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(54) Controllable or dimmable electronic ballast provided with a lamp power measurement

(57) The invention relates to a controllable or dimmable electronic ballast provided with a lamp power measurement for a low-pressure discharge lamp, especially a fluorescent lamp. A halfbridge inverter (TR1, TR2; V2, V3) supplies high-frequency alternating current into a load circuit including a discharge lamp (LL). A regulation or control block (A1/I, II) controls light output of the lamp by regulating frequency of the inverter. Measurement information about a current proportional to the load circuit power is fed to the regulation or control block, which is also supplied with measurement information about a voltage proportional to a current passing through the filament of the lamp, the latter information being used for compensating the effect of filament power out of the measuring result of the load circuit power.

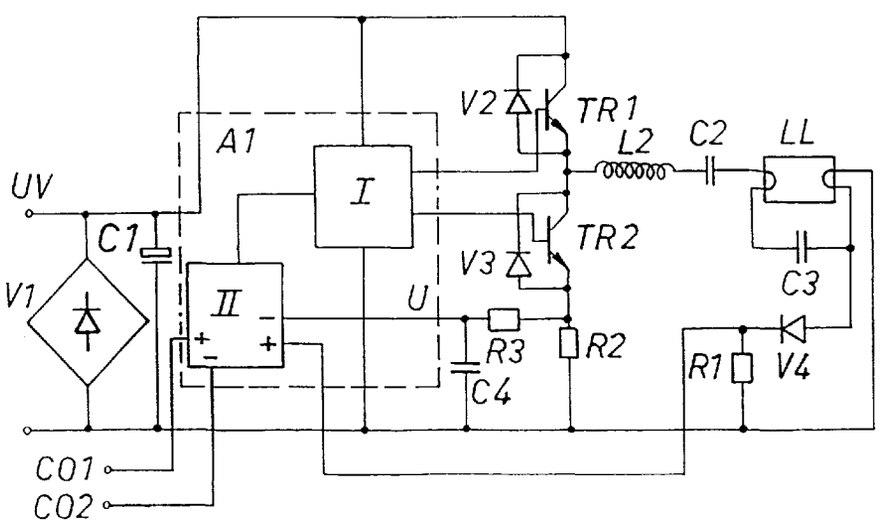

Fig. 3

EP 0 853 445 A1

Description

The present invention relates to a dimmable or controllable electronic ballast for a low-pressure discharge lamp, especially a fluorescent lamp, whose operation is based on regulating the light output of a lamp by varying the frequency of voltage supplied to the lamp. The invention relates to a method and a circuit system for accurately measuring the power supplied by such a ballast to a lamp load so as to find out the proportional share of power consumed by the lamp cathodes.

The structure of electronic ballasts for low-pressure discharge lamps is prior known from the Applicant's patent No. 64478 as well as the theoretical foundations from the Applicant's patent No. FI 63314. On the other hand, the Applicant's patent No. FI 63146 discloses the structure and operation of a low-voltage controlled electronic ballast for gaining a light output proportional to an external control signal.

The structure and operation of a controllable or dimmable ballast prior known from the Applicant's patent No. FI63146 will be described in more detail with reference to fig. 1 of the attached drawings, depicting one preferred embodiment for such a ballast. In order to simplify the representation, fig. 1 only illustrates the structural components that are most essential in terms of understanding the operation.

The ballast shown in fig. 1 includes a rectifier V1 connected to a supply voltage UV, a smoothing capacitor C1, a high-frequency oscillator A1, as well as transistors TR1 and TR2 constituting a semi- or half-bridge circuit. A lamp LL is connected as part of a resonance circuit, constituted by a capacitor C2 and a winding L2 and supplied by the push-pull transistors TR1 and TR2. A filament pre-heating current for the cathodes of the lamp LL at a switch-on stage of the lamp is passed via a capacitor C3. The oscillator AI is provided with a control connection CO1 - CO2, wherethrough the control signal influences the oscillating frequency of the oscillator. The electronic ballast must generally be fitted with a separate safety feature for against certain special circumstances, such as over- or undervoltage in an electric network supplying the ballast, overheating of the device, a missing lamp, or breaking of the lamp cathodes, as described e.g. in the Applicant's patent application FI 955695.

It is general knowledge that heating the cathodes of low-pressure discharge lamps during the switch-on sequence of a lamp has a positive contribution to the service life and operating characteristics of the lamp. The appropriately dimensioned filament power can be used for prolonging the service life of a lamp by reducing a stress applied to the lamp cathodes and especially to the emission material layer serving as a coating therefor. At the same time, this enables a lamp to be switched on without flicker with a voltage across the lamp that is lower than what is required when pre-heating is not used. The requirements set on electronic ballasts regarding the heating of cathodes during the ignition of a lamp are set forth in the International standard IEC 929. The purpose of these requirements is to make sure that fluorescent lamps according to standards IEC 81 and IEC 901 reach the service life specified therefor. Deviation from the requirements of said standards may cause also other adverse effects, such as blackening of the glass bulb of a lamp in areas next to the cathodes, as material emitting from the cathodes accumulates on the internal surface of the glass bulb.

It is also prior known that said heating of the lamp cathodes is necessary whenever it is desirable to regulate the light output of the lamp. Sufficient cathode incandescence is used to make sure that a sufficient number of charge carriers are emitted from the cathodes to sustain discharge in a lamp as the current passing therethrough is diminishing. An optimal heating level is again necessary for maintaining the service life of a lamp at an acceptable level. Fig. 2 of the drawings depicts one preferred embodiment for heating of the cathodes of a lamp LL. In this circuit, a coil L2 includes two secondary windings for supplying the cathodes of the lamp LL with filament heating energy of a desired magnitude via capacitors C5 and C6. Circuit elements R4 and V5 are used for a measuring purpose in a manner explained in more detail in connection with the description of the characterizing features of the invention.

It is essential for the operation of an electronic ballast as described above that the power supplied to the lamp LL can be measured at a sufficient accuracy. This measuring information is utilized in the operation of a control block AI, such that the lamp LL can be supplied in a stable manner with a power proportional to a voltage between control lines CO1 and CO2 for regulating the light output of the lamp. The power delivered by the half-bridge connected transistor circuit TR1 and TR2 to the lamp load LL consists of two components: an actual lamp power, which sustains a light-generating discharge within the lamp, and a filament power, which is used for heating the lamp cathodes. Especially at lower regulation levels, whereby the power consumed by the discharge of a lamp is low, the power of cathode heating constitutes a substantial share of the power of the entire circuit. A problem with the above-described ballast is the measurement of a load power in such a fashion that the actual lamp power can be measured at a sufficient accuracy without the power required by cathode heating having a significant effect on the measuring result.

An object of this invention is to introduce a measuring circuit connection for a ballast of the type defined in the preamble of claim 1, whereby the power of a low-pressure discharge lamp, especially a fluorescent lamp, can be measured such that the proportion of a power used for incandescence of the cathodes is compensated out of the measuring result.

This object is achieved in the invention by means of the features set forth in the annexed claim 1. The non-independent claims disclose preferred embodiments of

the invention.

In the drawings,

fig. 1 illustrates the prior art as described above;

fig. 2 shows one circuit configuration for the incandescence of a lamp cathode, said circuit being provided with elements R4, V5 for measuring the proportion of a power used for heating the cathodes; and

fig. 3 shows an electronic ballast, provided with a lamp power measurement of the invention and including a circuit configuration slightly different from that of fig. 2 for heating the cathodes and for measuring the proportion of a power used therefor.

The invention will be described in more detail in terms of its operation with reference made to fig. 3, most of the functions thereof having already been explained by means of fig. 1 of the drawings. An addition to this are so-called freewheel diodes V2 and V3, which allow the forward passage of the current of an oscillating circuit whenever a transistor TR1 or TR2 in parallel therewith has broken the circuit in the opposite direction of the current.

The effective energy consumed by a half-bridge TR1 - TR2 is primarily transferred into a load circuit C2, L2, LL, and C3. As a result of the symmetrical action of the circuit, the current through either one of the half-bridge supplies is proportional to the energy consumed by the load circuit, if the half-bridge supply voltage is maintained constant.

$P_{load} \sim I_{halfbridge,supply}$

The load circuit is constituted by a coil or winding L2, a lamp LL, and capacitors C2, C3. The lamp LL is the only one of these to use effective power. The energy spent by the lamp LL is divided into the use of energy caused by the lamp discharge and the energy consumed by filaments. In terms of light output, the energy of a lamp current is interesting.

When the effective power of a load circuit or the light output produced by the lamp LL is regulated by using the halfbridge supply current as a reference value, the regulation functions well as long as the lamp power exceeds the filament power. When said powers are equal or the lamp power is lower than the filament power, the regulation becomes inaccurate. Depending on the type of lamp, this occurs between about 10...20 % light level. When it is desirable to adjust this to a lower light level, the effect of the filament power must be eliminated from the measuring signal. This can be effected e.g. by measuring a voltage existing across one of the cathodes of the lamp LL. The cathode voltage is a product of the cathode resistance and the square sum of a filament current as well as a lamp current. It should be noted that the filament current and the lamp current have a phase difference of about 90 degrees. At low light levels, the filament voltage is constituted primarily by the filament current, as the lamp current is low. Thus, a preferred compensating signal is obtained by simply subtracting an appropriately dimensioned voltage proportional to the filament voltage from a voltage proportional to the halfbridge supply current.

The compensation is dimensioned to be significant at lower light levels only. The filament power can be calibrated, i.e. the effect of filament resistance fluctuations between various individual lamps can be compensated for prior to the ignition of a lamp by comparing the halfbridge current with the filament voltage.

A measurement from the end of a lamp yields both the filament and lamp current. The dynamic impedance of a fluorescent lamp is almost resistive over a wide frequency range and the value of impedance is keenly dependent on the level of a lamp current such that, on low currents, the effective resistance is very high and, on high currents, it is respectively low.

Fig. 3 of the drawings illustrates one embodiment of the above-described measuring principle. In this case, the total output of a load circuit is measured by using a resistance R2, which produces a voltage proportional to the current of a halfbridge TR1 - TR2, said voltage bing filtered by means of elements R3 and C4 and forwarded to an oscillator block A1. Here, the oscillator block A1, in terms of its function, is divided in two sections, whereby a sub-block II handles the processing of measuring signals and a sub-block I the control of the halfbridge transistors TR1 and TR2.

The voltage proportional to a power used for the heating of the cathodes of the lamp LL is developed by means of elements V4 and R1 and this measuring signal is likewise forwarded into the sub-block II of the oscillator circuit A1. The difference between said measuring signals is obtained here, whereby the control block has at its disposal a real measuring signal proportional to the lamp power. By means of this and a control signal fed into the lines CO1 - CO2, the control block II is able to conduct its control function in such a manner that control of the halfbridge TR1 - TR2 by way of the sub-block I guarantees a stable lighting regulation as designed for the ballast.

When the pre-incandescence of cathodes is carried out by using a circuit as set forth in fig. 2, the voltage proportional to the filament power of the cathodes is obtained across a resistance R4 and the measuring signal is delivered to the control block by way of a diode V5.

It is evident for a skilled person that the invention is not limited solely to the described embodiments but it equally well adaptable to numerous other frequency-regulation based ballast circuits, e.g. to multiple-lamp ballast versions. Especially, the technology of switching transistors used in the halfbridge bears no significance on the usefulness of the described circuit, i.e. applicable in this context are a.o. a bipolar transistor and various versions of field effect transistors. It is also obvious that

the control signal of the oscillator A1 in the circuit CO1 - CO2 can also be digital, in which case the sub-block II includes necessary circuit elements for processing digital information, e.g. by means of a programmable microcontroller.

Claims

1. A controllable or dimmable electronic ballast provided with a lamp power measurement for a low-pressure discharge lamp, especially for a fluorescent lamp, said ballast comprising

   - at least one halfbridge inverter (TR1, TR2, V2, V3) or a corresponding AC-source, which supplies power to a load circuit,
   - a load circuit, which includes a current limiting inductance (L2) and a filament current supplying capacitance (C3) as well as a discharge lamp (LL) connectable to the ballast,
   - a regulation or control block (A1/I, II) for controlling the frequency of the inverter or a corresponding AC-source for regulating the light output of the lamp; and
   - elements (R2, R3, C4) for measuring a current proportional to the load circuit power and for delivering measurement information ($U_{meas.}$) to the regulation or control block,

   characterized in that the device further includes elements (R1, V4; R4, V5) for measuring a voltage proportional to a current passing through one or more filaments of the lamp and for delivering measurement information to the regulation or control block (A1/I, II), wherein the measurement information is used for compensating the effect of filament power out of the measuring result of the load circuit power.

2. A ballast as set forth in claim 1, **characterized** in that from a voltage proportional to the load circuit current is subtracted a voltage proportional to the filament current and the difference is used for controlling the regulation of the light output of a lamp.

3. A ballast as set forth in claim 1 or 2, **characterized** in that said elements for measuring a voltage proportional to the filament current include a resistance (R1, R4) connected to the end of a filament, and the elements for delivering measurement information to the regulation or control block (A1/I, II) include a diode (V4, V5) connected to one of the poles of the measuring resistance (R1, R4).

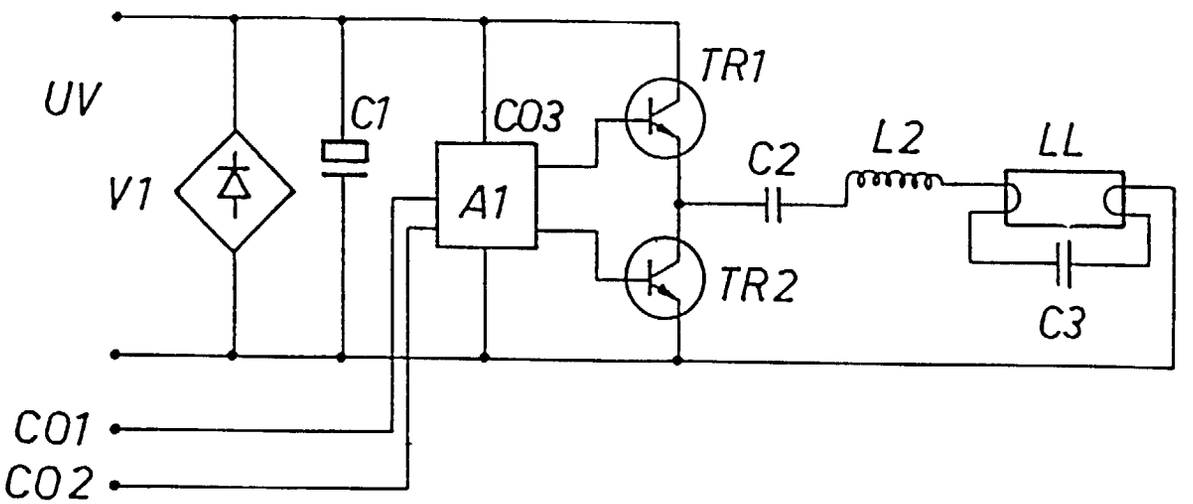

Fig.1

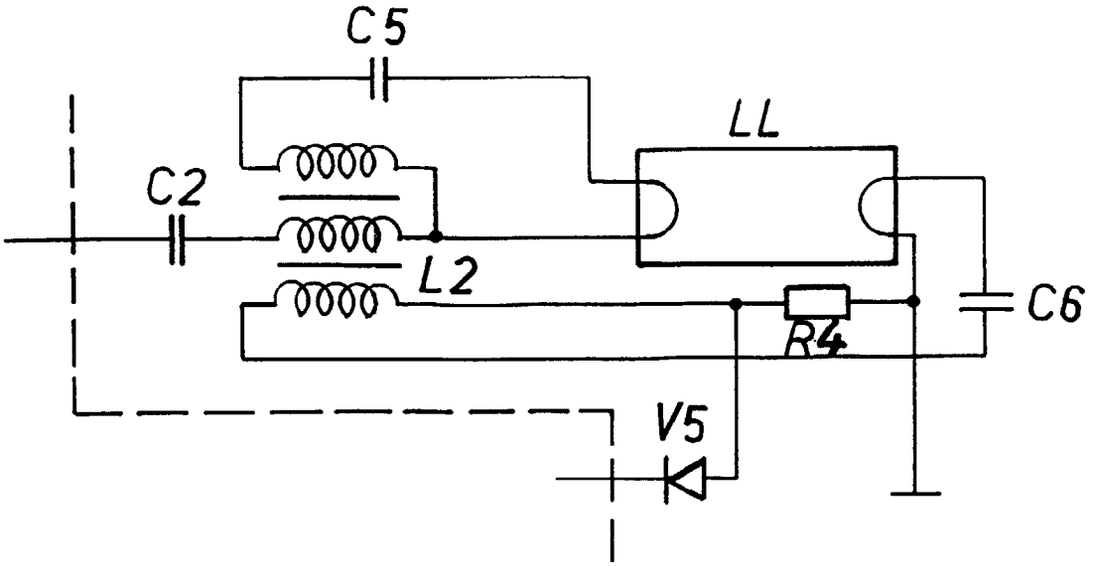
C5
LL
C2
L2
C6
R4
V5

Fig. 2

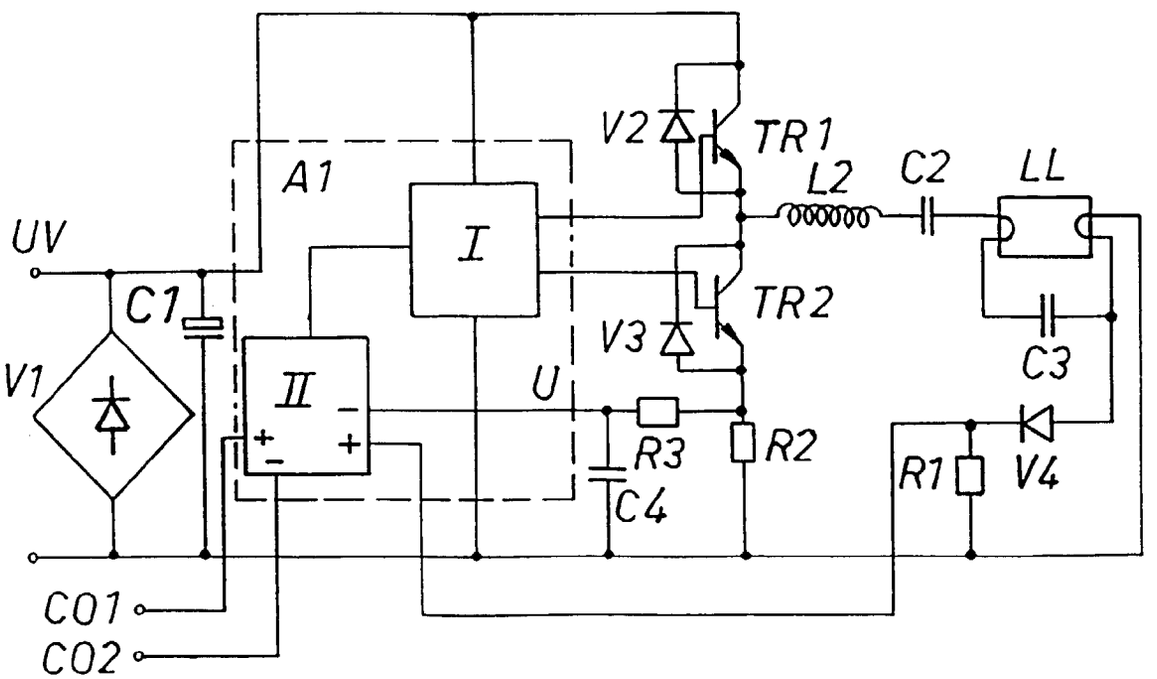
V2
TR1
A1
L2
C2
LL
UV
I
TR2
C1
V3
C3
V1
II
U
R3
R2
R1
V4
C4
CO1
CO2

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 97 66 0148

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X,P	WO 97 01945 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) * page 1, line 14 - page 2, line 30; figure 1 *	1,2	H05B41/00 H05B41/392
A	EP 0 422 255 A (SIEMENS AG) * column 2, line 28 - column 5, line 38; figure 1 *	1,2	
A	US 5 424 611 A (MORIARTY JR JOHN K) * column 4, line 64 - column 5, line 15; figure 1 *	1	
A	EP 0 707 438 A (TRIDONIC BAUELEMENTE) * column 5, line 51 - column 7, line 33; figure 1 *	1	
A,P	US 5 612 595 A (MAHESHWARI AJAY) * column 1, line 26 - column 1, line 62; figure 1 *	1	
A	EP 0 461 441 A (ZUMTOBEL AG)		TECHNICAL FIELDS SEARCHED (Int.Cl.6) H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 April 1998	Speiser, P

CATEGORY OF CITED DOCUMENTS

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