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

(11) EP 0 955 794 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.11.1999 Bulletin 1999/45

(51) Int. Cl.[6]: H05B 41/29

(21) Application number: 99201358.1

(22) Date of filing: 01.05.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 06.05.1998 IT MI980982

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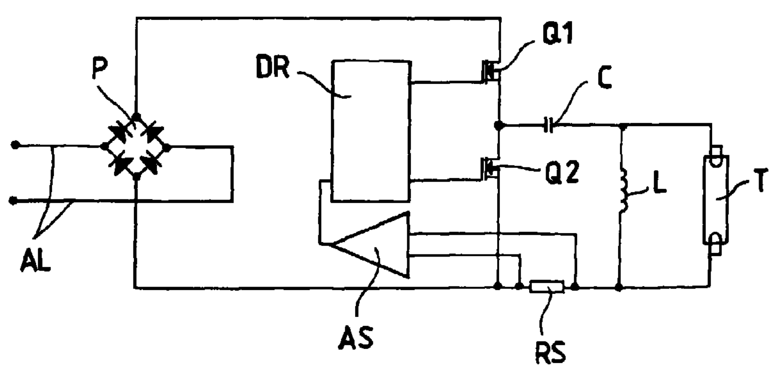
(54) High frequency electronic control circuit for fluorescent lamps

(57) A high frequency electronic control circuit for fluorescent lamps or tubes (T, T1, T2), comprising a half bridge circuit (MP), formed by a couple of power switches (Q1, Q2) and by the related control circuit (DR), a voltage rectifier bridge (P), a resonance circuit (C-L), which supplies the electric current to the fluorescent tubes (T, T1, T2) and a synchronisation or control circuit (CC), which properly controls the switchover of the power switching means (Q1, Q2), according to the direction of the current in the resonance circuit (C-L).

Using the circuit configuration according to the invention, it is possible to obtain a significant reduction in the number of components with respect to the known art, thus substantially reducing the costs.

Fig.4



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Description

[0001] The present invention refers to a high frequency electronic control circuit for fluorescent lamps.

[0002] In parallel to the development of the technology, there has been a progressive increase of the need for producing higher quantities of light, at a higher quality level.

[0003] In order to keep the costs down there has been a progressive change from very low efficiency systems, as the gas combustion system, to higher efficiency systems, as the ones which use the discharge lamps.

[0004] A large group of lamps belong to this last type and all said lamps work according to the same principle; more exactly, the light production is realised through the electric discharge between two electrodes placed inside a tube filled with gas.

[0005] During the Thirties, based on this principle, the fluorescent lamps have been developed, wherein most of the emitted light is not directly produced by the electric discharge but instead by a fluorescent material which covers the tube.

[0006] These lamps have a negative voltage/current characteristic, therefore once these lamps have been lighted and without additional devices, said lamps would increase the current passage up to self-destruction.

[0007] It is, then, necessary to provide, in the circuit, a feeding device, which limits the current and the lamp power according to the data provided by the manufacturers and which provides the proper preheating current intensity to the tube cathodes and the proper voltage value to start the discharge.

[0008] Further, an efficient feeding device has to guarantee a good efficiency of the system and, so, it has to have limited losses, and to limit the harmonic distortions of the lamp current, while having, additionally, a noiseless working conditions, low thermal dispersion, high reliability and limited costs with respect to the attainable performances.

[0009] Currently, there are several types of feeding devices, which can be, anyhow, divided essentially in two main groups: the magnetic feeders, with which the lamp works at a grid frequency and the electronic feeders, with which the lamp works at high frequency and, specifically, in the range of frequencies from about 20 to 40 kHz.

[0010] The simplest and most economical traditional system and, consequently, the most currently used to feed fluorescent lamps, uses simple impedance magnetic feeders: the feeding device is formed by a linear inductor placed in series with the lamp and, in parallel to said inductor, a discharge starting circuit is placed, which has the function to circulate a preheating current in the cathodes and to provide the correct turn on voltage. However, this circuit can be utilised only when the grid voltage is about the double of the lamp voltage.

[0011] If the lamp voltage is particularly low with respect to the grid voltage, it is possible to connect two lamps in series to the same feeder, however, with this particular type of circuit, proper starting circuits have to be utilised, since the vacuum voltage is normally distributed between the two lamps.

[0012] Vice versa, if the lamp voltage is too high with respect to the grid voltage, the system will work in an unstable manner and, to avoid that, it will be necessary to place an autotransformer downstream the circuit to increase the grid voltage and to correct the power factor in order to obtain an adequate power factor.

[0013] Generally, the power factor correction is realised by putting capacitors in parallel to the grid, said capacitors have a voltage rating equal to or slightly higher than the feeder line; sometimes, a series power factor correction is used by connecting an inductive circuit to a circuit wherein a capacitor, having an impedance value which is about the double of the input impedance value of the feeder, is in series with the feeder. In this case, we must pay attention during the realisation of the circuit, since, at the capacitor ends, a voltage is created whereby the voltage value is equal to about the double of the value of the grid voltage and, consequently, capacitors having a proper voltage rating value, will be utilised.

[0014] Because of the energy crisis during the Seventies, there has been the need to improve the lighting system efficiency both through the research of new light sources having a better efficiency and through the loss reduction in the auxiliary devices needed for their operation.

[0015] As a consequence, there has been a significant boost to improve the electronic feeder.

[0016] The basic working concept of the electronic feeder is to feed the lamp in high frequency, in order to decrease the inductance value until it is included in the electronic apparatus itself.

[0017] An electronic feeder of the traditional type comprises, in series, a filter, which does not allow to introduce the high frequency transients generated by the apparatus into the power grid, a first converter, which converts the 50 Hz grid alternate voltage to continuos voltage, a second converter which converts the continuos voltage to alternate voltage, thus allowing to feed the high frequency lamp with a proper voltage, a circuit, which allows, when required, the preheating of the tube cathodes before the lamp start so as to guarantee a substantial duration. Since during the working at high frequency it is possible to noticeable reduce the cathodes preheating time, the lamp, front the point of view of fast turn on, behaves as a filament lamp; further, the electronic feeder does not need, thanks to the easiness to create an elevated voltage when it is turned on independently from the grid voltage value, the start circuit with a consequent simplification of the harness.

[0018] Between the other advantages of the electronic type feeder, we can mention the almost continuos value of the light emission, a substantial increase of the light efficiency, compared with the previous art, lower losses, lower energy consumption, a smaller change of the flow in function of the temperature, a substantial stabilisation of the light flow with respect to the grid changes, a high power factor and low noise.

[0019] However, a significant limitation to the spreading of the electronic feeders is caused by the initial costs of the circuit, which requires several years of operation to be recovered in terms of permitted energy saving.

[0020] The high cost of a circuit of this type is due to the complexity of the components and to the length of the cabling between the feeder and the lamp, due to the need to observe the rules related to the electromagnetic compatibility and to the current harmonics; further, the electronic feeders commercially available have additional problems linked to the high frequency dispersion current.

[0021] A purpose of the present invention is to disclose a high frequency electronic control circuit for fluorescent lamps which overcomes the above mentioned disadvantages and which allows to obtain all the advantages of a feeder device of the electronic type, reducing, at the same time, the number of components.

[0022] An other purpose of the present invention is to realise a high frequency electronic control circuit for fluorescent lamps which allows to simplify the procedure of control synchronisation, with respect to the known art.

[0023] A further purpose of the present invention is to realise an electronic control circuit which guarantees a high reliability and a long life to the connected fluorescent lamps, allowing, at the same time, the respect of the operational mode and of the applicable electromagnetic rules.

[0024] Last but not least purpose of the present invention is to obtain a high frequency electronic control circuit for fluorescent lamps of easy and inexpensive realisation, without using components particularly expensive and/or complex technologies.

[0025] These and other purposes are achieved by a high frequency electronic control circuit for fluorescent lamps according to claim 1, which is taken as a reference for brevity sake.

[0026] Advantageously, according to the invention, a control of the capacitive type is obtained by controlling the energy entering a resonance circuit with an innovative configuration, so as that, since the absorption is proportional to the feeding voltage, it is possible to eliminate, with respect to the known art, the components relative to the power corrector device, which are very expensive.

[0027] Therefore, there is a compensation of the negative resistance characteristic of the tube of the fluorescent lamp and, consequently, a better efficiency and reliability, with respect to the known art and a higher stability in performances, with respect to the traditional control techniques. The operation of the current resonance electronic circuit allows to deliver only the active current to the power switches, thus allowing to obtain, at the same time, a simplified control synchronisation, so as to guarantee more reliability and less dissipation with respect to the known art and reduced noise intensity levels.

[0028] Since the current which circulates inside the inductive element of the resonant control circuit is not related to the lamp current, a significant reduction of the dissipation on the inductor is obtained, thus achieving an improved control of the two fluorescent tubes in series and/or of the auxiliary preheating windings; therefore we obtain a reduction of the dimensions of the inductor and, so, of the realisation costs, with respect to the known art, and significant simplification and flexibility by the point of view of the circuit components and of the control system.

[0029] Further purposes and advantages of the present invention will be clear from the description which follows and from the appended drawings, given merely as a non limiting example, wherein:

- Figure 1 shows, schematically, an electromagnetic control circuit, of a known type, for a fluorescent lamp;
- Figure 2 shows, schematically, a high frequency electronic control circuit, also of a known type, for two fluorescent lamps;
- figure 3 shows a block diagram of a high frequency electronic control circuit for two fluorescent lamps, according to the invention;
- Figure 4 shows, schematically, a basic circuit configuration of the high frequency electronic control circuit for a fluorescent lamp, according to the present invention;
- Figures 4A, 4B, 4C, 4D show portions of the electronic control circuit of Figure 4, according to the present invention, wherein four typical phases of the operation are shown;
- Figure 5 shows, schematically, a first embodiment of an high frequency electromagnetic control circuit for two fluorescent lamps, according to the present invention;
- Figure 6 shows a block diagram of an integrated circuit named "IR2151";
- Figure 7 is a Cartesian diagram which shows, as a time function, the output or lamp voltage values and the feeding voltage of an electronic control circuit according to the invention;
- Figure 8 is a Cartesian diagram which shows, as a time function in the steady stage, the voltage values for two fluorescent lamps in series, having the sequential start mode, through an electronic control circuit according to the invention;
- Figure 9 is a Cartesian diagram which shows, as a time function, the voltage, the current and the power values

referred to a fluorescent lamp controlled through an electronic control circuit, according to the present invention;

- Figure 10 shows a block diagram of a second embodiment of a high frequency electronic control circuit for fluorescent lamps according to the present invention;
- Figure 11 shows an electric diagram of a light control circuit, suitable to be used in a high frequency electronic control circuit according to the present invention;
- Figure 12 is a Cartesian diagram which shows, as a time function, certain wave-forms detected during the operation of the electronic control circuit of Figure 10, according to the invention;
- Figure 13 shows a complete electric diagram of a second embodiment of a high frequency electronic control circuit for fluorescent lamps, according to the present invention.

[0030] Referring to the above figures, AL indicates a traditional line to carry the electric signal and the corresponding feed voltage, VT, VT1 and VT2 indicate the voltage at the fluorescent lamps, IT indicates the current at the fluorescent lamps, IL indicates the current which circulates in the inductors L, IC indicates the current which circulates in the capacitors C, PT indicates the power dissipated by the fluorescent lamps, F indicates a fuse, P indicates a signal rectifier diode bridge, R indicates the resistors present in the electric circuits, C indicates the capacitors, L indicates the inductors, D indicates the diodes, A indicates the amplifiers, T, T1 and T2 indicate the fluorescent lamps or tubes, S, S1 and S2 indicate the switching devices, Q1 and Q2 indicate two power electronic switches and RS indicates a current "shunt" resistor.

[0031] With specific reference to the block diagrams shown in the attached figures, EM indicates a signal filter device, PFC indicates a circuit suitable to correct the power factor, PS indicates an apparatus comprising the power electronic switches Q1 and Q2 and the corresponding control circuit DR, LC indicates a current limiter circuit, CR indicates a resonance circuit, while CP indicates a protection or control circuit and AS indicates an amplifier device of synchronisation.

[0032] Further, IN indicates an inlet section of the electronic control circuit according to the invention, MP indicates a portion of the half bridge integrated resonant circuit, CC indicates a control or synchronisation circuit, RT indicates the input of a feedback signal, FF indicates an electronic device of the "flip-flop" type, UV indicates a voltage sensor element, DT and DL indicate delay circuits, PG indicates an impulse generating device, F1 and F2 indicate two phototransistors, IF indicates two electronic integrator devices, RIF indicates a reference signal, ERR indicates an error signal, A indicates amplifier devices, CPR indicates a control signal, while LA shows schematically the available light signal and the corresponding voltage signal for the brightness.

[0033] The known art controls the fluorescent tube T by means of an inductor L, which, as in the traditional low frequency circuit of figure 1, has the double task of starting the discharge in the gas of the lamp or tube T thus generating an initial very high voltage, so as to ionize the gas, and then of limiting the discharge current at the required levels; in practice, we have a resonance circuit of the L-C type, fed through a circuit with a half bridge configuration MP, which supplies a square wave voltage source.

[0034] In the initial phase of operation, when the tube T is not yet activated and, therefore, the circuit impedance is equal to an infinite value, the frequency answer of the resonance circuit L-C will have a pick in correspondence with the resonance frequency and said pick will allow the activation of the tube T; once the activation is performed, the system frequency answer will become flat. In practice, the circuit answer goes to zero for frequencies higher than the resonance frequency, while it goes to 1 for lower frequencies.

[0035] Substantially, when the tube T is activated, the circuit is modified, since the current which, before the activation, was carried only through the two inductive elements L and C, afterward the current goes through the fluorescent tube T and the inductor L becomes, therefore a frequency control current generator.

[0036] According to an embodiment of the present invention, it is advisable to provide the possibility of inverting the position of the two inductive elements L, C, by placing, in this case, the inductor L in parallel to the fluorescent tube T and the capacitor C in series with said inductor and tube; this simple inversion allows to radically modify the behaviour of entire circuit, as it can be clearly seen from the frequency answer in function of the load, which, as opposed to the previous case, now goes to 1 for frequency values which go toward the infinite value.

[0037] By controlling the resonance circuit C-L, according to the present invention, through a half bridge circuit (MP) and, therefore, through a square wave, wherein the content of higher odd harmonics having a frequency higher than the fundamental frequency is particularly elevated, the current is controlled through the control of the energy released to the resonance circuit CL every half cycle; therefore, the control is done in a capacitive manner and the control of the current discharge to the fluorescent lamp T is done by controlling the energy stored in the capacitor C. Therefore, by changing the load voltage signal of the capacitor C and the value thereof, it is possible to control the driving power of the lamp T.

[0038] The inductor L, in parallel to the fluorescent tube T, has the task to start a resonance process with the capacitor C, in order to create a voltage sufficient to turn on the lamp and to maintain the lamp current IL. The basic configuration of the high frequency electronic control circuit, according to the present invention, comprises a circuit with a half bridge MP, formed by a couple of power electronic switches Q1, Q2, for instance of the "MOSFET" type, by the corresponding control circuit DR, by a resonance circuit C-L, as previously described, which controls the fluorescent tube T, by a synchronisation circuit AS, which controls the on and off positions of the switches Q1, Q2, in function of the direction of the current which circulates in the resonance circuit C-L and by a diode bridge P, which rectifies the signal from alternate current to direct current.

[0039] Figures 4A-4D show the four typical working stages of the control circuit and the position of the power switches Q1, Q2, in function of the directions of the currents IL and IC which circulate in the resonance circuit C-L.

[0040] By feeding the half bridge circuit and the corresponding resonance circuit C-L with a triangular shaped voltage, the current IT absorbed by the fluorescent lamp T is proportional to the feeding voltage AL, which means that, if we have a modulation of the current IT proportional to the modulation of the feeding voltage AL, we will obtain a power factor of the absorbed current IT which goes to 1 and, consequently, the compliance with the current rules.

[0041] According to a non limiting example of an embodiment of the present invention, a high frequency electronic control circuit for two fluorescent lamps T1, T2, having a power equal to 36 Watt each, is shown in figure 5.

[0042] Said circuit comprises an inlet section IN, a half bridge oscillator circuit MP, a resonance circuit C-L and a control or synchronisation circuit CC. The inlet section IN is formed by an ordinary filter cell, by an element limiting the input overvoltage, by a rectifier bridge P with the diodes D1-D4 and by a capacitor (C2A), which is suitable to meet the current impulse requirements of the half bridge oscillator circuit MP.

[0043] The oscillator circuit MP utilises a specific integrated circuit, which contains an unstable section, as the one used in the integrated circuit "NE555", shown in figure 6, and a control section DR to control the couple of "MOSFET" switches having the power Q1, Q2.

[0044] The group R59, R60, C4, D6, R8 feeds the oscillator circuit MP, while the group D5, C5 is the loading circuit to feed the high voltage control section DR. The resonance circuit C-L comprises, in this specific embodiment, a series of auxiliary inductive coils L2A, L2D, L2E, which are utilised to provide a proper value of the preheating current to the cathodes of the fluorescent lamps T1, T2, connected together in series.

[0045] Once the first oscillation has been started, the inductor L2C provides the feeding voltage to the control or driving circuit DR through the drop current on the resistors R59, R60. The grid R21, L3 has the function of damping the current peaks on the resonance circuit C-L and on the fluorescent tube T1, T2, thus limiting the electric stress on the tube T1, T2 and the high frequency noise component.

[0046] The capacitor C14 starts the sequential operation to turn on the tubes T1, T2; in the case of using two fluorescent tubes T1, T2 in series, during the turn on phase, when both the tubes T1, T2 are not activated yet, the impedance of the tubes goes to an infinite value, therefore the capacitor C14 moves the whole voltage generated by the resonance circuit C-L to the ends of the tube T2.

[0047] Once the tube T2 is turned on, the impedance of the tube is greatly reduced and becomes significantly lower than the impedance of the capacitor C14.

[0048] Therefore, at this point, the generated voltage will drop at the ends of the tube T1 in order to turn it on.

[0049] Once the turn on operation is executed, the impedance of the capacitor C14 shall be negligible with respect to the impedance of the tube T1, in order to avoid any unbalance in the control of the two fluorescent lamps T1, T2. Said turn on procedure, using a sequential start, allows to limit the electric stress on the components, thus reducing by half, with respect to the traditional systems, the voltage and current values necessary to turn on the lamps.

[0050] The varistor element VDR1 allows to protect the control circuit according to the invention, which, as above mentioned, controls the power PT dissipated by each fluorescent lamp T1, T2 through the control of the power released to the resonance circuit C-L, by a capacitor C8 in series; the presence of the varistor VDR1 at the ends of the capacitor C8 allows, in fact, to control the maximum power stored in the capacitor C8 itself by limiting the voltage at its ends. This also allows to limit the values of the current intensity in the resonance circuit C-L, thus avoiding the possible saturation of the inductor L2 and saving, in the meantime, the integrity of the switches Q1, Q2, of the inductor L2 itself, and of the capacitor C8, from dangerous overvoltages.

[0051] The function of the varistor VDR1 becomes fundamental in the case that the lamps T1, T2 are not turned on; in fact, in this case, the circuit works naturally at the resonance frequency, in absence of load, the Q-factor of the resonance circuit C-L is very high and this generates very high voltage and current values, surely destructive for the power switches Q1, Q2.

[0052] Now, when the voltage at the capacitor C8 ends exceeds the intervention voltage of the varistor VDR1, said varistor becomes conductive and dissipates power, so that the additional energy, released from the half bridge circuit MP to the resonance circuit C-L, at every half cycle, would not increase the current on the resonance circuit C-L, but it would be dissipated by the varistor VDR1 itself. It has to be noted that this way of working must be temporary, since the varistor devices are classified for defined energy values and, so, they can dissipate a certain power for a limited period of time; the limiting function of the current must therefore be linked to the presence of a turn off or protection circuit CP of the half bridge circuit (MP).

[0053] Therefore, in the case that the system is not activated, the circuit initially dissipates the energy in excess and maintains the maximum turn on voltage at the ends of the fluorescent tube T1, T2 for a period of time of about 10-100 millisec., allowing, in this case, also the turn on of old lamps or of lamps working at low temperature, conditions wherein the turn on of the tube T1, T2 could be delayed with respect to a rated turn on voltage. At the end of this period of time, the protection circuit CP will turn off the half bridge circuit MP.

[0054] The control circuit CC synchronises the operations of the half bridge circuit MP with the flow direction of the current which circulates in the resonance circuit C-L, and further, by controlling in the current resonance mode, it turns off the control circuit DR of the power switches Q1, Q2, in the case that dangerous overvoltages are detected in the resonance circuit C-L, and it realises an initial increase of the working frequency above the resonance frequency, so that a preheating phase of the cathodes of the tubes T1, T2 is realised, said operation is essential for limiting the electric stress on the cathodes during the turn on phase of the fluorescent load lamps T, T1, T2.

[0055] The resistor R15 is the current "shunt", which has the function of reading the current of the resonance circuit C-L, by turning on the circuit formed by the components R11, R12, R13, R14, Q3, Q4, C7, C10, D7 which can short-circuit the feeding of the integrated control circuit DR, thus turning off the half bridge circuit MP, in case of overvoltages, failures, malfunctions.

[0056] The typical delay time of about 10-100 millisec. can be set through the time constant RC of the components R14, C7. Further, the resistor R15 produces a square signal from the circuit formed by the components D17, D18, R56, able to synchronise the half bridge circuit MP with the direction of the current on the resonance circuit C-L.

[0057] The synchronisation is done utilising a synchronisation signal to the capacitor C6, which is loaded and discharged through the resistor R2, thus causing the working frequency of the integrated circuit DR.

[0058] Practically, the synchronisation is achieved as in the case of the integrated circuit of the "NE555" type, already known, utilised in an unstable configuration, as it is clearly shown in Figure 6.

[0059] The preheating function of the cathodes of the fluorescent tube T, which is necessary to increase the average life of the lamps while being used with repeated turn on and turn off operations, is realised, as said before, by setting an initial working frequency higher than the resonance frequency.

[0060] In this way, it is possible, for example, by increasing the working frequency by 10 kHz above the resonance value, to obtain a reduction of about 10 times of the voltage gain of the resonance circuit C-L.

[0061] Consequently, the circuit is maintained in function without risking to reach the turn on voltage value; after a period of time which ranges typically between 0,5 and 2 seconds, it is possible, therefore, to bring the working frequency to the resonance frequency and to obtain the turn on of the fluorescent tube T.

[0062] In order to realise this function, in the initial phase, only a portion of the capacitor of the unstable circuit is connected, while the remaining portion floats through the circuit formed by the components Q11, Q12 and the corresponding bias grid R54, R55, R57, R58, C23. The oscillation frequency of the unstable phase is, notoriously, equal to: $F = 1/(1{,}4x(RT + 75\ Ohm)xCT)$, where RT and CT are referred to the impedance values, respectively, of the resistance RT and of the capacitor CT illustrated in Figure 6.

[0063] It is evident that by reducing the impedance value of CT it is possible to obtain a consequent increase of the oscillation frequency value.

[0064] After a certain time range, defined by the time constant of the circuit formed by the components C23, R58, R57, the capacitor C22 is placed in parallel to the capacitor C6 and this allows the unstable circuit to slow down its working frequency until the resonance frequency and, therefore, the turn on point is reached.

[0065] By calculating the dimensions of the resonance circuit C-L according to the present invention, it is possible to obtain a simulation of the behaviour of the electronic control circuit in the frequency domain, through a computer software of the "SPICE" type; we can then, for instance, assume that the component values are given by:

V (output voltage of the MP circuit) = 78 Volt;
F (working frequency) = 40 kHz;
C1 (in series capacitor of the circuit C-L) = 10 nF;
C2 (in parallel capacitor, if present) = 0.471 nF;
RT (inlet impedance of the tube T) = 900 Ω;
L (inductor of the circuit C-L) = 1,3 mH.

[0066] Each one of the fluorescent lamps T, T1, T2 used in this specific example is of the "36WT8" type, with 36 Watt of power, which can be dissipated, and their active working voltage VT1, VT2 matches the voltage indicated by the manufacturer.

[0067] The power dissipated on the load impedance at the resonance frequency is equal to $PT=RTxIT^2$ and the current on the load impedance at the resonance frequency is equal to

$$IT=(2xVxRTxC1)/(Lx(4xRT^2x(C1+C2)-L))^{1/2}.$$

[0068] The resonance frequency is given by the formula $F0=2^{1/2}xRT/(Lx(2xC1xR^2+2xC2xR^2-L))^{1/2}/(2x\pi)$, while the current on the loading impedance at the working frequency of the example is:

$$IT=Vx(W^2xLxC1/(C1^2xL^2xRT^2xW^4+2xC1xLxRT^2xW^2x(C2xLxW^2-1)+C2^2xL^2xRT^2xW^4-2xC2xLxRT^2xW^2+L^2xW^2+RT^2)^{1/2}), \text{ where } W=2x\pi xF.$$

[0069] The output voltage values, i.e. the values of the voltage drop at the ends of the fluorescent lamp T, during the lamp turn on sequence, are shown in the Figure 7, wherein the three typical phases of preheating (H phase in the Figure), of the lamp turn on (J phase in the Figure) and of steady working (K phase in Figure).

[0070] As it is clearly possible to note from the diagram, even during the steady working phase, the feeding voltage AL of the half bridge section MP goes to zero and, therefore the lamp T turns off at each half cycle of the grid voltage; when the voltage AL starts again to increase, there is a new turn on phase, which requires a voltage VT lower than the first turn on voltage, since the lamp T is still hot and the gas inside the lamp is still partially ionized.

[0071] At steady conditions, the active voltage VT value of the lamp T stays at the rated levels.

[0072] At steady conditions, the voltage values VT1, VT2 of the two fluorescent lamps T1, T2, which are controlled in series according to sequential discharges, are shown in the diagram of figure 8; wherein it is possible to note that the voltage VT2 of the second lamp T2 starts to grow as a consequence of the fact that the first lamp T1 has been turned on with the voltage VT1. The control sequence of the lamp T is shown in the diagram of figure 9 wherein the voltage VT at the ends of the lamp T, the current IT which circulates in the lamp or tube T and the power PT dissipated by said lamp or tube T are shown.

[0073] It should be noted that the behaviour of the electronic circuit, according to the invention, from the point of view of the control of the lamp T, is exactly in line with the traditional control circuit of the ferromagnetic type, however, in reality, the shape shown in the diagrams is the envelope of a high frequency signal.

[0074] Therefore, the electronic circuit behaviour, from the lighting engineering point of view, is close to that of the traditional control circuits, while the electric efficiency is equal to that of the high frequency electronic circuits; the current absorption from the grid is almost sinusoidal, while the harmonic content is extremely low.

[0075] According to a further non limiting example of embodiment of the present invention, the high frequency electronic control circuit for fluorescent lamps T allows to adjust the power to lamp T and, consequently, the emitted light flux.

[0076] In particular, a system to adjust the power released by the lamp T, in function of the conditions of available light, is realised so as that each lighting device T1, T2, is able to autonomously and automatically compensate possible changes in the available light around the lamp T, in order to optimise the emitted light flux in function of the real lighting needs, thus allowing a significant energy saving, thanks to the synergy between the high frequency control technology and the specific control system, which automatically limits the released power when it is not needed.

[0077] The change of the control power of the lamp T is obtained by adjusting the resonance frequency F0 through the direct feedback of the signal formed by the light emitted by the lamp T so as to obtain the stability of the adjusting system, in order to effectively guarantee, at any time, the same emitted light flux.

[0078] It is, therefore, obtained an adjustment by means of the phase subdivision through the action on the control of the preheating signal of the cathodes of the tube T; in fact, as previously explained, by changing, in the electronic control circuit of the invention, the capacity value of the time constant of the unstable configuration, the oscillation or resonance frequency changes and two working states are defined at two different values of capacity, the working state K at steady conditions, at the resonance frequency F0 and the preheating state H, at a frequency higher than the resonance frequency F0.

[0079] In the preheating conditions H, as already mentioned, the resonance circuit C-L lowers its gain and the output voltage VT is sufficient to guarantee the proper heating of the cathodes of the tube T, but it is not sufficient to turn the lamp T on.

[0080] Therefore, once the start of the tube T is created, if the working phases K at steady conditions are alternated with preheating phases H, it is possible to decrease the power PT of the lamp T, without jeopardising the proper preheating of the cathodes of the tube T.

[0081] The ratio between the duration of the two half cycles defines the emitted light flux, working with a rated voltage V which is the grid voltage AL rectified by the bridge P with a 100 Hz signal.

[0082] The operations of the electronic circuit is then cyclic, with a period of 10 millisec.

[0083] The block diagram of a preferred embodiment of an electronic circuit which adjusts the power released by the lamp or tube T is shown, in particular, in figure 10.

[0084] A properly positioned phototransistor F2 generates an electric signal proportional to the available light LA, said signal is filtered by an integration circuit IF which has a relatively long time constant (about 1-2 seconds); the so obtained signal becomes a RIF reference signal of the system.

[0085] A further phototransistor F1, optically connected to a fluorescent lamp or tube T, reads directly the emitted light power and the output signal from the phototransistor F1 is filtered by an integration electronic device IF which has a time constant much lower (between 100 and 1000 times) than the time constant of the integration circuit IF of the signal coming from the phototransistor F2.

[0086] The comparison between the reference signal RIF and the output signal ERR from the phototransistor F1 and from the electronic integration device IF connected therewith generates a control pulse, which is then synchronised with the grid AL, through a synchronisation amplifier AS and a "LATCH" type transistor circuit, so as to obtain a new lighting or discharge of the lamp T at each working cycle.

[0087] However, at any moment, the lighting or discharge power of the lamp T can change for reasons connected to the tube itself T or for circuit problems and, therefore, it is not possible to fix a predefined oscillation or resonance frequency F0 of the system and to require that, at each new half cycle of the grid feeding AL, the discharge process in the tube T is repeated in the same way. Instead, it is necessary to control, autonomously, each single discharge phenomenon as a single event.

[0088] More precisely, the luminosity of the available light LA generates a reference signal RIF and, at each half cycle of the grid feeding AL, the system can freely go to the natural resonance frequency F0, thus guaranteeing that the lamp T is turned on; when the lamp is turned on, the sensor F1 detects the light effectively emitted from the tube T and, when the signal corresponding to the light emitted from the tube T exceeds the reference signal RIF, a control or turn off signal CPR is generated which causes the resonance circuit C-L to work at the preheating frequency; the "LATCH" type transistor circuit, which is synchronised with the feeding grid AL, does not allow the system to go in self-oscillation, by guaranteeing a single discharge for each grid half cycle AL, even when the emitted light is at minimum levels.

[0089] The adjustment is realised in conditions of subdivision playing on two frequency values which are related to the values of the resonance F0 and preheating frequencies, thus eliminating the traditional technique of linear adjustment utilised in the resonance circuit at series inductance.

[0090] Further, the control is done on the light beams effectively emitted from the tube T at each half cycle, said beams are detected, through a feedback signal, by a ring shaped autonomous system and are compared to the available light LA, while the adjustment inside each half cycle of the grid signal AL is obtained by anticipating the lamp T turn off through the preheating signal CPR.

[0091] A partial electric diagram of the adjustment system of the power emitted from the lamps T and a complete electric diagram of a preferred embodiment of a high frequency control circuit, according to the present invention, are shown, respectively, in figures 11 and 13.

[0092] It should be noted that the adjustment circuit is very simple and the components are reduced with respect to the known art; the phototransistor F1 is connected to the terminals J3 and has the task of reading the light emitted from the tube T and R26, C15 form a fast integration circuit, suitable to provide the error signal ERR, while the phototransistor F2 is connected to the terminals J4 and the group formed by the components R24, C16 form the slow integration circuit.

[0093] The gauge device IC2A compares the RIF and ERR signals, while the transistors Q7, Q8 and the corresponding bias grids form the "LATCH" electronic device.

[0094] The gauge device IC2B is used to realise the synchronisation with the feeding grid AL of the half bridge circuit MP; the feeding signal AL is properly transformed into a square signal by the grid formed by the components R33, R34, R35, ZD1 and it is then compared with a reference signal, in such a way that, at the outlet of the gauge device IC2B, a squared signal synchronised with the feeding signal AL is obtained.

[0095] Said signal is utilised to feed the circuit which comprises the transistors Q7, Q8 so as to set it up each time the feeding signal AL goes to zero.

[0096] The circuit outlet, which comprises the transistors Q7, Q8, is connected to an additional transistor Q10, which has a "OR" logic configuration, so that the output signal CPR controls another transistor suitable to change the oscillation or resonance frequency F0, by changing from a preheating frequency, which implies a high impedance output, to a resonance frequency F0, which implies a direct connection between the putput and the mass.

[0097] The transistor Q10 is used during the first working phase in order to guarantee the proper initial preheating before the lamp T is turned on.

[0098] The reference voltages VPOS and VDD, needed for the proper operation of the circuit, are obtained starting from an auxiliary winding realised on the coil of the electronic control feeder.

[0099] The trend of the available light LA signals, the luminosity VL of the lamp T, the feeding voltage AL of the resonance circuit C-L, the preheating control CPR and the current IT which goes through the lamp T is shown in the diagram of figure 12.

[0100] From the given description, the characteristics of the high frequency electronic control circuit, which is the object of the present invention, for fluorescent lamps are clearly defined, as well as the advantages.

[0101] In particular, said advantages are as follows:

- reduction of the electric and electronic components, with respect to the known art, with consequent substantial

reduction in costs;
- - better efficiency and reliability, with respect to the known art and greater stability in the performances, with respect to the traditional control techniques;
- operation of the electronic circuit in the presence of current resonance, which allows to deliver only the active current to the power switches;
- simplified control synchronisation, so as to guarantee more reliability and less dissipation, with respect to the known art;
- reduced Intensity of the produced noise;
- compliance with the effective rules, since the energy released to the resonance circuit is proportional to the feeding voltage and, therefore, the current absorption of the resonance circuit is proportional to the grid voltage;
- facilitated control, with respect to the known art, of the two fluorescent lamps connected in series and/or of the auxiliary preheating windings;
- reduction of the oversized dimensions of the reactive elements and, therefore, reduction in the design costs, with respect to the known techniques;
- simplification, reliability and flexibility of the circuits and of the control.

[0102] It is clear that several other modifications can be done to the high frequency electronic control circuit for fluorescent lamps, which is the object of the present invention, without departing from the novelty principles present in the inventive idea, so as it is clear that, in the practical realisation of the invention, the materials, the shapes and the dimensions of the illustrated details could be changed according to need and that said details could be substituted with other equivalent details.

Claims

1. High frequency electronic control circuit for fluorescent lamps (T, T1, T2), of the type comprising means (EM) suitable to filter a signal, so as to prevent that high frequency transients generated by said electronic circuit are discharged into the feeding grid (AL), electric and/or electronic conversion devices (P) of at least an alternate signal of said feeding grid (AL) into a continuos signal and means (PS, LC, CC) for the control in high frequency and/or the control of the "turn on" and "turn off" operations of said fluorescent lamps or tubes (T, T1, T2), which are connected to said conversion devices (P), characterised in that said means (PS, LC, CC) for the high frequency control and/or driving of said fluorescent lamps or tubes (T, T1, T2) comprise a resonance circuit (C-L), formed by at least an inductive element (L), placed in parallel to at least one of said fluorescent lamps or tubes (T, T1, T2), and by a capacitor (C), which is connected in series to an equivalent impedance formed by the connection in parallel of said inductive element (L) and said fluorescent lamp (T).

2. Electronic circuit as claimed in claim 1,
characterised in that said resonance circuit (C-L) is controlled by a square wave signal having a substantial content in the higher harmonics with frequency values higher than that of a predefined frequency.

3. Electronic circuit as claimed in claim 1,
characterised in that said filtering means (EM) comprise an ordinary filter cell and a limiting element against possible inlet overvoltages.

4. Electronic circuit as claimed in claim 1,
characterised in that said conversion devices (P) comprise at least a diodes rectifier bridge and at least a capacitor (C2A), which is suitable to meet the current impulse requirements by said electronic circuit.

5. Electronic circuit as claimed in claim 1,
characterised in that said high frequency control and/or driving means (PS, LC, CC) comprise at least a half bridge oscillator (MP), which includes an integrated circuit (DR) to control a plurality of electronic power switches (Q1, Q2).

6. Electronic circuit as claimed in claim 5,
characterised in that said integrated circuit (DR) with at least an unstable electronic device of the "NE555" type and a control section fed by a load circuit (D5, C5).

7. Electronic circuit as claimed in claims 1 and 5,
characterised in that said resonance circuit (C-L) comprises a series of auxiliary inductor elements (L2A, L2C, L2D, L2E), which provide feeding voltage to said integrated circuit (DR) and adequate current intensity for preheating the

cathodes of said fluorescent lamps or tubes (T) connected together in series.

8. Electronic circuit as claimed in claim 1, characterised in that said resonance circuit (C-L) comprises an electric grid (R21, L3) suitable to dampen the current peaks on said fluorescent lamps or tubes (T), limiting the electric stresses and the high frequency noise components.

9. Electronic circuit as claimed in claim 1, characterised in that said resonance circuit (C-L) comprises means (C14, VDR1, TB1, TB2) to sequentially turn on said fluorescent lamps or tubes (T) connected in series.

10. Electronic circuit as claimed in claim 9, characterised in that said means (C14, VDR1, TB1, TB2) comprise a capacitor (C14), and the impedance thereof, once the turn on operation has been started, is negligible with respect to the inlet impedance of a transistor (TB1).

11. Electronic circuit as claimed in claims 1 and 9, characterised in that said means (C14, VDR1, TB1, TB2) comprise a varistor (VDR1) suitable to protect said electronic circuit through the control of the maximum energy which can be stored inside said capacitor (C) of the resonance circuit (C-L), by limiting the voltage value at the ends of said capacitor (C).

12. Electronic circuit as claimed in claims 1 and 5, characterised in that said resonance circuit (C-L) comprises a protection circuit (CP) in order to turn off said half bridge oscillation device (MP).

13. Electronic circuit as claimed in claims 1 and 5, characterised in that said high frequency control or driving means (PS, LC, CC) comprise at least a resistor (R15), suitable to evaluate the value of the current which circulates inside said resonance circuit (C-L) by turning on a circuit portion (R11, R12, R13, R14, Q3, Q4, C7, C10, D7) suitable to stop the feeding to said half bridge oscillation device (MP), in case of malfunction.

14. Electronic circuit as claimed in claims 1 and 5, characterised in that said high frequency control or driving means (PS, LC, CC) comprise an electric grid (D17, D18, R56) suitable to generate a square synchronism signal, so as to synchronise said half bridge oscillation device (MP) with the direction of the current which circulates inside said resonance circuit (C-L).

15. Electronic circuit as claimed in claims 1 and 6, characterised in that said unstable device comprises at least a capacitor (CT), and that the capacity value thereof is proportional to the oscillation frequency value of said resonance circuit (C-L).

16. Electronic circuit as claimed in claim 1, characterised by comprising a lighting power adjustment system of said fluorescent lamps or tubes (T) in function of the available light.

17. Electronic circuit as claimed in claim 16, characterised in that said adjustment system comprises a feedback circuit on said high frequency, double ring control and/or driving means (PS, LC, CC).

18. Electronic circuit as claimed in claims 1 and 16, characterised in that said adjustment system comprises at least two transducer devices (F1, F2), which generate a first (RIF) and a second (ERR) electric signal which are proportional , respectively, to the available light (LA) and to the light power of said fluorescent lamp or tube (T), each of said first (RIF) and second (ERR) signal is filtered by an integration circuit (IF), and is sent to at least a gauge device (A), which generates a control impulse (CPR) synchronised, through a synchronisation element (AS), with the feeding grid (AL).

19. Electronic circuit as claimed in claim 18, characterised in that said adjustment system comprises a transistor circuit which stops said system from entering self-oscillation, by guaranteeing a single discharge on said fluorescent lamp or tube (T) at each half cycle of the grid feeding signal (AL).

20. Electronic circuit as claimed in claims 1, 5 and 18,
characterised in that, when the signal (ERR) linked to the light power released by said fluorescent lamp or tube (T) exceeds the signal (RIF) linked to the available light (LA), a turn off signal is generated which brings said half bridge oscillation device (MP) to work at a preheating frequency value.

21. Electronic circuit as claimed in claim 18,
characterised in that said adjustment system comprises a first transistor, suitable to change the oscillation frequency value of said half bridge oscillation device (MP), by changing from a preheating frequency value to a resonance frequency value, and a second transistor, suitable to guarantee a proper initial preheating before said fluorescent lamp or tube (T) is turned on.

Fig.1

PRIOR ART

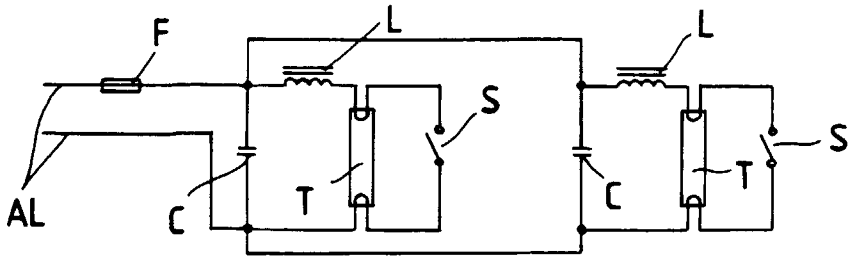


Fig.2

PRIOR ART

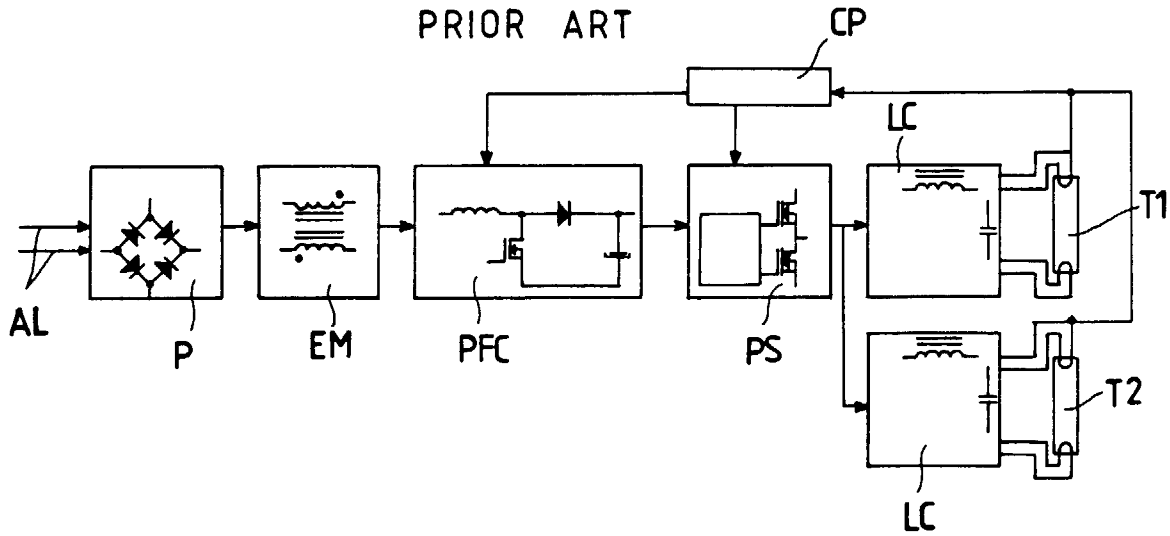


Fig.3

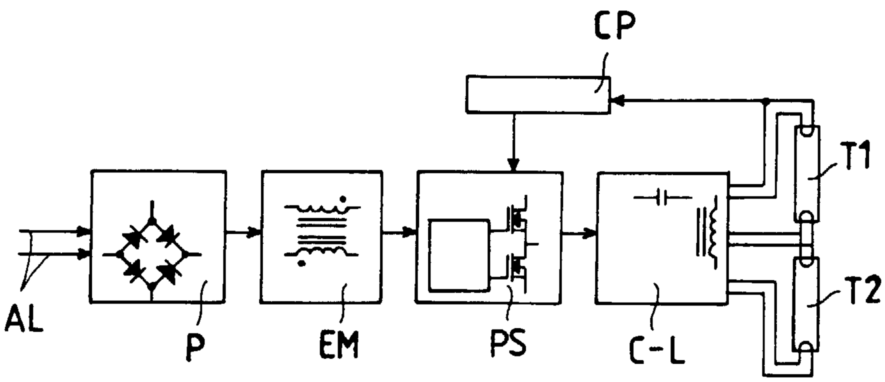


Fig.4

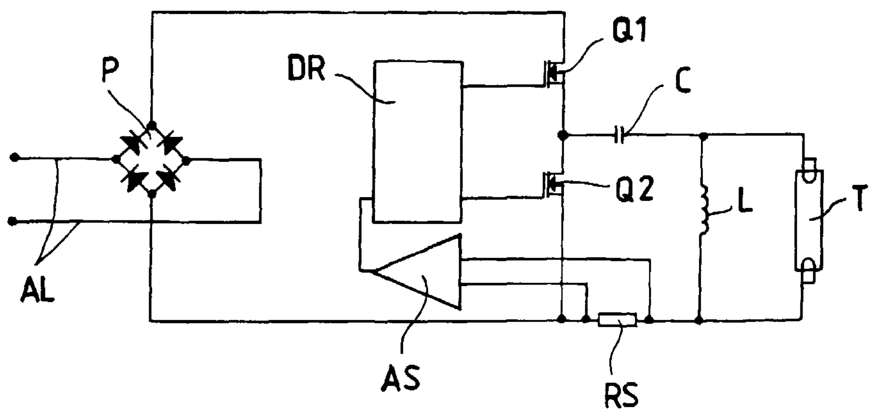
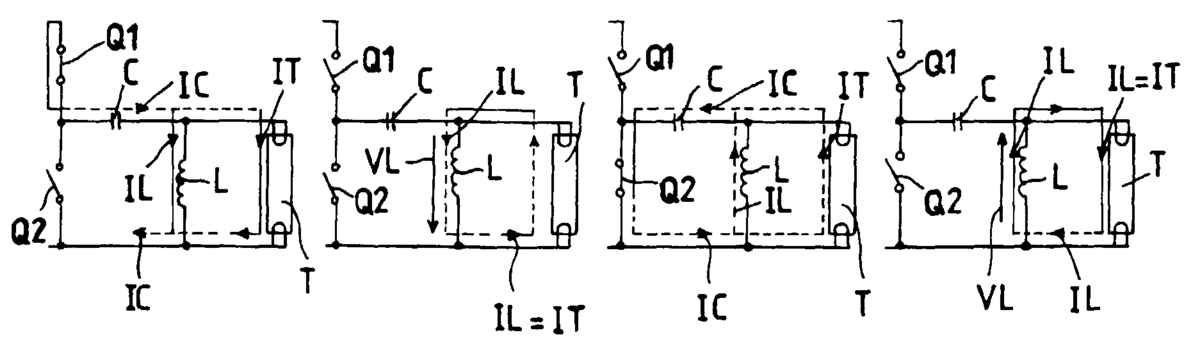


Fig.4A Fig.4B Fig.4C Fig.4D



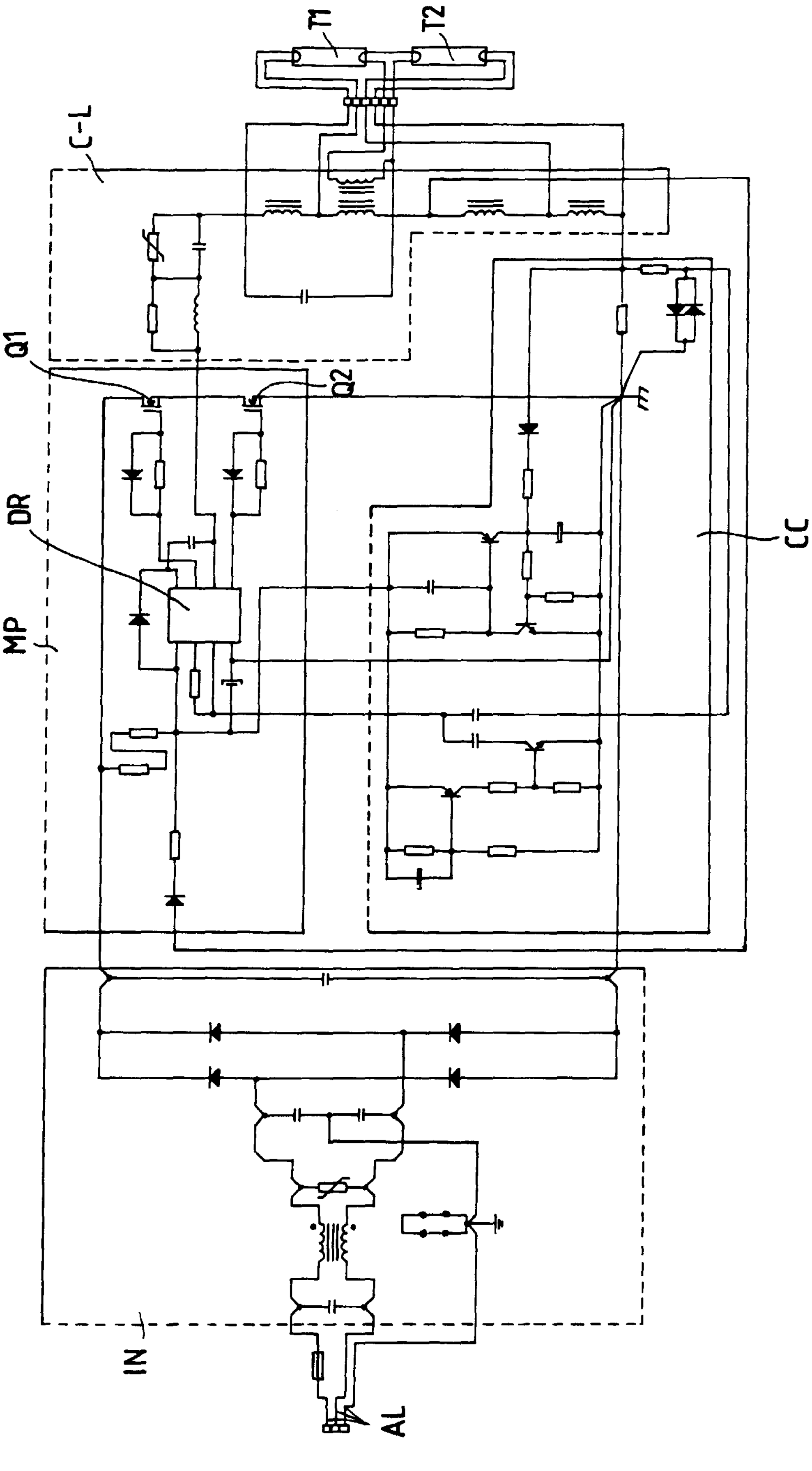


Fig.5

Fig.6

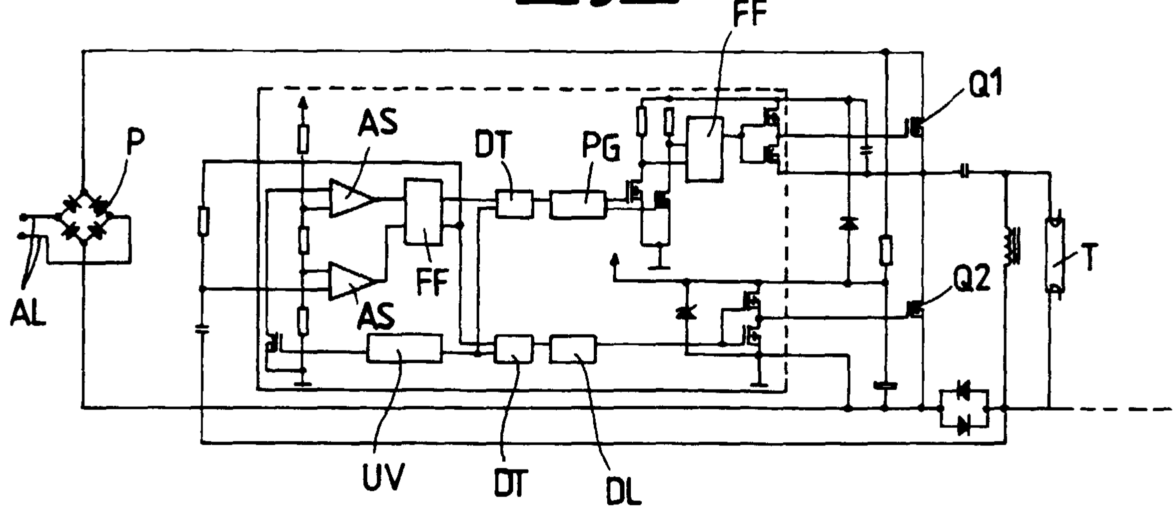


Fig.7

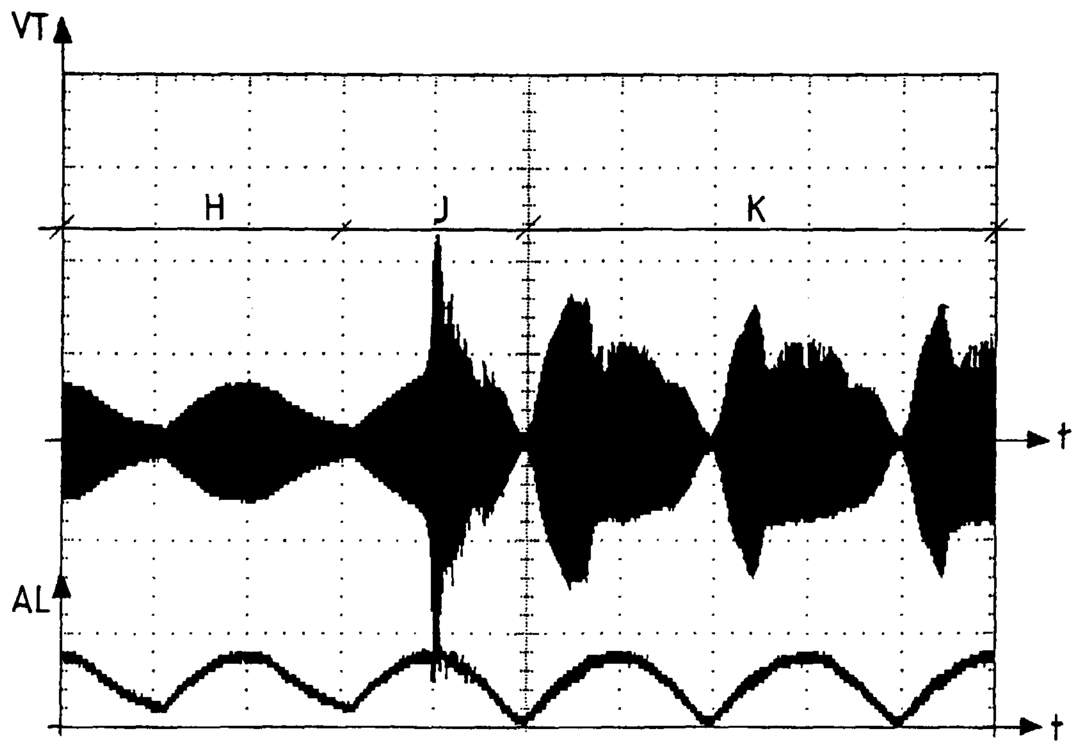


Fig.8

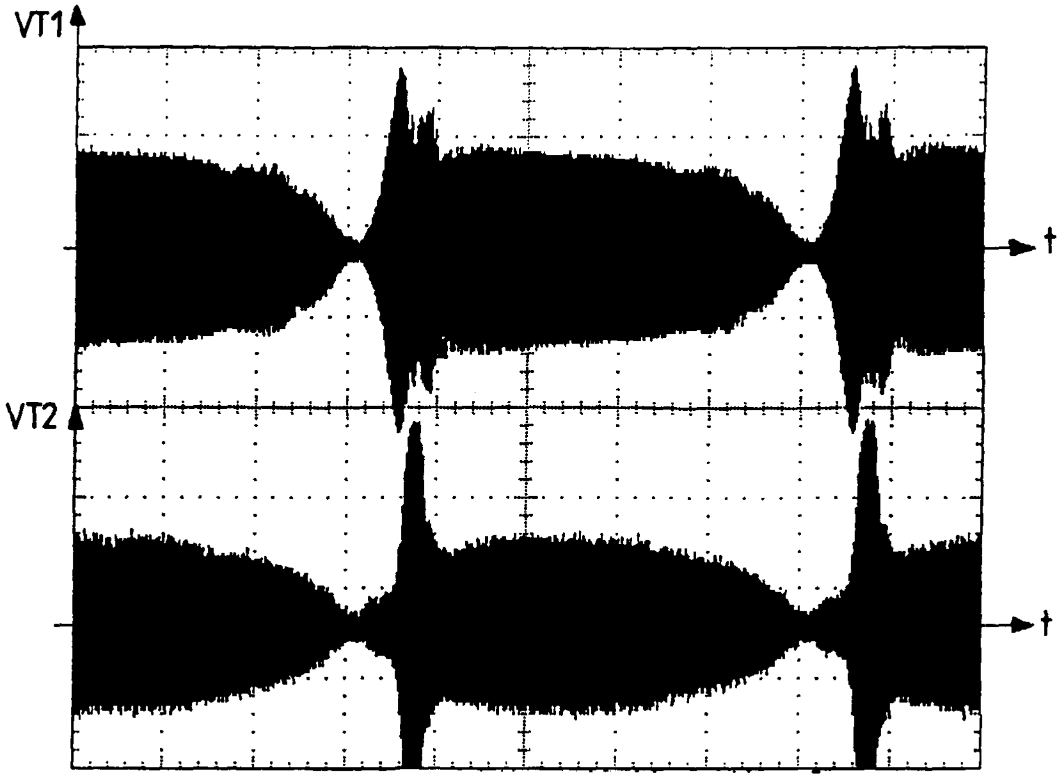


Fig.9

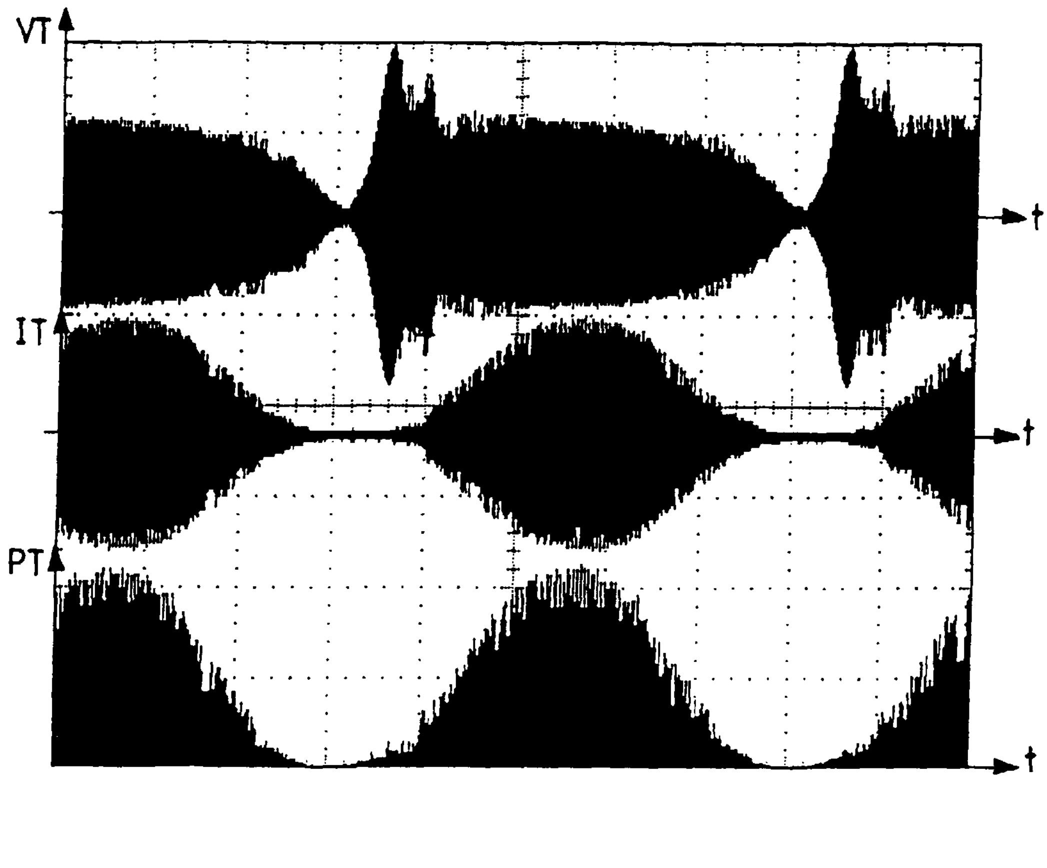


Fig.10

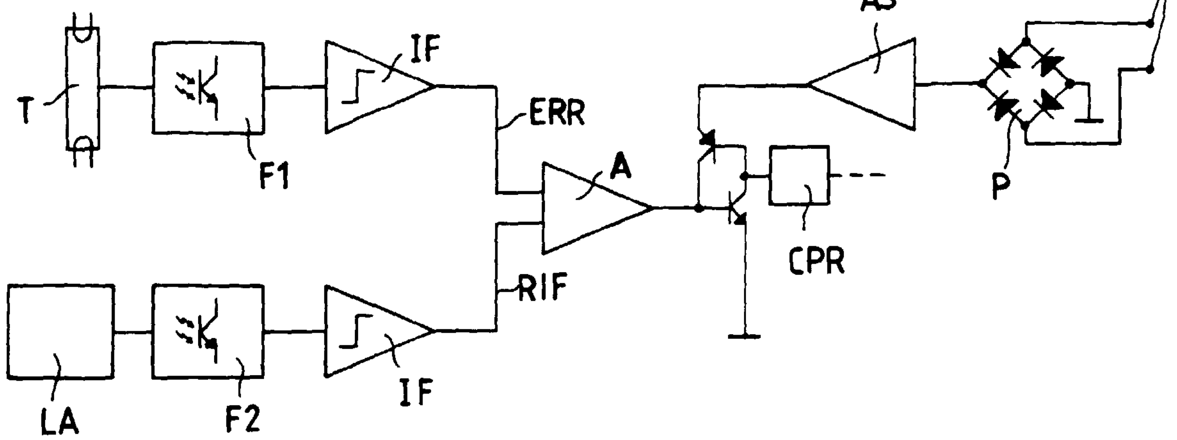


Fig.11

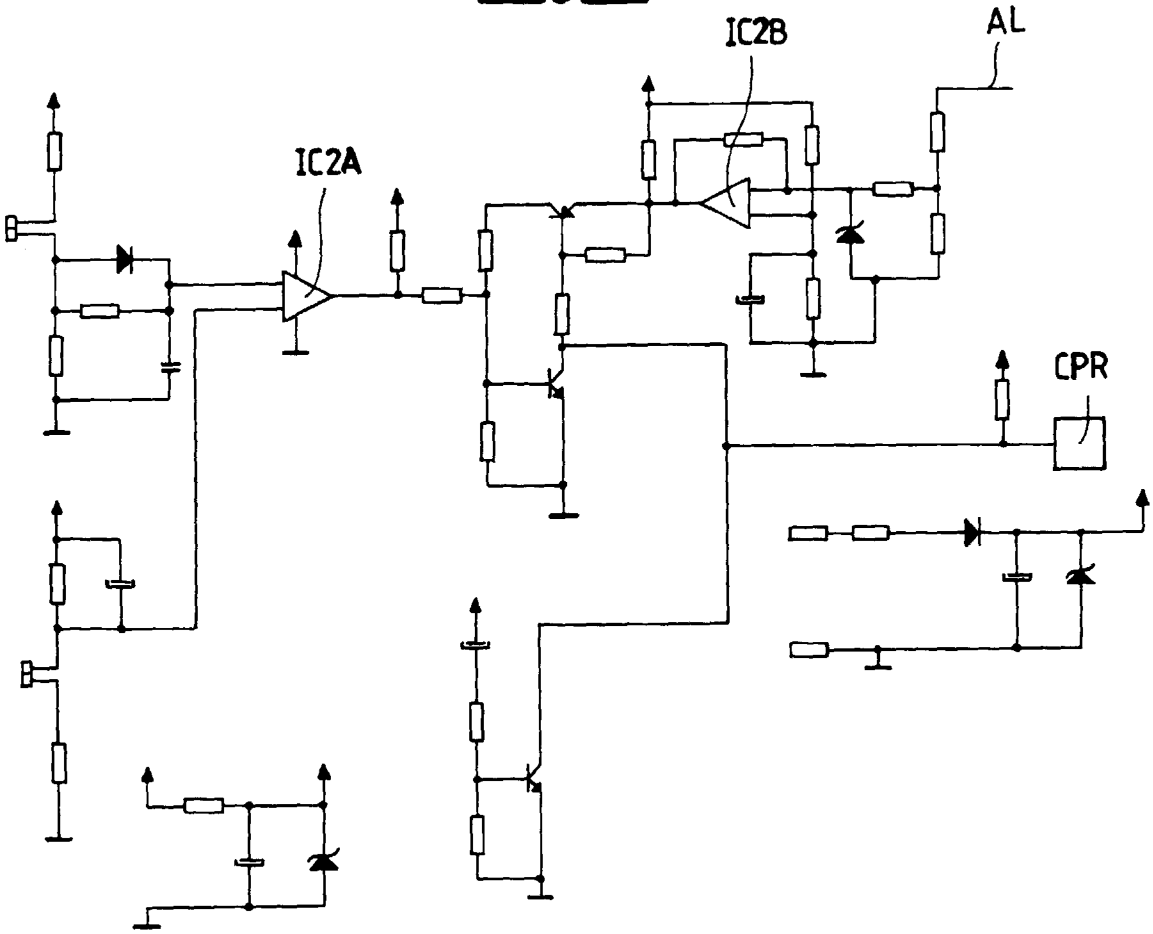


Fig.12

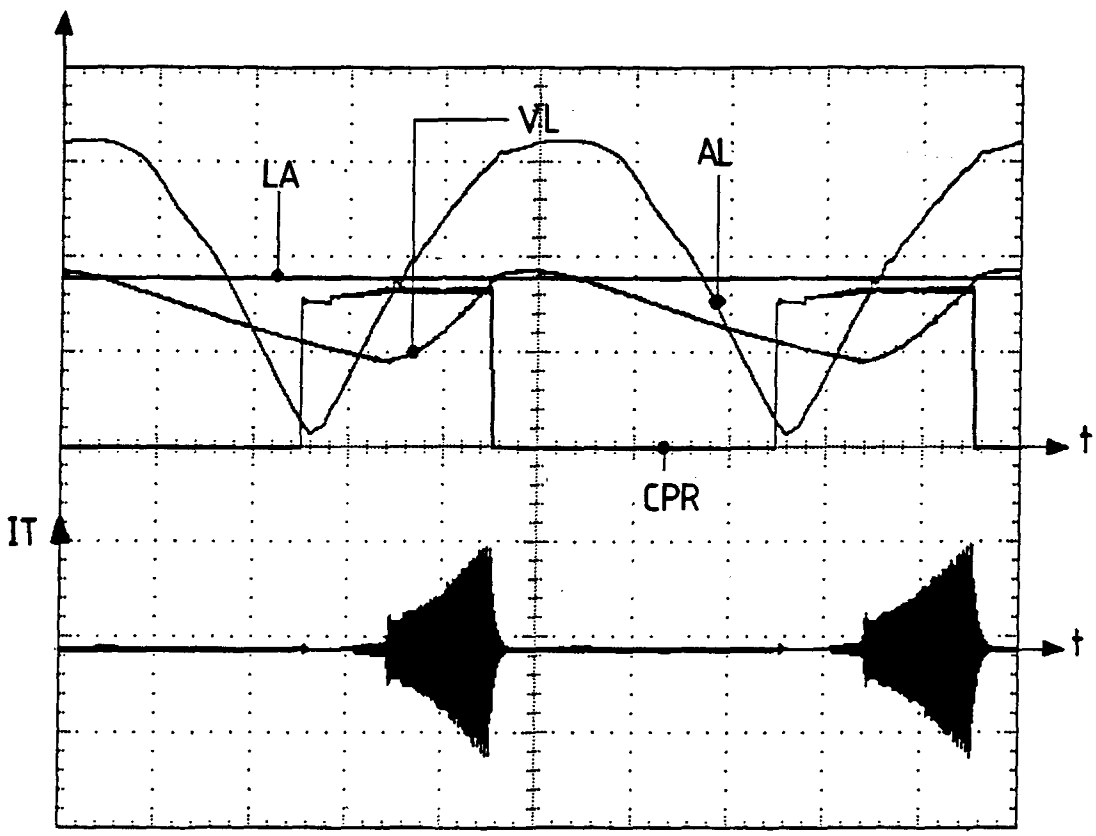


Fig.13