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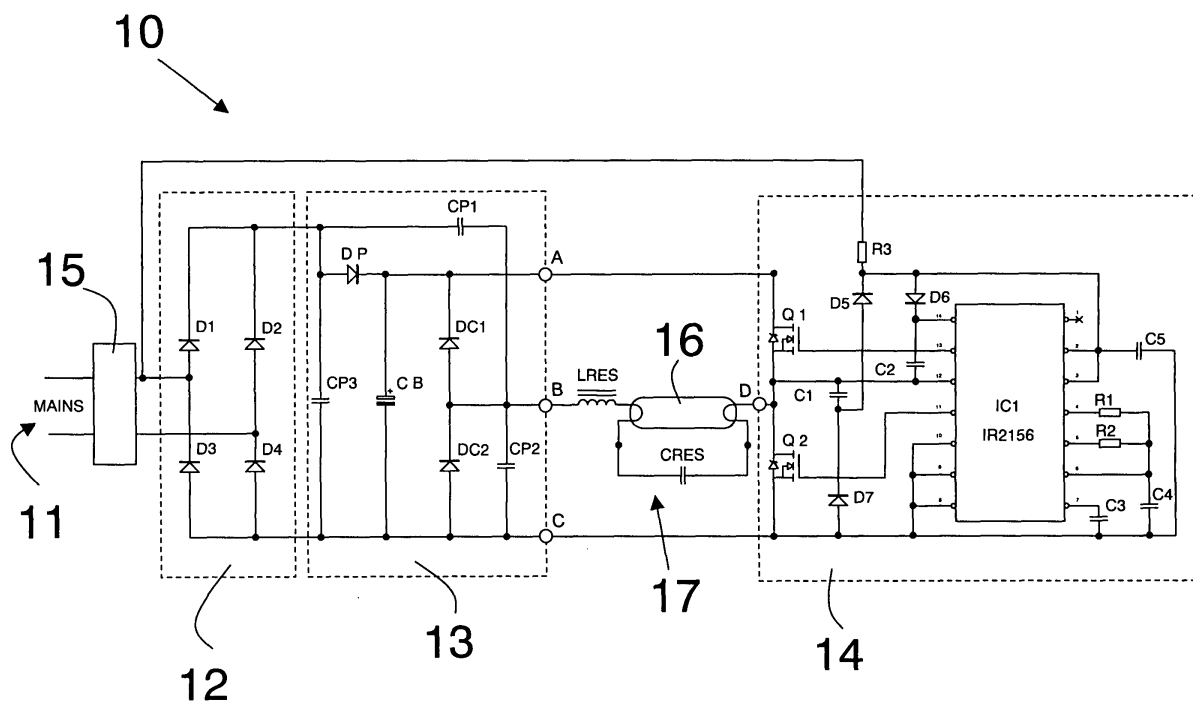
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(54) **High power-factor electronic reactor for discharge lamps**

(57) An electronic device for powering a fluorescent lamp (16) starting from a sinusoidal alternating voltage comprises a whole-bridge rectifier (12) which rectifies the alternating voltage, a circuit (13) for processing the rectified voltage connected in parallel to the output of the rectifier (12) and a half-bridge inverter (14) with an output (D) for high frequency powering of the lamp (16). The processing circuit has a direct voltage output (A-C)

at the ends of a bulk capacitor (CB) connected in parallel to the output of the rectifier (12) through a first diode (DP). A resonant network (17) to which is connected the lamp (16) is connected between the output (D) of the half-bridge inverter (14) and an intermediate point (B) of a series of two capacitors (CP1,CP2) connected in parallel to the output of the rectifier (12). The circuit allows obtaining with simplicity a power factor near unity and a limited lamp current crest factor.



Description

[0001] The present invention relates to a compact electronic circuit or ballast for powering from the mains discharge lamps such as fluorescent lamps with a power factor near unity and a limited lamp current crest factor.

[0002] Electronic ballasts are devices for powering high frequency (on the order of tens of kHz) discharge lamps with indubitable advantages in terms of efficiency and performance such as absence of flicker, protectors et cetera.

[0003] To generate high frequency current a half-bridge converter or inverter commuting an almost continuous voltage at the desired frequency is typically used. Starting from the mains it is therefore first of all necessary to rectify the sinusoidal voltage to 50Hz. The most economical way to do this is to use a diode bridge (whole wave or double half-wave rectifier) followed by a filtering capacitor of appropriate value (typically on the order of tens of μF) to reduce the residual ripple to 100Hz.

[0004] This simple circuit suffers from the disadvantage of causing absorption of current from the mains with a trend very far from the ideal sinusoidal wave form. Indeed, the diode bridge conducts for a small period of time for each hemicycle giving origin to absorption of a pulsed current from the mains with resulting high harmonic distortion. In addition, there is a high lamp current crest factor.

[0005] To improve the lamp current crest factor it is necessary to increase the filter capacity but this further worsens the harmonic content of the current absorbed from the mains.

[0006] Various methods have been suggested in the art to seek to obviate these problems.

[0007] For example an active stage for active correction of the power factor (active Power Factor Corrector [PFC]) can be used. Typically such a stage comprises a switching power supply supplying an adjusted direct voltage to ensure an approximately sinusoidal wave form of the current absorbed from the mains and easily obtaining a power factor near unity. This circuit completely resolves the problem of limitation of harmonic currents and also allows obtaining excellent lamp current crest factors. The main disadvantages are cost and the large number of added components required, to wit, the controller (typically an 8-pin integrated circuit), a power MOSFet, a transformer and numerous passive surrounding components. Another disadvantage is the need for a larger mains filter because of the noise introduced by the MOSFet switching.

[0008] To avoid the use of a stage for active correction of the power factor various circuit solutions have been proposed which however display different disadvantages. For example, in patent US 6,057,652 numerous circuits based on the use of charging pumps have been proposed. The proposed circuits comprise a bulk capacitor connected to the output of the rectifier bridge

through a diode at the ends of which the direct voltage feeding the inverter is taken. A relatively complex circuit within which is the lamp is connected between the output of the half bridge and the bulk capacitor.

[0009] Many of these circuits have the disadvantage of needing a costly and cumbersome coupling transformer for the lamp which cannot be connected directly to the circuit because of the insufficient voltage developed. In addition, with the circuits proposed in US 6,057,652 there is the basic disadvantage that the voltage at the ends of the bulk capacitor is not under control as it is linked to the voltage present in the network of capacitors which also fix the value of the resonance frequency of the circuit to which the lamp is connected. This frequency is one of the design parameters of the power supply and is therefore very important. To have the resonance at the desired frequency these capacitors have a very critical value and therefore cannot be sized to ensure a definite and limited voltage at the ends of the bulk capacitance. The problem is particularly important in European countries having nominal mains voltage of 230Vac or even 240Vac. In addition to causing operational instability of the circuit which could lead to deterioration of its performance there is the disadvantage that the bulk capacitor is subjected to high voltages (700-800V) which impair its operation unless a costly, cumbersome and difficult to find component suited to very high voltages is used. High working voltages in the circuit compel the use of active components (power MOSFet and integrated circuits) with higher breakdown voltages (over 600V) which are more costly and difficult to find.

[0010] The general purpose of the present invention is to remedy the above mentioned shortcomings by making available an electronic reactor circuit for discharge lamps which would be simple, economical and strong and would provide satisfactory limitation of the harmonic content of the current absorbed from the mains with a good lamp current crest factor and limited voltage at the ends of the bulk capacitance.

[0011] In view of this purpose it was sought to provide in accordance with the present invention an electronic device for powering a fluorescent lamp from a sinusoidal alternating voltage source comprising a whole bridge rectifier which would rectify said alternating voltage, a rectified voltage processing circuit connected in parallel to the rectifier output, a half-bridge inverter with an output for high frequency powering of the lamp starting from a direct voltage output of said processing circuit obtained by means of a bulk capacitor connected in parallel to the output of the rectifier through a first diode characterized in that there is a resonant network comprising the lamp which is connected between the output of the half-bridge inverter and an intermediate point of a series of two capacitors connected in parallel to the rectifier output.

[0012] To clarify the explanation of the innovative principles of the present invention and its advantages com-

pared with the prior art there is described below with the aid of the annexed drawing a possible embodiment thereof by way of non-limiting example applying said principles.

[0013] With reference to the figure, it shows the electrical diagram of an innovative electronic device or ballast designated as a whole by reference number 10 for powering a discharge lamp 16 and in particular a fluorescent lamp from a source of sinusoidal alternating voltage applied to the input terminals 11. Said source is generally the normal electrical power distribution mains.

[0014] The circuit comprises a whole-bridge diode rectifier 12 which rectifies the alternating voltage applied to the input 11. The rectified voltage output from the bridge 12 is applied to a circuit 13 connected in parallel to the output of the rectifier 12. The circuit 13 supplies a direct voltage output (terminals A-C) which is converted by a generically known half-bridge inverter 14 for high frequency powering of the lamp 16, and a point B for connection of one end of a resonant network 17 consisting of the series of an inductance LRES and a capacitor CRES and comprising the lamp 16 connected in parallel to the resonance capacitance CRES. The other end of the resonant network 17 is connected to the output D of the inverter.

[0015] Advantageously the inverter 14 has the half bridge made up of a pair of power MOSFets Q1, Q2 controlled by a half-bridge pilot circuit comprising a specialized integrated circuit IC1 with its own network of accompanying components (D5-D7, C1-C5, R1-R3). The diagram of the inverter 14 using by way of example the known integrated circuit IR2156 produced by International Rectifier is of a known type and not further described (any half bridge driver can be used). It supplies to its own output D a square wave with 50% duty cycle and frequency at least above 10kHz (advantageously around 40kHz). The resistance R3 connected between the pins 2,3 of the integrated circuit and the anode of the diode D1 ensures powering of the integrated circuit during startup. When the half-bridge driver starts to oscillate, the power supply of the integrated circuit is ensured by the charge pump consisting of the capacitor C1 and the diodes D5 and D7.

[0016] The circuit 13 supplies the virtually direct voltage to points A-C by means of a bulk capacitor CB connected in parallel to the output of the rectifier 12 through a first diode DP. Point B is obtained as the intermediate point of a series of two capacitors CP1, CP2 connected in parallel to the output of the rectifier 12.

[0017] Advantageously the circuit 13 comprises a second diode DC2 connected to the cathode at the intermediate point B and with the anode to the negative pole C of the direct voltage output A-C and a third diode DC1 connected to the anode again at the intermediate point B and to the cathode at the positive pole A of the direct voltage output A-C. The two diodes DC1 and DC2 have the function of containing the range of the voltage at the ends of the resonant network of the load so as to

keep the lamp current crest factor limited.

[0018] Another considerable increase in performance is obtained by using in the processing circuit 13 another capacitor CP3 connected in parallel to the output of the rectifier 12 and therefore upstream of the diode DP.

[0019] Thanks to the circuit 13 the input diode bridge 12 leads practically for the entire half-wave through a charge pump circuit consisting in the complete circuit shown of the capacitances CP1, CP2, CP3 and the diodes DP, DC1 and DC2.

[0020] For good operation of the circuit the voltage VB must be greater than the rectified input voltage; this way the bridge diode and the diode DP cannot be polarized directly simultaneously, i.e. they cannot both conduct at the same time. The input line current is thus equal to the charge current of the capacitance CP1 combined with the current running in CP3 with each switching cycle of the half bridge (on the order of tens of microseconds). The diodes D1, D2, D3 and D4 of the input rectifier bridge 12 are thus run through by a high frequency current and will therefore have to be fast diodes (fast switching rectifiers). This current is of course proportionate to the input voltage at each switching cycle of the inverter; its mean value thus has a sinusoidal behavior.

This reduces harmonic distortion to the minimum.

[0021] If desired or necessary to meet particular standards, a known simple antistatic filter 15 can be fitted at the input of the rectifier 12 so as to curb the reduced EMI noise which might be generated.

[0022] As is now imaginable to those skilled in the art, by appropriate sizing of the capacitances CP1, CP2 and CP3 it is possible to set a desired voltage VB at the ends of the bulk capacitor CB. It is important to note - as readily seen in the FIG - that these capacitances do not intervene in setting the resonance frequency of the network 17 as was the case with the above mentioned prior art circuits.

[0023] Sizing of the various components is closely tied to the nature of the load it is desired to power and in particular to its electrical parameters, to wit, nominal power, current and voltage.

[0024] Typically the inductance LRES is on the order of mH while the capacitance CRES is measured in tens of nF. For good operation of the harmonic current limitation circuit the capacitances CP2 and CP3 must be of the same order of magnitude of CRES while CP1 is on the order of hundreds of nF.

[0025] The voltage at the ends of the bulk capacitor - typically an electrolyte with capacitance on the order of tens of microfarads - is little more than 400V in order to be able to use capacitors with nominal voltage of 450V which are readily available on the market.

[0026] Performance obtained is extremely interesting and especially allows respecting the standard, to wit, power factor over 0.97 and harmonic content (up to the thirty-ninth harmonic) well below the limits set in EN-61000-3-2.

[0027] It was found that with a ballast realized in ac-

cordance with the present invention an extremely limited harmonic content is obtained without a preregulator stage of input and without the disadvantages of the prior art load pump circuits. In particular, the stability of the circuit is ensured and the voltage on the bulk capacitor is always under control and of a value such as to be able to use an economical and readily found bulk capacitor suited to not very high voltages.

[0028] Thanks to the stability of the inverter supply voltage it can be held at a value sufficient to allow direct lighting of the lamp without the interposition of step-up transformers with the resulting cost and space savings.

[0029] It is now clear that the predetermined purposes have been achieved by making available a discharge lamp electronic power supply circuit combining great simplicity and construction economy with an extremely limited harmonic content, a power factor near unity and a reduced lamp current crest factor.

[0030] Naturally the above description of an embodiment applying the innovative principles of the present invention is given by way of non-limiting example of said principles within the scope of the exclusive right claimed here. For example the half-bridge inverter circuit could be different from that shown here and comprise any other known half-bridge driver.

Claims

1. Electronic device for powering a fluorescent lamp (16) from a sinusoidal alternating voltage source comprising a whole-bridge rectifier (12) which rectifies said alternating voltage, a circuit (13) for processing of the rectified voltage connected in parallel to the rectifier output (12) and a half-bridge inverter (14) with an output (D) for high frequency powering of the lamp (16) starting from a direct voltage output (A-C) of said processing circuit obtained by means of a bulk capacitor (CB) connected in parallel to the rectifier output (12) through a first diode (DP) **characterized in that** there is a resonant network (17) comprising the lamp (16) which is connected between the output (D) of the half-bridge inverter (14) and an intermediate point (B) of a series of two capacitors (CP1,CP2) connected in parallel to the rectifier output (12).
2. Device in accordance with claim 1 **characterized in that** the processing circuit (13) comprises a second diode (DC2) connected by the cathode to said intermediate point (B) and by the anode to the negative pole (C) of said direct voltage output (A-C).
3. Device in accordance with claim 1 **characterized in that** the processing circuit (13) comprises a third diode (DC1) connected by the anode to said intermediate point (B) and by the cathode to the positive pole (A) of said direct voltage output (A-C).
4. Device in accordance with claim 1 **characterized in that** the processing circuit (13) comprises another capacitor (CP3) connected in parallel to the output of the rectifier (12).
5. Device in accordance with claim 1 **characterized in that** the resonant network is a resonant circuit (LRES,CRES) in series with the lamp connected in parallel to the resonance capacitance (CRES).
6. Device in accordance with claim 1 **characterized in that** at the input of the rectifier (12) is an antistatic filter (15).
7. Device in accordance with claim 1 **characterized in that** the inverter has the half-bridge made up of a pair of power MOSfets (Q1,Q2) controlled by a half-bridge pilot circuit.
8. Device in accordance with claim 1 **characterized in that** the inverter output is a square wave with 50% duty-cycle and frequency over 10kHz.
9. Device in accordance with claim 5 **characterized in that** the resonant circuit in series comprises an inductance (LRES) on the order of mH and a capacitance (CRES) on the order of tens of nF.
10. Device in accordance with claims 4 and 9 **characterized in that** said other capacitor (CP3) and one (CP2) of the two capacitors of said series have the same order of magnitude as said capacitance (CRES) of the resonant circuit in series while the other capacitor (CP1) of said series is on the order of hundreds of nF.

