means of said control signal.

7. Control system for igniting and adjusting a plurality of discharge lamps (5), **characterized in that** it comprises an adjustment and control unit (6), as defined in claims 1-6, connected with each one of said discharge lamps (5), a remote central unit (4) provided with main data transceiving means, preferably in GPRS/UMTS, capable of transmit ranges of ignition and work values of said discharge lamp (5), at least one concentrator (3), connected with said power supply line (2), and comprising further data transceiving means, preferably in GPRS/UMTS mode for connection with said remote central unit (4), and a modulator/demodulator (32) for conveyed waves, for transmitting and receiving data to/from said adjustment and control units (6), for controlling said lamps (5) connected with them on the basis of said ranges of ignition and work values received from said remote central unit (4).
8. Ignition and adjustment method of a discharge lamp (5), supplied by a power supply network (2) and connected with an adjustment and control unit (6) for operation of a plurality of operating power levels set beforehand, said method comprising:
 - a setting step, wherein, for each one of said one or more operating parameters of said discharge lamp (5), said adjustment and control unit (6) acquires a range of ignition values that can be programmed, for regulating the power supply at one of said operating power levels set beforehand;
 - a step of actuation of said discharge lamp (5), wherein said adjustment and control unit (6) brings the value of each one of said operating parameters at the respective range of ignition values acquired during said setting step, for allowing the passage of said discharge lamp (5) to a worm up mode;
 - an operative step, wherein said adjustment and control unit (6) acquires a range of working values set beforehand for each one of said one or more operative parameters, and sets each one of said operative parameters at the respective range of working values, for allowing the passage of said discharge lamp (5) to a state corresponding to one of said operating power levels set beforehand.
9. Method according to claim 8, **characterized in that** said setting step further comprises the following steps:

- waiting for a first discharge lamp (5) cooling time interval (Dt1);
- and
- enabling the generation of a control signal modulated in pulse frequency modulation for driving the supply of said discharge lamp (5), the frequency of said control signal being function of said ignition or working values.

10. Method according to anyone of claims 8 or 9, **characterized in that** said step of actuation further comprises the following steps:

- comparing the value of the supply voltage (Vlamp) of said discharge lamp (5) with a maximum supply voltage threshold (Max_Ignition_Vlamp), and, if said value of the supply voltage is less than or equal to said threshold, then go to the next step;
- comparing the value of the supply current frequency (Flamp) of said discharge lamp (5) with a maximum frequency threshold (Ignition_Max_Flamp), and if said supply current frequency (Flamp) is less than or equal to said threshold, then increase the value of said supply current frequency (Flamp) of a first frequency range, preferably equal to about 10MHz for any second time interval (Dt2), preferably equal to about 1 millisecond, or otherwise said setting step is carried out again;
- detecting if values of each one of said operating parameters is included within the relevant range of ignition values acquired in said setting step, and, if at least one of said operating parameters has the relevant value not included in the relevant range, then said adjustment and control unit (6) transmits an error signal, otherwise go to said operating step; and
- generating said control signal corresponding to said ranges of ignition value received.

11. Method according to anyone of the claims 8 - 10, **characterized in that** said operative step comprises the following further steps:

- cyclically detecting the supply operating frequency of said discharge lamp (5) for any third time interval (Dt3), preferably equal to about 250 milliseconds;
- detecting, after a fourth time interval (Dt4), if the values of each one of said operative parameters is included within the relevant range of working values set during said setting step, so that, if at least one of said parameters has the value not included within the relevant operating range, then said adjustment and control unit (6) transmits an error signal;
- comparing the supply voltage value (Vlamp) of

said discharge lamp (5) with a maximum operating threshold (M)ax_WarmUp_Vlamp), and, if said supply voltage value (Vlamp) is greater than or equal to said threshold then go to next step, otherwise go back to warm up state; and
- generating said control signal corresponding to said ranges of working values received.

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12. Method according to anyone of the claims 8 - 11, **characterized in that** it comprises, after said operative step, a step of detection of said values of said parameters, and a step of calculation of a power factor by said values of said parameters.

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13. Method according to anyone of the claims 8 - 12, **characterized in that** said parameters comprise the supply voltage (Vlamp) across the terminals of said discharge lamp (5) and/or the supply current frequency (Flamp) of said discharge lamp (5) and/or the frequency of the wave of said control signal pulse frequency modulated, the supply current of said discharge lamp (5) and/or the power factor and/or the temperature of the discharge lamp (5).

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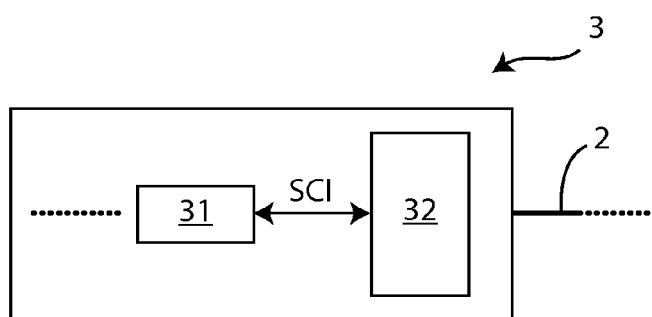
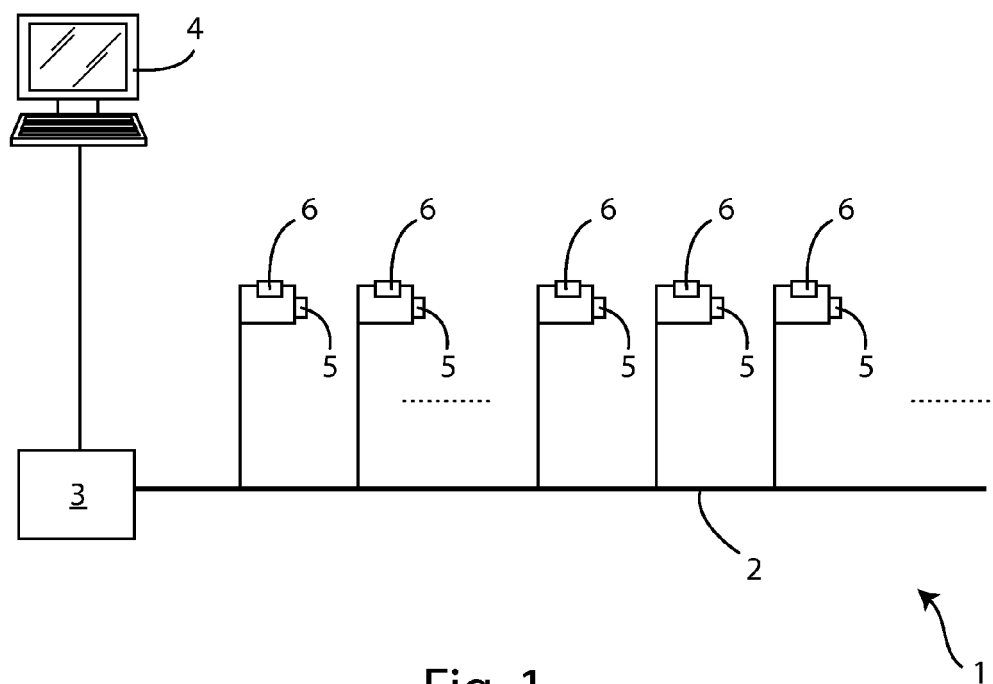
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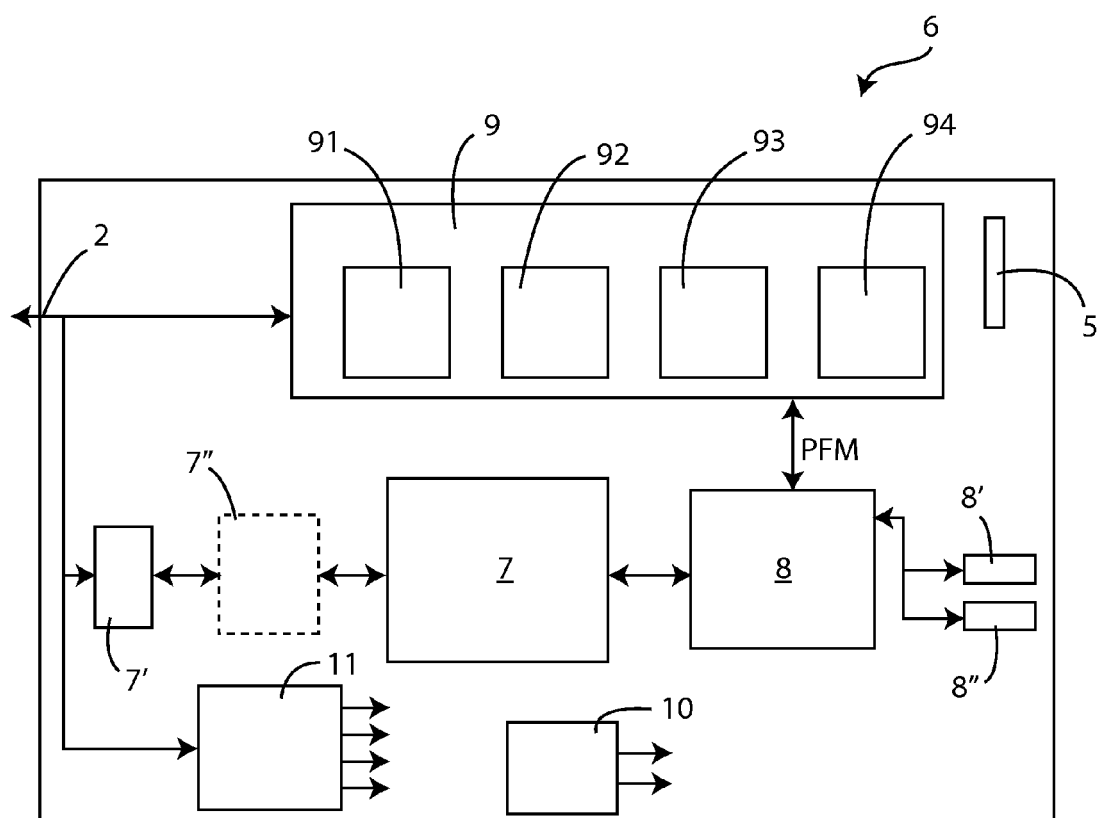


Fig. 3

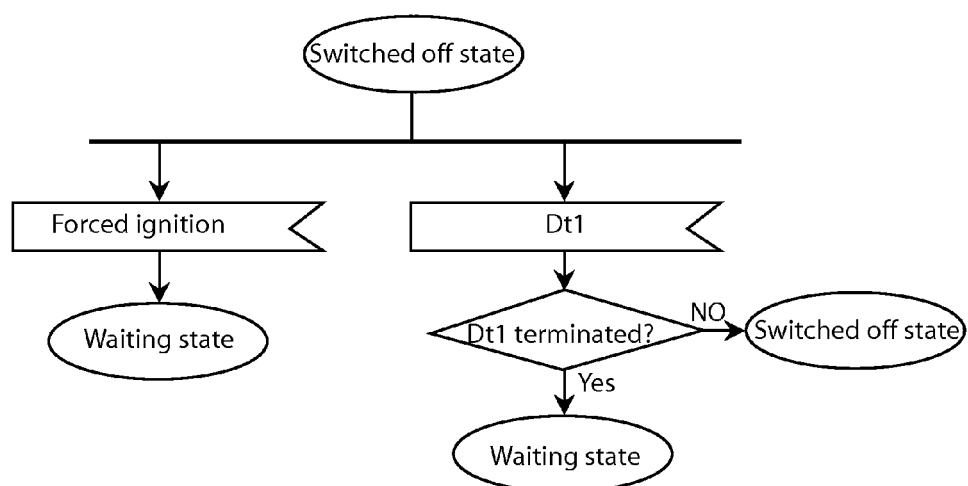


Fig. 4a

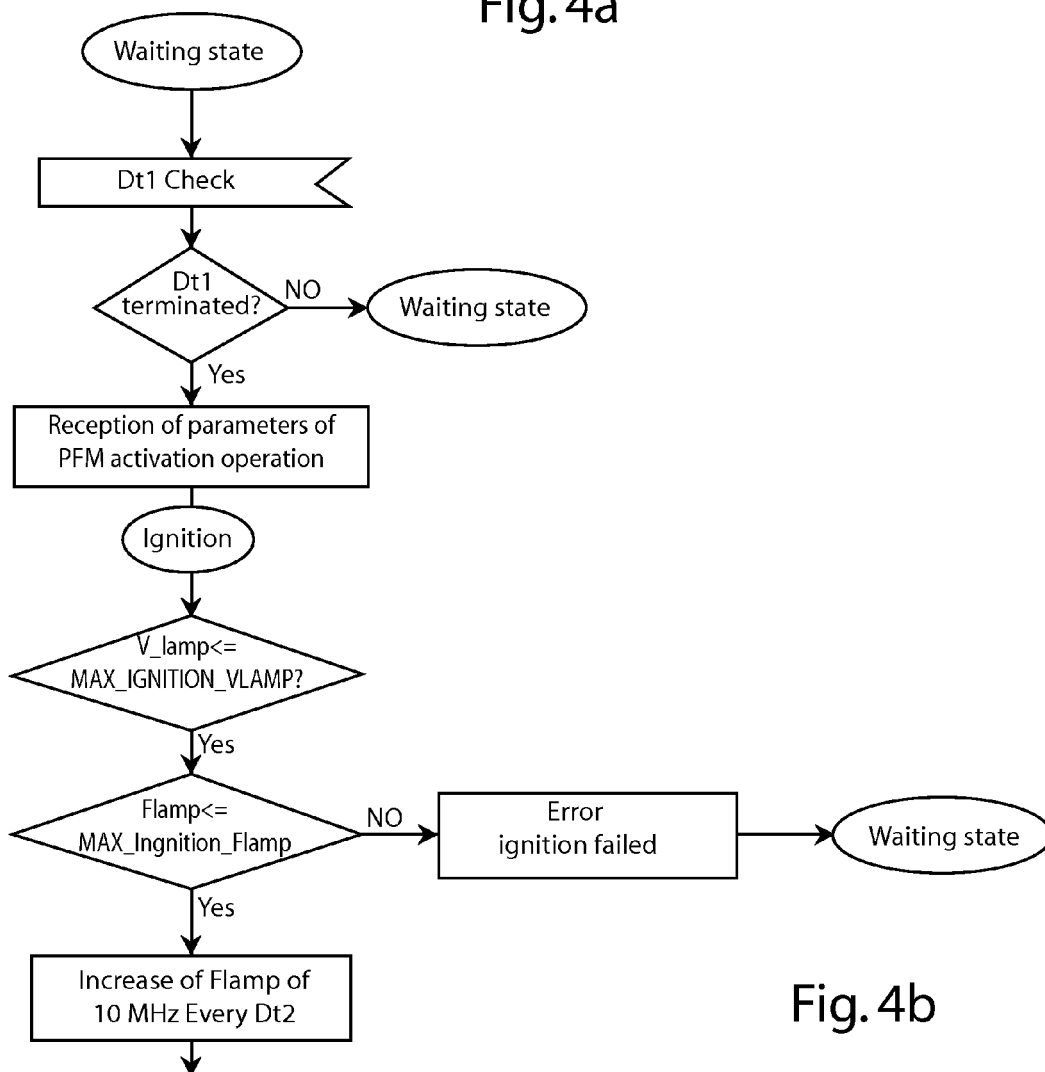


Fig. 4b

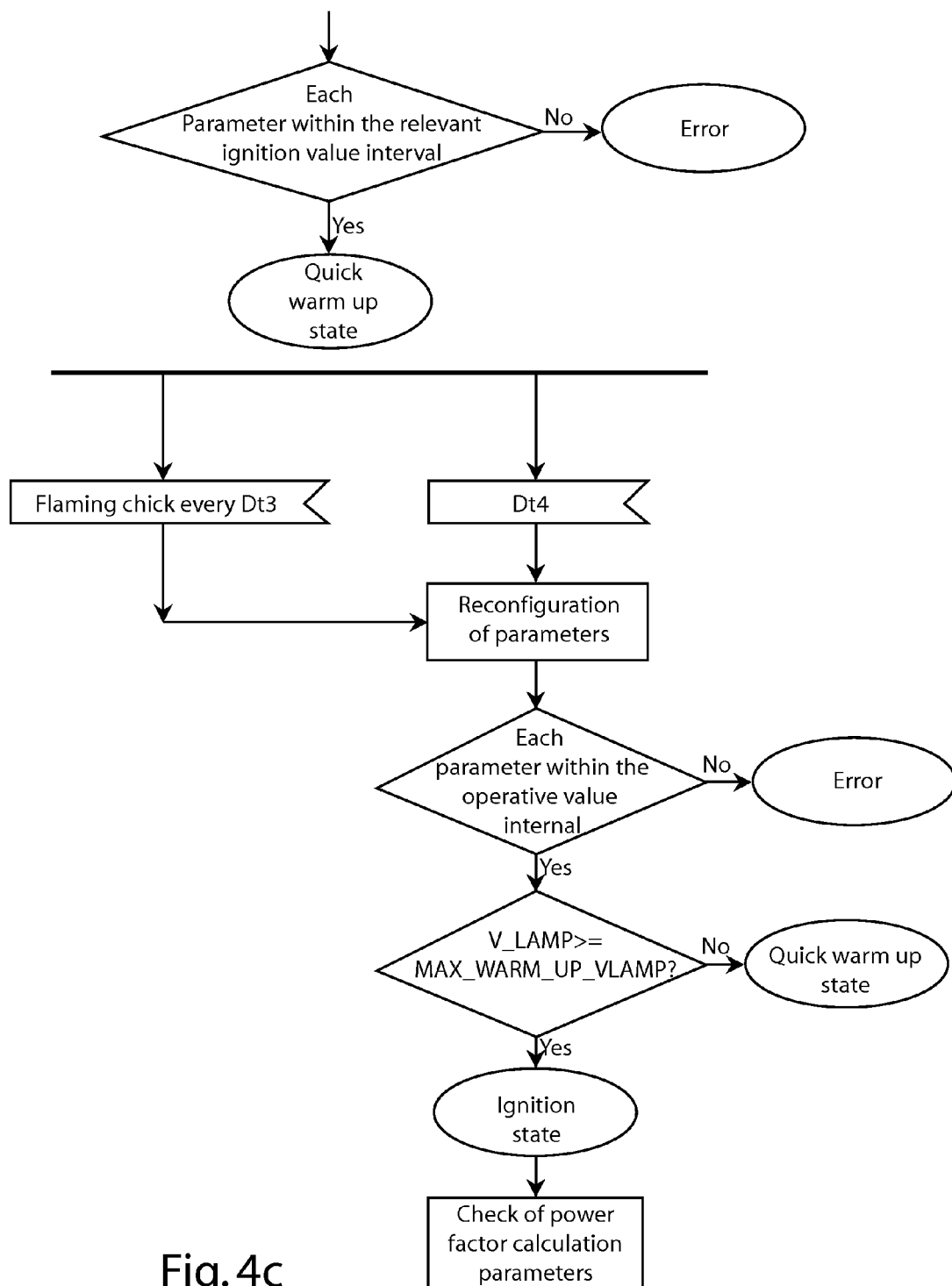


Fig. 4c



EUROPEAN SEARCH REPORT

Application Number
EP 10 42 5213

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 August 2010	Examiner Brosa, Anna-Maria
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EPO FORM 1503 03.82 [P04C01]

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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