(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 224 791 A2**

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**01.09.2010 Bulletin 2010/35**

(51) Int Cl.:
***H05B 41/04*** *(2006.01)* ***H01J 7/32*** *(2006.01)*
***H02M 1/02*** *(2006.01)*

(21) Application number: **09180359.3**

(22) Date of filing: **22.12.2009**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**
Designated Extension States:
**AL BA RS**

(30) Priority: **22.12.2008 IT PD20080375**

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## (54) Electronic power supply unit for a discharge lamp, lighting system and method of lighting a discharge lamp

(57) An electronic power supply unit (4)for discharge lamps, comprises an electronic power supply circuit (8) suitable to receive a mains voltage in input ($V_{cc}$) and to generate, on the two output terminals (18), a triggering voltage ($V_{imp}$) to trigger an associable discharge lamp (12). Advantageously, the power supply unit (4) sends the output terminals (18) two impulse voltages ($\pm V_{imp}$) of the same value and opposing polarities, so as to generate a total power supply voltage of double the value of the voltages ($\pm V_{imp}$) of the single output terminals (18) and suitable to trigger the lamp (12).

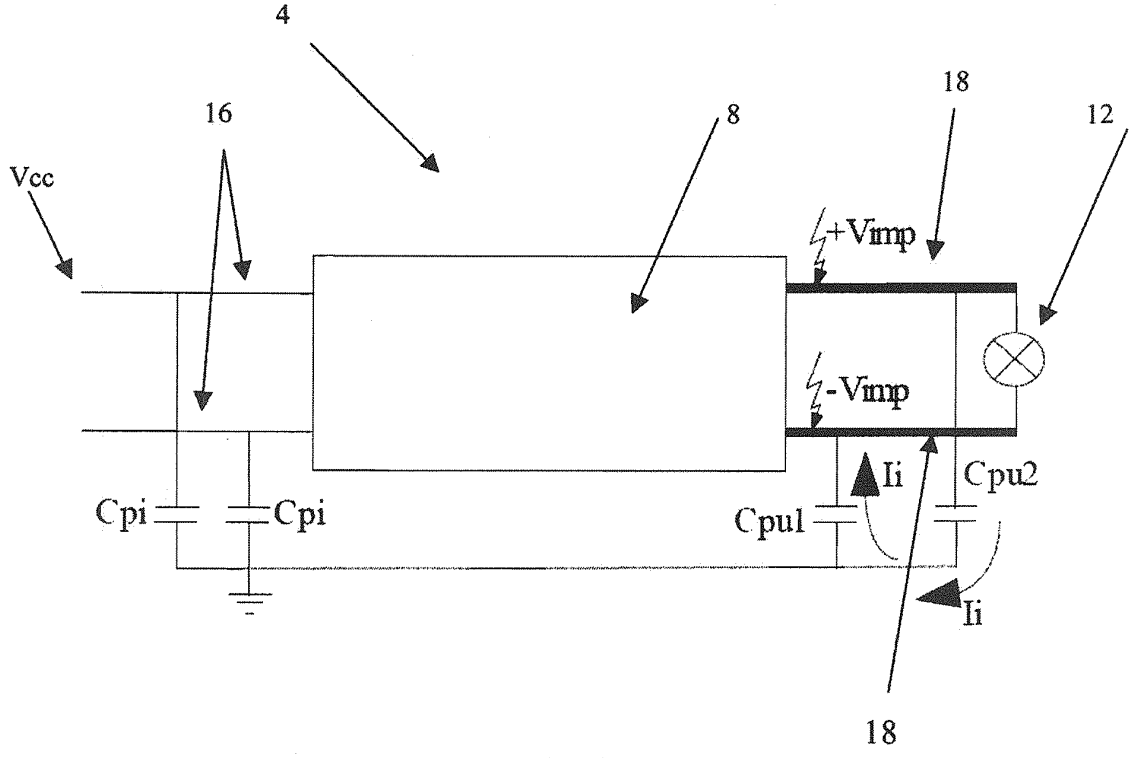


Fig. 2

EP 2 224 791 A2

## Description

**[0001]** The present invention relates to an electronic power supply unit for lamps, in particular for cold cathode discharge lamps, a lighting system and relative method of lighting a cold cathode discharge lamp.

**[0002]** Power supply units for lamps, commonly known as 'ballast', which send an impulse to a terminal of the lamp for the entire amount of its value (typically up to 5kV; figure 1) are known of in the art.

**[0003]** Such impulse causes an impulse current "Ii" in the stray capacitance "Cpu2"; the current of which must be closed through the stray input capacitances Cpi crossing the circuits of the power supply unit once again (which does not normally have galvanic isolation barriers, and, where such exist, said barriers would be put under dangerous stress by the return impulse).

**[0004]** From the above, one may see that the power supply units of the known art have numerous drawbacks.

**[0005]** In fact, such impulse current may significantly disturb the internal circuitry of the electronic power supply unit.

**[0006]** In addition, the insulation may be jeopardised; moreover the impulse present on the input propagates itself onto the line causing disturbance to the other equipment as well as electromagnetic disturbance.

**[0007]** The Cpu capacity, the dielectric of which is composed of the sheath of the connection cable to the lamp, is under stress with almost 5 kV and may therefore give rise to discharge in the presence of damp or with ageing.

**[0008]** In addition, the current Ii must be supplied by the power supply unit and is subtracted from the current which it should supply to the lamp to ionise the gas contained in the burner.

**[0009]** The devices of the known art present, as a result of what has been said, several considerable limitations.

**[0010]** For example, the electronic power supply units for discharge lamps of the known art create limitations to the maximum length of the lamp connection cables or maximum stray earthing capacitance of the same; for this reason the manufacturers pose constraints in this sense.

**[0011]** The purpose of the present invention is to realise a power supply unit which resolves the limitations and drawbacks mentioned with reference to the known art.

**[0012]** Such drawbacks and limitations are resolved by a power supply unit according to claim 1, by a lighting system according to claim 10 and by a lighting method according to claim 11.

**[0013]** Other embodiments of the power supply unit according to the invention are described in the subsequent claims.

**[0014]** Further characteristics and advantages of the present invention will be easier to comprehend from the description below made by way of a non-limiting example of its preferred, embodiments, wherein:

**[0015]** figure 1 shows a schematic view of a lighting system according to the known art;

**[0016]** figure 2 shows a schematic view of a lighting system according to the present invention;

**[0017]** figure 3 shows a schematic view of a detail of the system according to the present invention.

**[0018]** The elements or parts of elements in common to the embodiments described below will be indicated by the same reference numeral.

**[0019]** With reference to the aforesaid figures, reference numeral 4 globally denotes a power supply unit comprising a capacitor discharge electronic power supply circuit 8 suitable to trigger an associable lamp 12.

**[0020]** The electronic power supply circuit 8 is suitable to receive a mains voltage in input and to generate an impulse voltage in output to trigger the associable lamp 12.

**[0021]** In particular, the circuit 8 comprises a pair of input terminals 16, through which the mains voltage $V_{cc}$ is supplied to power the circuit 8, and a pair of output terminals 18 electrically connected to said lamp 12.

**[0022]** Preferably, the circuit 8 comprises a control switch 20 equipped with a relative control terminal 24.

**[0023]** The control switch 20 is powered by a high powered mains voltage generator.

**[0024]** The circuit 8 comprises, in addition, a transformer 26 having a primary winding 28 and a secondary winding 32.

**[0025]** The primary winding 28 receives the power supply voltage from the input terminals 16 and the secondary winding 32 receives the voltage from the primary winding 28 multiplied by the relative transformation ratio of the transformer 26.

**[0026]** Upline of the primary winding 28 the circuit 8 comprises a condenser 36 charged by the mains voltage, for instance of 300-400V.

Preferably, a resistance 40 is placed between the condenser and the primary winding.

**[0027]** Advantageously, the secondary winding 32 is divided into two semi-windings 44', 44" each one of which dispenses half the impulse voltage needed to trigger the lamp. For example, to trigger 5kV, each of the two semi-windings 44' e 44" will dispense 2.5 kV.

**[0028]** A voltage generator 48 is preferably placed halfway along the two semi-windings 44', 44", in other words is in series with them.

**[0029]** Preferably, said voltage generator 48 is of the variable voltage and frequency type. Preferably a shunt 53, that is current deviator is positioned in series with the voltage generator 48. Said shunt 53 is able to measure the current sent through the voltage generator 48 to the lamp 12.

**[0030]** The potential of the two ends of the generator 48 differs from earth only slightly (about a hundred V).

**[0031]** The generator 48 powers the lamp 12 providing it with the voltage $V_{lamp}$ so as to keep it lit subsequent to its being triggered.

**[0032]** Advantageously, the two semi-windings 44', 44" are 'phased' so that at the ends of the lamp 12 there

are two impulses of 2.5 kV of opposite polarity.

**[0033]** Overall, the lamp "feels' a total of 5 kV between its two ends, needed to trigger it.

**[0034]** In particular, when the control switch 20 receives an impulse, sent through the relative control terminal 24, the control switch 20 becomes a short-circuit; so that the condenser 36 finds itself in parallel with the primary winding 28 of the transformer 26.

**[0035]** On the secondary winding 32 an impulse is induced of an equal amplitude to the voltage which was present on the condenser 36 at the moment of the command multiplied by the voltage ratio of the transformer 26.

**[0036]** Such impulse is summed with the voltage dispensed by the generator 48, in series with the secondary winding 32.

**[0037]** The lamp 12 is triggered and the generator 48 keeps it lit subsequent to it being triggered.

**[0038]** Preferably, the transformer 26 is traversed by the operating current of the lamp 12 but is designed to saturate itself with such current, thereby ensuring minimum power loss.

**[0039]** The electronic power supply unit 4 comprises in addition a microprocessor 59 which is electrically connected, by means of connections 50, 51 to the shunt 53 and to the generator 48.

**[0040]** In particular, the microprocessor 59 measures the voltage and power supply current of the lamp 12 by means of the connection 50; moreover the microprocessor 59 is able to control the voltage and frequency parameters of the generator 48 by means of the command 51.

**[0041]** In addition, the microprocessor 59 comprises a connection 52 by which the microprocessor 59 connects to the switch 20 and is able to control the temporal moment in which the switch 20 receives the closure impulse

**[0042]** According to one embodiment, the power supply unit comprises devices able to memorise the thermal image of the lamp. In particular, it is known that when a lamp is cold it can be triggered immediately but that when the same lamp is hot (has been turned off a short time previous) then it is generally necessary to wait for it to cool down. If this were not the case there would a risk of non-triggering or of damage to the electrodes in that the spark erodes the hot electrodes more easily given that in such conditions the metal is much softer.

**[0043]** The power supply unit of the present invention create and memorises a thermal image of the lamp; so that if this is found to be 'cold' at the moment of supplying voltage to light it, the lamp will be triggered immediately.

**[0044]** If, however, the thermal image consulted in that moment indicates that the lamp is too hot to be lit, a period of time will elapse, not a fixed period but the time strictly necessary to allow it to cool to a sufficiently cool temperature and therefore be triggered again without particular damage.

**[0045]** This functioning mode provides maximum protection of the lamp with minimum downtime while waiting to retrigger.

**[0046]** In any daytime or night-time condition the lamp will always be immediately available without tiresome delays and in the presence of brief black-outs or on-off-on manoeuvres by inopportune manual piloting of the system, the power supply unit protects the lamps for the minimum time needed for them to cool and therefore prevent damage.

**[0047]** The functioning of a power supply unit according to the invention will now be described.

**[0048]** To achieve lighting of the lamp the condenser 36 must be charged. Advantageously, thanks to the microprocessor 59 fitted with the command 52, the switch 20 can be turned off at any moment during charging of the condenser 36 so as to obtain a discharge of varying voltage and consequently a triggering voltage of the lamp which, being worth 5 kV when fully charged at 36 can be proportionally inferior starting from little more than 1 kV. This leads to triggering attempts at increasing voltages being obtained (a new or good quality lamp will trigger at relatively low voltages while a "hard" or old lamp needs higher voltages of up to 5 kV). As soon as the lamp triggers, the processor 59 reads the current off the shunt 53 and stops the triggering attempts. The lamp will have been triggered at a barely sufficient impulse voltage and will therefore be subject to less wear.

**[0049]** The impulse present on both input terminals 16 of the lamp 12 for half the amount of its total value with different polarities ($+V_{imp}$, $-V_{imp}$) causes current impulse peaks "Ii" in the two stray capacitances "Cpu1" and "Cpu2" (figure 2).

**[0050]** The lamp is, for example, generally stressed, between its ends with 5 kV, obtained with voltages $\pm V_{imp}$ on the terminals of $\pm$ 2.5 kV.

**[0051]** The value of 5 kV is purely indicative; the invention being applicable to lamps 12 having variable triggering voltages.

**[0052]** Assuming that the two stray capacitances are the same value, as are the two impulse voltages, then the two impulse currents will also be of the same value but opposing polarity

**[0053]** In fact, by being of opposite polarity they compensate each other and no resulting current can recirculate on the input and through the power supply unit 4.

**[0054]** Advantageously, the lamp is lit gradually: in fact at the moment of lighting the power supply unit 4 begins to dispense a series of impulses, generally limited to a total of about 2.5 kV, to the lamp 12, continuing then with repeated impulses at gradually increasing voltages reaching the 5 kV total after about 20 seconds.

**[0055]** Obviously, the impulses on the output terminals 18 are always of the same intensity and of opposite polarity so as to supply the lamp 12 an overall voltage equal to the sum of the voltages on said output terminals 18.

**[0056]** Preferably, the initial overall voltage, equal to the sum of the voltages $\pm V_{imp}$ on the output terminals 18, is about 2.5kV and up to 5.0kV if necessary to trigger the lamp 12.

**[0057]** According to one embodiment, the rate of in-

crease of the voltage on the output terminals 18 is from 0.10 kV/s to 0.15 kV/s; preferably said rate is equal to about 0.125 kV/s.

**[0058]** AS soon as the lamp 12 triggers, repetition of the impulses is stopped and the effect is thereby obtained of triggering the discharge at the minimum voltage required by the lamp that is with the minimum possible erosion of the electrodes of the lamp 12.

**[0059]** In fact, among the factors determining ageing of the lamp one is connected with the erosion of the two electrodes inside the burner of the lamp, between which the arc strikes. Such erosion is attributable to normal functioning with nominal voltage and current but is considerably increased by the initial discharge, generated by the lighter. Consequently if low voltages of the level 2.5 to 3 kV were dispensed such effect would be minimised but there would be a risk of not triggering some "hard", "old" or "warm" lamps. If, however, one worked with trigger voltages of 5 kV all lamps would certainly be triggered but ageing of the same due to erosion of the electrodes would also be increased. The power supply unit of the present invention ensures gradual lighting of all types of lamp, minimising erosion of the electrodes and therefore maximising the life of the same.

**[0060]** With the lamp triggered the connections 50 make it possible to read the current and voltage of the lamp 12 and the processor 59 can calculate the power which the lamp absorbs. This makes it possible to plan appropriate run-up phases and maintain constant power to the lamp. The same consumed power and the same luminous emission of different lamps at different stages of their useful life, even up to half-dead lamps, may thus be obtained. All this would be absolutely impossible with a traditional power supply unit based on electromechanical ballast.

**[0061]** The control performed by the microprocessor 59 permits further lamp dead signalling functions as well as preventing the tiresome periodic flashing of the lamp when close to dead, thanks to the continuous monitoring of the functioning parameters of the lamp.

**[0062]** As may be seen from the description, the power supply unit according to the invention makes it possible to overcome the drawbacks mentioned in relation to the known art.

**[0063]** In particular, the power supply unit is of a limited size and suitable for the great majority of luminaires on sale.

**[0064]** In addition, the power supply unit of the present invention has a high yield, of over 96%, and thus permits a considerable saving of energy compared to the electromechanical ballast of the known art.

**[0065]** The power supply unit of the present invention can function at temperatures of over 50°C present at specific moments inside the luminaires.

**[0066]** Advantageously, the piloting of the lamp is performed in low frequency (<200Hz) to prevent any acoustic resonance phenomena.

**[0067]** Advantageously, the power supply unit of the present invention has a high MTBF (mean time between failures) reliability, no lower than the best electromechanical ballast of the known art.

**[0068]** In addition, the power supply unit has a very high power factor (close to one) thereby preventing the circulation of reactive power and exploiting the supply system to the most.

**[0069]** The power supply unit presents, in addition, low harmonic distortion on the current and insensitivity to mains voltage variations, even within extremely wide limits, of 180 V to 250 V.

**[0070]** Advantageously, the power supplied to the lamp is constant and equal to the nominal power, essentially throughout the lifespan of the lamp itself.

**[0071]** The present invention also makes it possible to reduce the energy consumption (to less than half) of most or all of the system, at predefined times, generally in the middle of the night, by means of two methods:

- independently by setting the time
- by remote control via cabling (via a cable network) or by remote wireless control (via a wireless network).

**[0072]** Advantageously, the power supply unit makes it possible to prevent excessive reduction of the power with the ageing of the lamp without creating disservice; in other words an "elderly" lamp no longer permits great power reductions but the power supply unit according to the present invention keeps it lit without the periodic end-life on/off typical of electromechanical piloting of the power supply units of the known art.

**[0073]** In addition, the power supply unit according to the present invention allows the parameters of consumption, temperature, ageing index of the lamp, hours of diagnostics and many other remote data (when connected up)to be known.

**[0074]** In addition, the power supply unit permits a good rejection of disturbance and ensures resistance to the overvoltage induced by atmospheric discharge.

**[0075]** As seen, the power supply unit adapts to various lamp powers, such as for example lamps of 70, 100, 150, 250 W; in addition it also adapts to different lamp technologies.

**[0076]** In addition, the limitations to the length of the lamp connection cables typical of the known art are overcome, giving greater freedom for the connection of the lamp, the type of luminaire, the length and type of power supply line in AC.

**[0077]** In addition, there is no voltage on the inputs of the power supply unit due to the lighting impulses, the input insulations are therefore not stressed and there is no electromagnetic disturbance.

**[0078]** The Cpu capacities, the dielectric of which is composed of the sheath of the connection cable to the lamp are stressed with half the voltage of the power supply units of the known art, that is with only 2. 5 kV.

**[0079]** The current Ii which must be dispensed by the

lighter onto the stray capacitances is halved.

**[0080]** A person skilled in the art may make numerous modifications and variations to the power supply units described above so as to satisfy contingent and specific requirements while remaining within the sphere of protection of the invention as defined by the following claims.

## Claims

**1.** Electronic power supply unit (4) for discharge lamps, comprising

- an electronic power supply circuit (8) able to receive in input a mains voltage ($V_{cc}$-$V_{ca}$) and to generate in output a triggering voltage to trigger an associable discharge lamp (12),,
- two input terminals (16) to receive said mains voltage ($V_{cc}$-$V_{ca}$) and two output terminals (18), which can be electrically connected to the lamp (12), to power said lamp (12),
- wherein the electronic power supply circuit (8) comprises a transformer (26) having a primary winding (28) and a secondary winding (32), the primary winding (28) receiving the power supply voltage from the input terminals (16) and the secondary winding (32) being electrically connected to the output terminals (18) of the power supply unit (4), the secondary winding (32) being divided into two semi-windings (44', 44"), respectively connected to the terminals of the lamp (12), **characterised by** the fact that

the electronic power supply unit (4) comprises a voltage generator (48) able to supply the power supply voltage ($V_{lamp}$) to the lamp (12) to keep it lit, subsequent to its being triggered, the voltage generator (48) being of the variable voltage and frequency type,

in series with the voltage generator (48) is a current deviator (53) able to measure the current sent to the lamp (12) by the voltage generator (48),

the electronic power supply unit (4) comprises a microprocessor (59) which is electrically connected, by means of connections (50, 51) to the shunt (53) and to the generator (48) respectively,

wherein the microprocessor (59) measures the voltage and power supply current of the lamp (12) by means of the connection (50) and controls the voltage and frequency parameters of the generator (48) by means of the command (51) both when the lamp is lit and following triggering of the lamp (12).

**2.** Electronic power supply unit (4) according to claim 1, wherein the electronic power supply unit (4) sends the output terminals (18) two impulse voltages ($\pm V_{imp}$) of the same value and opposing polarities, so as to generate a total power supply voltage of double the value of the voltages ($\pm V_{imp}$) of the single output terminals (18) and suitable to trigger the lamp (12).

**3.** Electronic power supply unit (4) according to claim 1 or 2, wherein each semi-winding (44', 44") dispenses an impulse voltage ($\pm V_{imp}$) equal to half the overall trigger voltage of said lamp (12) and wherein the two semi-windings (44', 44") are phased so that at the ends of the lamp (12) there are two impulse voltages ($\pm V_{imp}$) of opposite polarities.

**4.** Electronic power supply unit (4) according to any of the previous claims, wherein said voltage generator (48) is placed halfway along the semi-windings (44', 44"), and in series with them.

**5.** Electronic power supply unit (4) according to any of the previous claims, comprising a control switch (20) equipped with a relative control terminal (24), the switch (20) short-circuiting itself as a result of an impulse sent through the control terminal (24).

**6.** Electronic power supply unit (4) according to claim 5 wherein the microprocessor (59) comprises a connection (52) with which it connects to the switch (20) and is able to control the temporal moment in which the switch (20) receives the closure impulse.

**7.** Power supply unit (4) according to claim 5 or 6, wherein upline of the primary winding (28) the circuit (8) comprises a condenser (36) charged by the mains voltage, said condenser (36) being in parallel with a primary winding (28) when the control switch (20) short circuits.

**8.** Power supply unit (4) according to any of the previous claims, comprising devices able to memorise the thermal image of the lamp (12), so as to enable or prevent triggering depending on whether the lamp (12) is respectively above or below a predetermined threshold temperature.

**9.** Lighting system comprising at least one power supply unit (4) according to any of the claims from 1 to 8, and at least one lamp (12) connected electrically to the output terminals (18) of said power supply unit (4).

**10.** Method of lighting on a discharge lamp (12) according to any of the claims from 1 to 8, comprising the phase of powering the output terminals (18) of the power supply unit (4) of said lamp (12) respectively by two impulse voltages ($\pm V_{imp}$) of the same value, phased so as to be of opposing polarity to each other, the sum of said voltages being equal to the trigger voltage of the lamp (12).

**11.** Method according to claim 10, comprising the phase of dispensing from the respective output terminals (18) a series of impulses ($\pm V_{imp}$) of a gradually increasing voltage until the triggering voltage of the lamp is reached (12), said impulses being equal to each other and of opposite polarities.

**12.** Method according to claim 11, wherein the rate of increase of the voltage in the output terminals (18) is between 0.10 kV/s and 0.15 kV/s.

**13.** Method according to any of the claims from 10 to 12, comprising the phases of:

- creating and memorising a thermal image of the lamp (12), so as to assess the temperature of the lamp over time (12),
- verifying the temperature of the lamp (12) simulated by the thermal image at the moment of lighting the same so as to enable it to be lighted if the lamp (12)is below a predetermined threshold temperature and so as to prevent it from being lighted if the lamp (12) is above said predetermined threshold temperature.

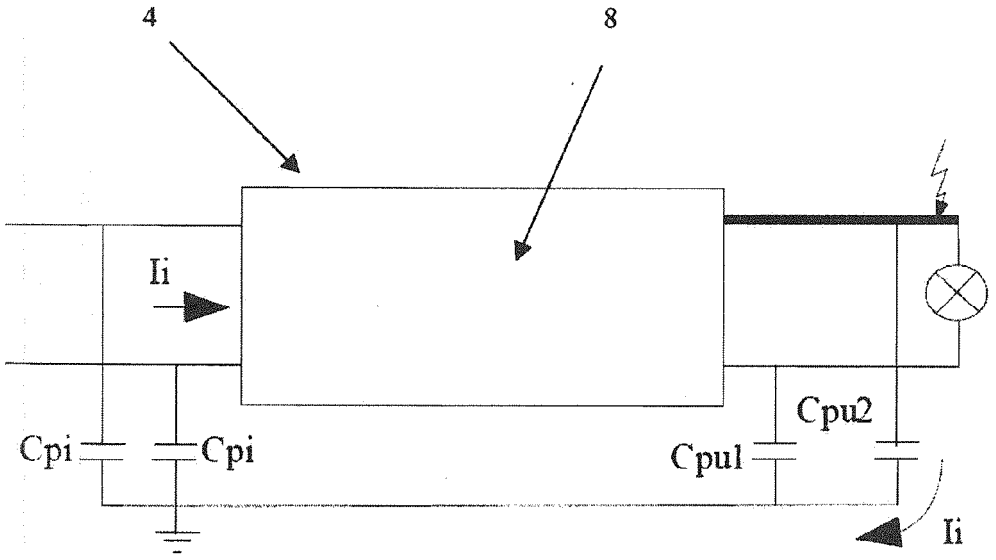
4
8
Ii
Cpi
Cpi
Cpu1
Cpu2
Ii

Fig. 1

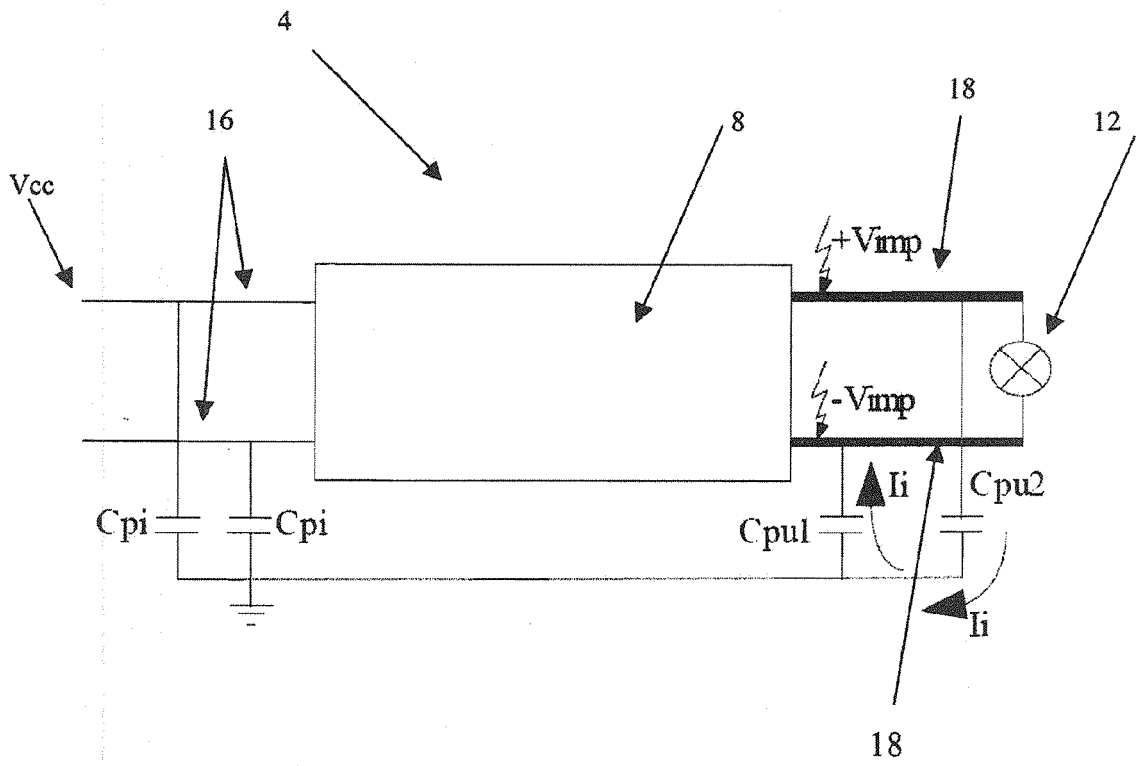
4
16
8
18
12
Vcc
+Vimp
-Vimp
Ii
Cpu2
Cpi
Cpi
Cpu1
Ii
18

Fig. 2

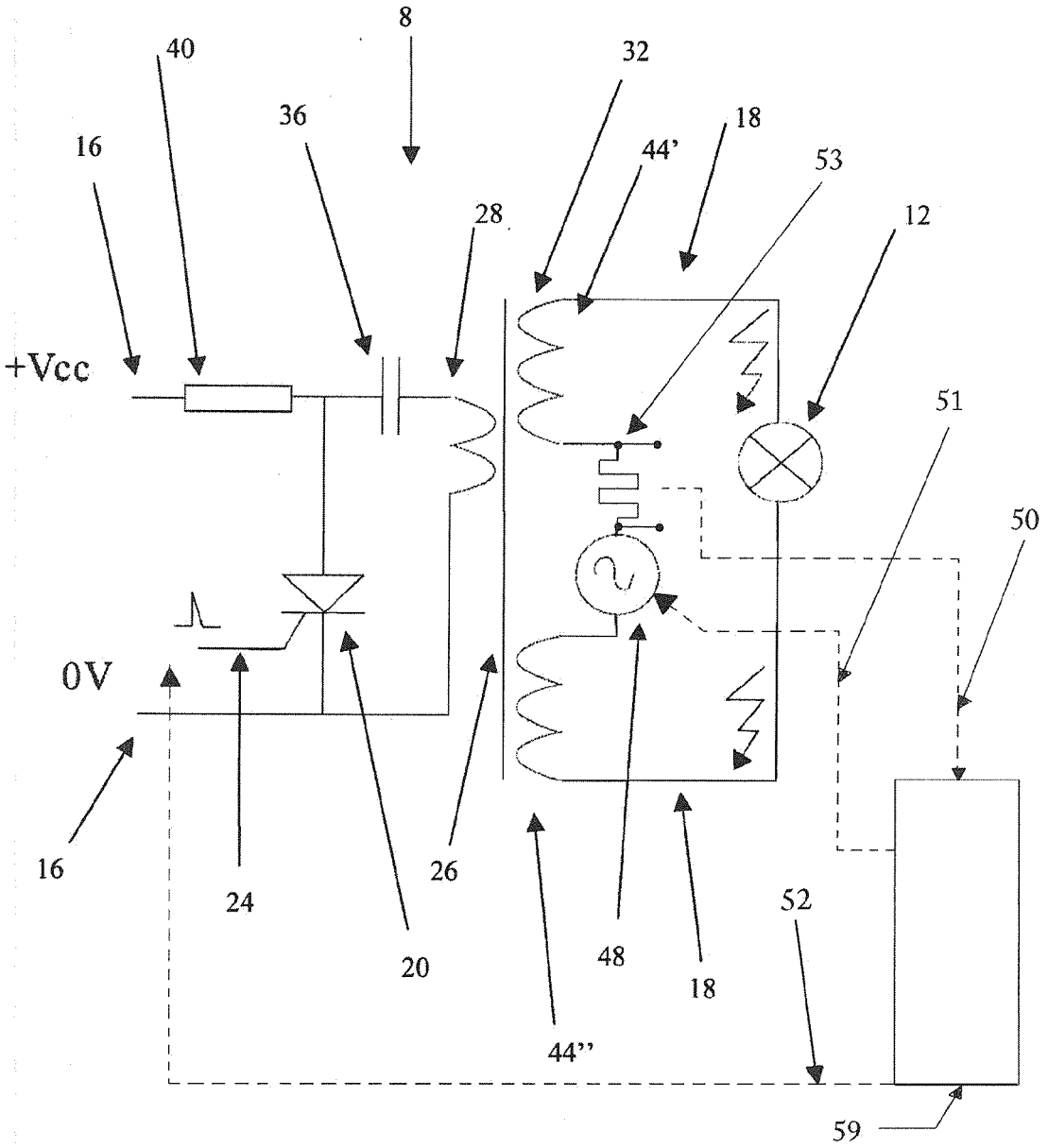


Fig. 3