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(54) Electronic ballast system with a micro-controller for use with high intensity discharge lamps

(57) Electronic Ballast system for high intensity gas discharge lamps (HID lamps) formed by a power factor correction circuit, a Buck - type regulator source, a DC-AC converter with an operating frequency equal to 150 Hz, an electronic igniter circuit, a power control circuit and a microprocessor integrated circuit which comprises means for sensing voltage and current, means for controlling output power to the ballast, means for controlling triggering of the igniter and means for communicating in series with peripheral circuits. The power control circuit and the microprocessor allow the use of the same ballast system with different lamp wattages.

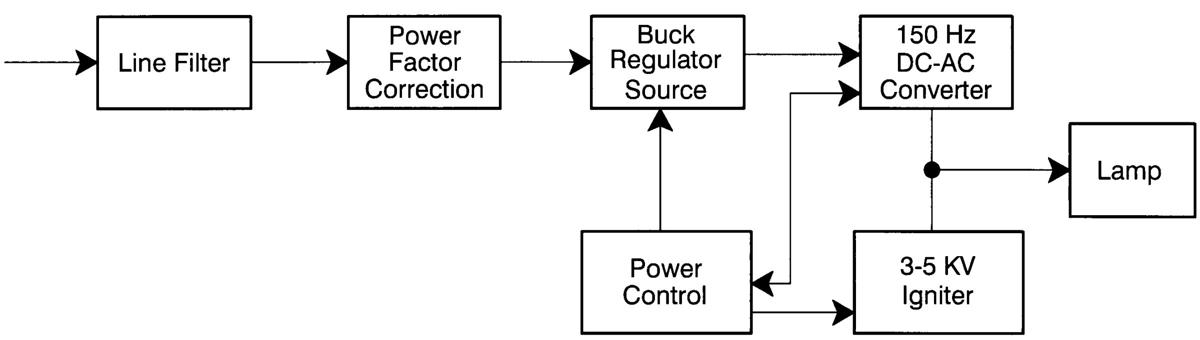

FIG. 1
General Block Diagram of the Equipment

EP 1 545 166 A1

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Description

Field of the Invention

[0001] The present invention discloses an intelligent electronic ballast system for 35 and 70[W] gas discharge lamps. More specifically, the invention refers to a microcontrolled electronic ballast system for High Intensity Discharge (HID) lamps, which has safety and protection features against short circuits, overtemperature, electrical network over-voltages, a system improving its power factor and the radiofrequency emissions and electromagnetic interference released and transmitted to the environment. This ballast increases the useful life of the lamp and the equipment by up to 30%, reducing losses associated with operation to less than 10%, complying with the international standards associated with equipment of this category.

Description of the Technique Used in the Present Development

[0002] Generally, lighting equipment mainly consists of a lamp, a ballast, some ignition device for the case of lamps which are of interest to us (gas discharge lamps) and a capacitor to carry out the corresponding power factor correction.

[0003] Knowing that the current of the lamp must pass through a bulb with two electrodes containing a certain class of gases, this lamp will have an inverse-type voltage-current feature, i.e., if the current is low or nil, the working voltage to maintain that current must be high, and on the contrary, if the current is high, the working voltage to maintain that current must be low. With this circumstance, since no current circulates through the lamp, it will be necessary to apply a voltage pulse much higher than the operational voltage rating of the equipment in order to be able to establish a circulation of current. This voltage peak is supplied by the ignition device. Once the current circulates through the lamp, it is necessary to limit it due to the aforementioned inverse feature, which would make this current indefinitely increase. This limitation is provided by an inductive-type reactance (reactor or ballast) connected in series to the current flow.

[0004] Electromagnetic ballasts, i.e., those using electric transformers, were developed to carry out this control of the current. The transformer functions as a source of current which provides a function for limiting the current in spite of the high impedance that the lamp has. When the lamp is turned on, the voltage approaches zero, and when the lamp is stabilized, it returns to a normal potential. However, to increase inductance of the transformer, large windings (coils) are needed for the windings of the transformer, which is translated into low efficiency of this class of ballast. Furthermore, electromagnetic ballasts normally operate at a frequency between 50 and 60 Hz, which causes noise and stroboscopic effect drawbacks.

[0005] Electronic ballasts, which have greater efficiency, fewer losses, less volume and weight, less noise and greater facility for external control, arose as a solution to these drawbacks. As is known in technology, conventional electronic ballast systems are formed by a converter circuit and an inverter circuit, which provides alternating current power to the lamp. There are numerous configuration and control alternatives for each one of these parts.

Objectives of the Invention

[0006] Since there is a great variety of high intensity (HID) lamps with different operative features.

[0007] There is a need for an electronic ballast which allows handling these different features of the lamps without needing to modify the circuits composing it, which is able to sense and control the different electronic system steps in an intelligent manner by means of some pre-programmed electronic device, to obtain an optimal useful life yield of the lamp and of the electronic circuitry associated to it.

[0008] Therefore, objectives of the present invention are:

- Providing an intelligent electronic ballast for HID lamps which is able to autonomously make decisions based on a general analysis of the lamp and the equipment.
- Carrying out self-monitoring thereof, of the operating condition of the device and of the lamp, of the useful life stage which the lamp is in, and which allows controlling the power delivered to the lamp.
- Providing a better lamp yield and useful lifetime ratio.
- Providing an electronic ballast adapted to the different types of gas discharge lamps with minimum hardware changes.
- Providing a microcontrolled electronic ballast complying with the different international standards applied to this type of equipments.
- Carrying out a highly reliable equipment which has safety systems for the safety of people and the areas where it will be installed.

Brief Description of the Drawings

[0009]

Figure 1 shows a general block diagram of the electronic ballasts and the different steps involved in this development.

Figure 2 shows a block diagram of the electronic ballast proposed in the present invention (35 [W] power), similar to the 70[W] electronic ballast.

Figure 3 shows a flow chart of the control method used.

Description of the Invention

[0010] The invention refers to a microcontrolled electronic ballast system for energizing High Intensity Discharge (HID) lamps. Figure 1 shows a block diagram of the electronic ballast and the different steps involved in this development.

1) Input step and line filter
2) Pre-converter and power factor correction
3) Main switching converter
4) Direct current to alternating current converters, pulse transformer and ignition system
5) Embedded control system with control by means of microcontroller.

[0011] As shown in figure 1, this microcontrolled electronic ballast system is formed by a line filter in the input step which provides filtering of the unwanted mid and high frequency signals coming from the electrical network to the ballast, and it also filters the mid and high frequency signals generated by the electronic system of the ballast which could eventually contaminate the electrical distribution grid. By means of this type of filters, elimination of spurious frequencies ranging from 10 KHz to signals of more than 30 MHz, product of the intense switchings generated by the equipment on the inside thereof, is achieved. Then it is possible to observe the pre-conversion and power factor correction step. Due to the intrinsic features of the type of lamps used in this type of equipments, a strong phase difference occurs between the waveforms of current and voltage, which causes a high reactive power due to the low power factor presented by these equipments, without the aforementioned step. It is possible to obtain factors equal to or greater than 98% of the entire equipment by means of the use of the correction step and improvement of the power factor; this step furthermore allows filtering the harmonics and stabilizes the output voltage of this block, which is subsequently entered into the preceding steps.

[0012] The next step is a Buck-type regulator source regulating the voltage at 88 volts, which feeds the converter. Furthermore, it protects the circuits from an over-consumption of current which the load (lamp) could present.

[0013] A DC-AC converter, as is shown in figure 2, delivers an alternating current to the lamp, which allows the latter to operate at a voltage ranging from 20 to 400 volts, at a frequency of 150 [Hz], which allows lighting stability, thus eliminating the stroboscopic effect; due to the incorporation of this square wave signal supplying the lamp with a voltage causing the lamp to turn on and off, which cannot be perceived by the human eye (elimination of unwanted flickering).

[0014] An electronic igniter circuit, as shown in figure 2, allows turning on the HID lamp by delivering an initial pulse train of 4 to 5 [kV] which, by means of an ignition system controlled by the software developed by Interlight, programmed in the microcontroller, allows quickly turning on lamps which are within their normal operating margins and useful life. It is also possible to achieve a longer useful life of lamps by means of this ignition system.

Description of the Ignition System Used

[0015] The ignition sequence of the electronic ballast of the present invention is detailed below:

[0016] Prior to the ignition sequence, there is no voltage in the ballast output. Once ignition of the lamp begins, the pulses are packaged in a frame or sequence of several pulses with a duration of 200 [ms] each, this frame or sequence contains 8 pulse intervals with amplitudes of 4 [KV], and they are overlaid on a DC voltage of 400 Vdc. Once ignition of the lamp has been achieved, the high voltage pulses are extinguished and the ballast, by means of its control system, automatically adjusts its output voltage to the working voltage rating value of the lamp, the square wave voltage of 150 [Hz] occurring, which causes normal operation of the ballast and the lamp.

[0017] Under hot lamp operating conditions and also with defective lamps, the ballast generates the first ignition pulses, beginning as in the case of a normal turning on, the impossibility of carrying out normal ignition is detected by means of the control algorithm, and the ignition pulses are stopped for 5 seconds, again generating an ignition sequence and then stopping for 5 more seconds, and so on successively for a 10 minute interval. Then, if normal turning on is not achieved in this period, the ballast control method stops equipment operation and enters into an idle state until it is turned on again and returned to its normal operation.

[0018] The microcontrolled electronic ballast system comprises a microprocessor integrated circuit, as is shown in figure 2, and software with a pre-programmed algorithm allowing carrying out different functions.

[0019] The microprocessor integrated circuit is that which carries out monitoring and control functions of the different electronic system steps, allowing, with its respective analysis, controlling the power defined by means of a program, and it stabilizes the lamp, therefore optimal yield of the useful life of the lamp is obtained.

[0020] The functions of the microprocessor are: sensing the regulated voltage V_{out} and current Iout levels, which allows knowing the condition of the lamp, i.e. knowing if it is disconnected, depleted, deteriorated, defective, etc. The output power of the equipment is calculated, having these current and voltage values, by means of cyclical operations Pout = V_{out} * Iout, this output power value is compared with a reference value, which corresponds to the value allowing optimal operation of the (39 w) and (70 W) HID lamp, then, the result is sent to a digital/analog D/A converter, and then to the Buck-type regulator source. The output power level for the lamp is controlled with this information.

[0021] The power control step is carried out by means of an 8-bit microcontroller, with its respective control program, it is determined if the lamp is within normal working power, and if it is not, the output power is deactivated.

[0022] It additionally has means for sensing the output voltage and current levels serving to determine when a short circuit occurs while the ballast is operating. It is able to detect this in an eight millisecond [ms] time lapse, when the short circuit is detected, power of the lamp is deactivated and is reactivated 1 minute later, finally, if the short circuit problem persists during ten attempts, the power output is deactivated until it is restarted again.

[0023] Another function of the microprocessor is to control the triggering of the electronic igniter circuit, it therefore delivers to the ignition system the triggering signal in necessary controlled times, i.e. it delivers the triggering signal during a maximum of two seconds to energize the lamp, if it does not achieve doing this within this time, the microprocessor will deactivate the power output during one minute. This process will be carried out during 10 attempts, if the lamp does not turn on during those 10 attempts, the program will abort the turning on, leaving recorded in the microprocessor that the lamp did not turn on, and it will not be ignited again until the ballast is restarted again.

Description of the Electronic Ballast Control Method

[0024] According to that presented in the flow chart of figure 3, it is possible to observe the different steps contemplated by the electronic ballast equipment control method.

[0025] All control system operating parameters, which will allow the microcontroller circuit to carry out each one of its actions, enabling the input and output ports of the microcontroller in order to begin the control task, are loaded in the memory at the beginning of the process. Maximum current levels allowed by the equipment in the output, the optimal operating voltage value of the lamp, the power at which the equipment is going to operate, operating frequency of the switching source, maximum and minimum operating temperature ranges of the ballast are loaded in the memory in this initialization.

[0026] Microcontroller port initialization is carried out in the next step, indicating by means of varied instructions which will be the information input and output ports for controlling the equipment. Three ports will mainly be used to convert analog signals into digital signals, which are used for sensing voltage, current and temperature levels of the ballast, for their part, three digital ports plus two analog ports are used for controlling power of the equipment, which allows setting a nominal range of operation of the equipment by means of defined points (set-point). Once the microcontrolled system ports have been enabled, acquisition of analog signals of voltage, current and temperature begins.

Ballast Control System Main Routine

[0027] This starts by checking the ballast temperature, if it is lower than the allowed maximum, the program tries to turn on the lamp, if the temperature is high, the program waits 1 minute and again tests the temperature level, and so on successively.

[0028] To turn on the lamp, the program calls the 'TurnOnlamp' subroutine and returns, if the lamp has been turned on, the program continues with the main cycle, or in the event that the lamp has not been turned on, the program stops.

[0029] The control system main cycle carries out the following tasks:

a) It measures three analog variables, namely: voltage, current and temperature, by means of the 'Measure' subroutine; then it calculates the power used by the lamp as:

$$\text{Power} = \text{voltage} * \text{current} * \text{time}$$

b) The program then calculates the average power value as the average value of the last four measurements of power taken, then the program carries out output voltage correction if the calculated power is too high or too low with regard to the previously defined set-point.

c) It carries out temperature and current checks, for safety purposes, to check if these have exceeded the limits established as maximum limits. If this should occur, the program will turn off the lamp and will try to carry out a re-ignition again. This will be carried out for a maximum period of 10 minutes. If turning on the lamp is carried out with normality and ballast parameters are within normality ranges, the program will return to its normal cycle, if this does not occur, the ballast will turn off the lamp and ballast operation will stop.

Turning on the Lamp:

[0030] This routine is responsible for sending the ignition pulses to the lamp to achieve turning it on.

[0031] The pulse set is sent during a 200 ms lapse each second. The first time this process is repeated during 8 seconds, and the value of current is measured to know if the lamp is turned on, if it is, this subroutine returns to its normal operation cycle.

[0032] If the lamp remains turned off, this subroutine waits 1 minute, it will try again with another ignition pulse set during a maximum of 2 seconds, and again tests if the lamp has been turned on, if it has achieved being turned on, the control subroutine will return, on the contrary, this turning on process will be repeated the following minute until the time maximum reaches 10 minutes.

Measurements:

[0033] This subroutine reads the analog to digital converter (ADC) by sampling: Voltage, current and temperature, a process which is repeated 16 times and in which average values of these three read parameters are returned.

[0034] This subroutine is called during a normal ballast operation cycle with a 150 Hz frequency range.

Timer Interruption:

[0035] This routine is managed by an interruption and is called with a 150 Hz periodicity to manage the output voltage frequency sent to the lamp when it is in normal operating conditions.

Claims

1. A Microcontrolled Electronic Ballast System, formed by an electronic device comprising the following blocks:

   - Power factor correction circuit;
   - Buck-type regulator source;
   - DC-AC converter with an operating frequency equal to 150 Hz;
   - Electronic igniter circuit;
   - Power control circuit;
   - Microcontrolled Electronic Ballast System **characterized in that** it comprises a microprocessor integrated circuit.

2. A Microcontrolled Electronic Ballast System according to claim 1, **characterized in that** said microprocessor integrated circuit comprises:

   - Means for sensing voltage and current levels;
   - Means for controlling output power to the ballast;
   - Means for controlling triggering of the igniter; and
   - Means for communicating in series with peripheral circuits.

3. A Microcontrolled Electronic Ballast System according to claim 2, **characterized in that** said means for sensing the voltage (V_{out}) and current (Iout) levels read by the microprocessor allow:

   - Obtaining the output power value (Pout = V_{out} * Iout) with which the lamp operates;
   - Comparing said power output value with a reference value by means of the microprocessor program; and
   - Delivering the result of said comparison to a digital to analog converter, then to the Buck-type regulator source, thus allowing controlling a stable power output to the lamp.

4. A Microcontrolled Electronic Ballast System according to claim 3, **characterized in that** said means for sensing the output voltage and current levels read by the microprocessor while the ballast is operating allow:

   - Determining when a short circuit occurs at the output, and it achieves detecting it in an 8 millisecond [ms] time lapse;
   - Deactivating the power of the lamp to activate it again a minute later; and
   - Deactivating the power output if the short circuit problem persists during 10 attempts until it is restarted again.

5. A Microcontrolled Electronic Ballast System according to claim 3, **characterized in that** the microprocessor determines if the lamp is within normal operating power, and if this were not the case, the output power is then deactivated.

6. A Microcontrolled Electronic Ballast System according to claim 2, **characterized in that** said means for controlling the triggering of the igniter allow:

   - Delivering a pulse train to energize the lamp at the moment it is turned on for a time maximum of 2 seconds;
   - Deactivating the power output for a 1 minute time lapse if the turning on of the lamp has not been achieved in said time maximum of 2 seconds;
   - Carrying out 10 more turning on attempts;
   - Aborting the turning on if the lamp is not turned on during said 10 attempts;
   - Leaving recorded in the microprocessor that the lamp was not turned on; and not re-igniting again until the ballast is restarted (off - on) again.

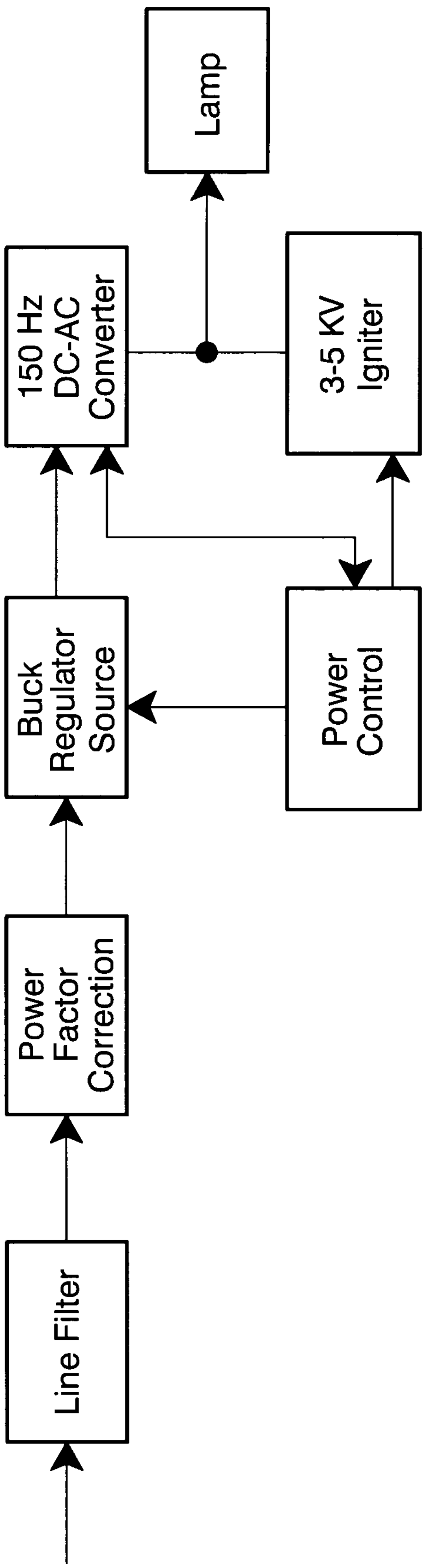

FIG. 1
General Block Diagram of the Equipment

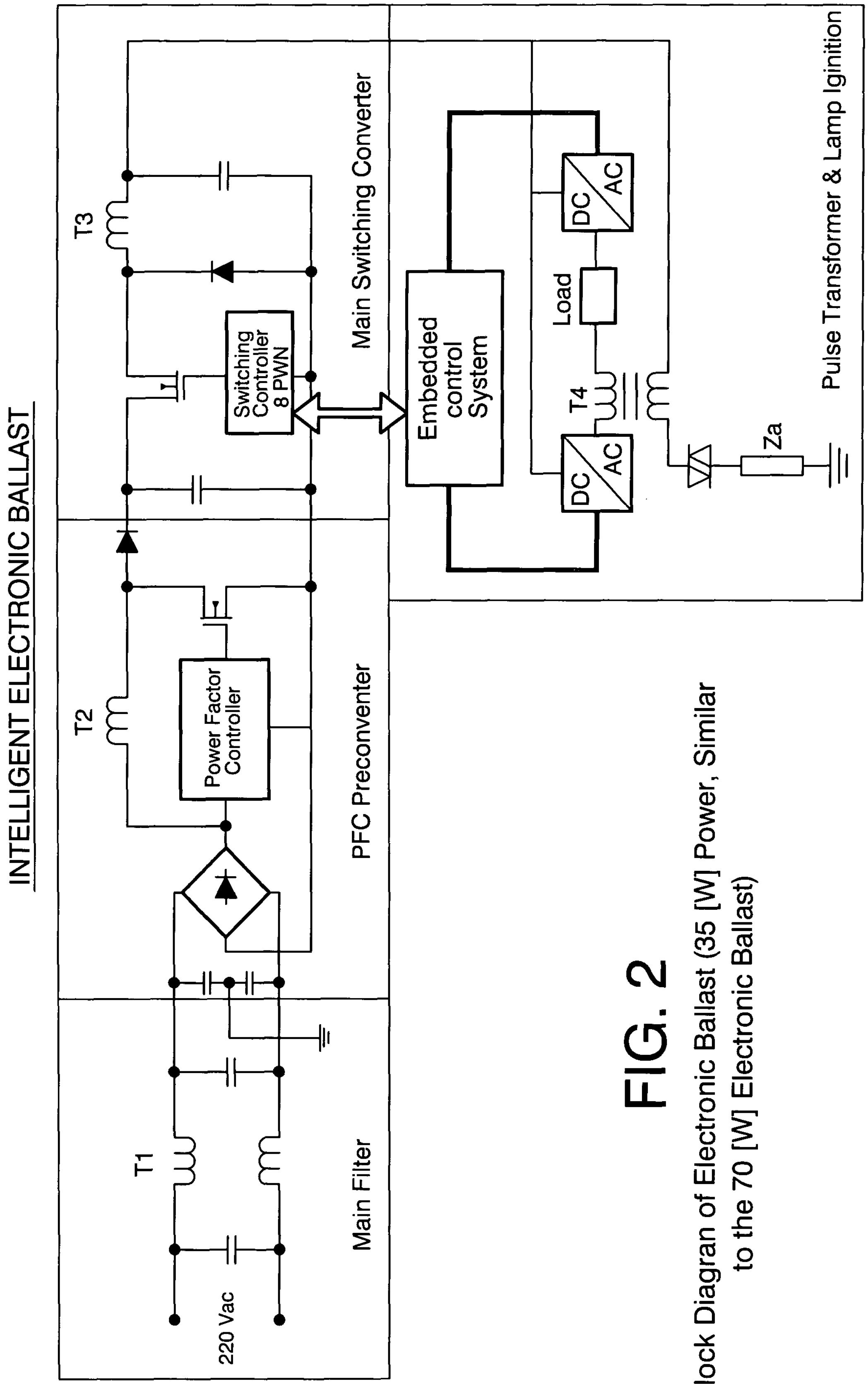

FIG. 2

Block Diagram of Electronic Ballast (35 [W] Power, Similar to the 70 [W] Electronic Ballast)

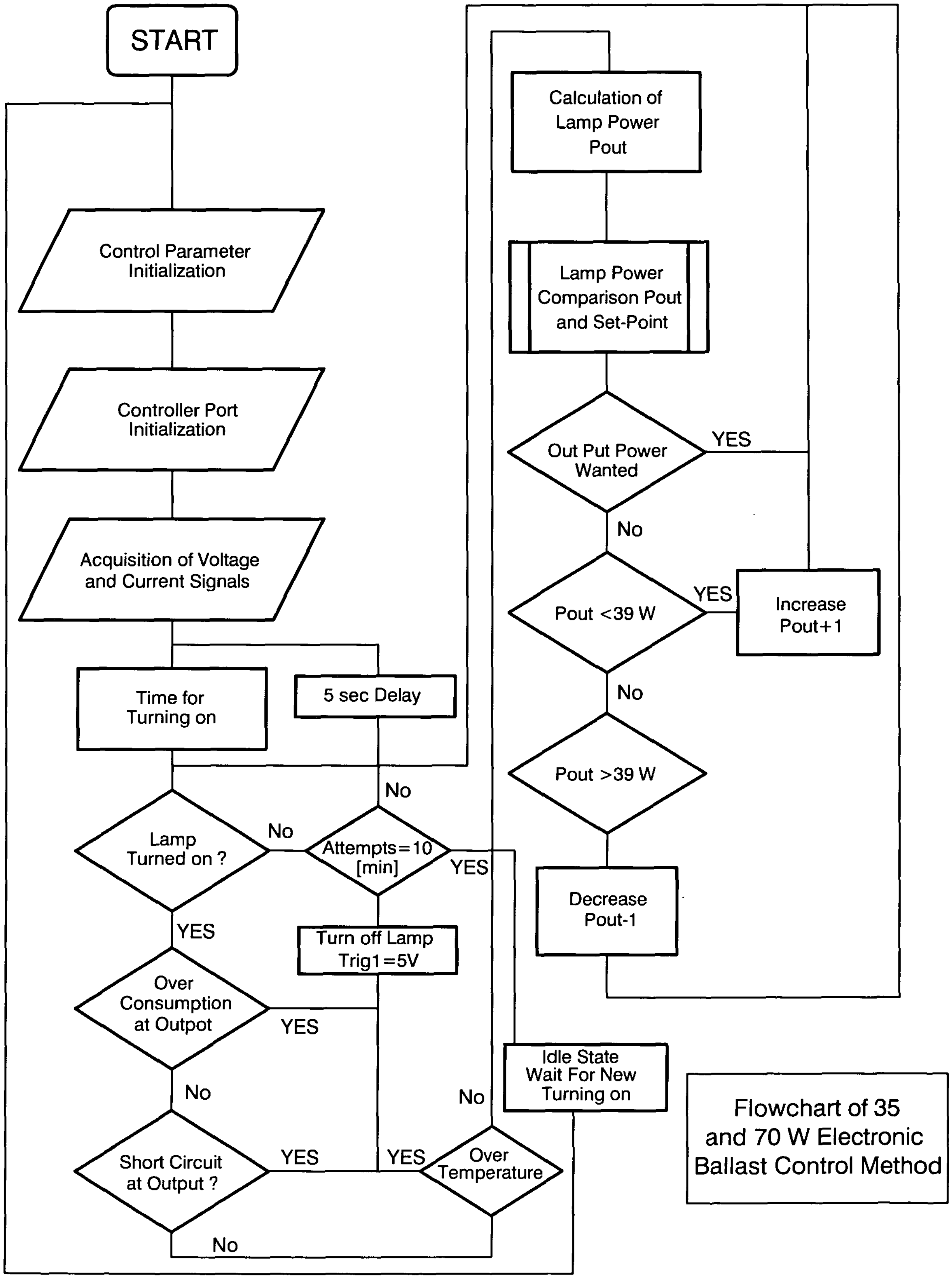

FIG. 3

Flowchart of the Control Method Used

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EUROPEAN SEARCH REPORT

Application Number
EP 03 38 0297

Category	DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	EP 1 322 141 A (IWASAKI ELECTRIC CO LTD) 25 June 2003 (2003-06-25) * page 3, line 50, paragraph 27 - page 4, line 52, paragraph 41; figures 1-3 * ---	1-3 4-6	H05B41/292 H05B41/288
Y	US 6 072 283 A (HEDREI GEORGE C ET AL) 6 June 2000 (2000-06-06) * column 1, line 65 - column 3, line 53 * * column 6, line 45 - column 7, line 3 * ---	4-6	
A	US 2002/145393 A1 (CHUNG SHU-HUNG ET AL) 10 October 2002 (2002-10-10) * page 5, paragraph 74 - page 5, paragraph 77 * ---	4-6	
A	EP 1 227 706 A (CITY UNIVERSITY OF HONG KONG) 31 July 2002 (2002-07-31) * column 10, paragraph 35 - column 10, paragraph 39; claims 18,20 * * column 11, paragraph 42 - column 11, paragraph 44; claim 14 * ---	4-6	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
MUNICH	16 April 2004	Burchielli, M

CATEGORY OF CITED DOCUMENTS

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