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(54) **Electronic ballast for a discharge lamp, provided with a lamp power measurement by means of a DC-signal**

(57) The invention relates to a controllable or dimmable electronic ballast for a low pressure discharge lamp, especially a fluorescent lamp. A halfbridge inverter (TR1, TR2; V2, V3) supplies power to a load circuit (L2, C2, C3, LL). A regulation or control block (A1/I, II) regulates the frequency of the halfbridge inverter for regulating the light output of a lamp. One branch of the halfbridge inverter is provided with current measuring elements (R2, R3, C4), from which is obtained current measurement information proportional to the load circuit power for the regulation or control block, which is further supplied separately with measurement information about a direct current that has passed through the lamp and is proportional to the internal resistance of the lamp. The latter measurement information is used for controlling regulation of the lamp at low regulation levels of the light output.

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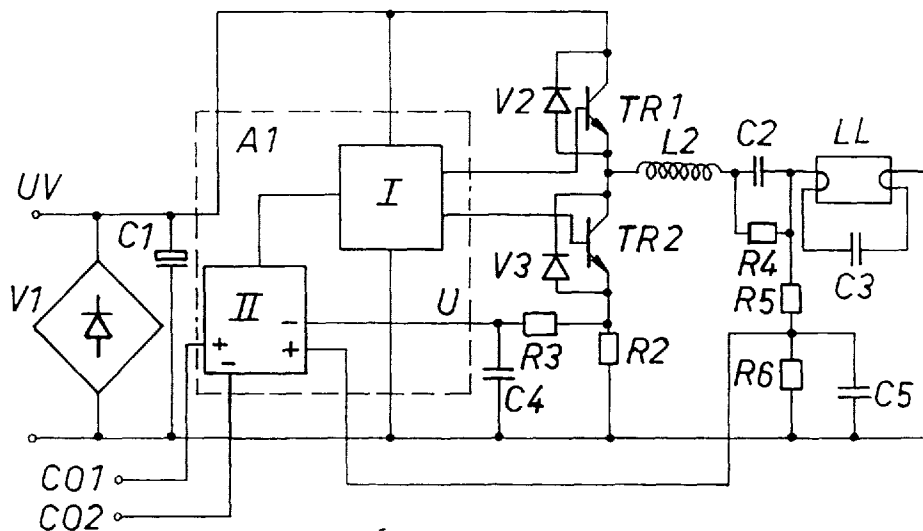


Fig. 2

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 a voltage supplied to the lamp. The invention relates to a circuit system for accurately measuring a power delivered by such a ballast to a lamp load so as to find out the proportion of power required for sustaining discharge of the lamp.

The structure of electronic ballasts for low-pressure discharge lamps is prior known from the Applicant's patent No. FI 64487 as well as the theoretical principles from the Applicant's patent No. FI 63314. The Applicant's patent No. FI 63146 in turn 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 set forth in the Applicant's patent No. FI 63146 will be described in more detail with reference made to fig. 1 of the appended drawings, which depicts one preferred embodiment of such a ballast. In order to simplify the representation, fig. 1 only depicts structural components that are most essential in terms of understanding the operation.

The ballast depicted 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 halfbridge circuit. A lamp LL is coupled as part of a resonance circuit, constituted by a capacitor C2 and an inductance L2 and supplied by the pushpull transistors TR1 and TR2. A filament pre-heating current for the cathodes of the lamp LL during a switch-on sequence of the lamp is conducted by way of a capacitor C3. The oscillator A1 is provided with a control circuit CO1 - CO2, where through a control signal influences the oscillating frequency of the oscillator. The electronic ballast must generally be provided with a separate safety feature in anticipation of certain special circumstances, such as over- or undervoltage in an electrical network supplying the ballast, overheating of the device, a lamp missing, 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 or ignition sequence of a lamp contributes positively to the service life and operating characteristics of the lamp. An appropriately dimensioned filament power can be attributed to prolong the service life of a lamp by reducing a stress applied to the lamp cathodes and particularly to the emission material layer serving as a coating therefor. At the same time, this enables the ignition of a lamp without flicker at a lower voltage across the lamp than what is required whenever the pre-heating is not employed. The requirements set for electronic ballasts re-

garding incandescence of the cathodes upon switching on 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. Diversion from the requirements set forth in said standards may cause also other adverse effects, such as blackening of the glass bulb of a lamp in areas next to the cathodes, some of the material emitting from the cathodes accumulating on the internal surface of the glass bulb.

It is also prior known that said incandescence of the lamp cathodes is unavoidable whenever it is desirable to regulate the light output of a lamp. The purpose of sufficient cathode heating is to make sure that a sufficient number of charge carriers are emitted from the cathodes for sustaining discharge in a lamp as the current passing therethrough is diminishing. A sufficient heating level is also necessary for maintaining the service life of a lamp at an acceptable level.

In terms of the operation of a controllable ballast as described above, it is essential that a power supplied to the lamp LL be measured at a sufficient accuracy. This measurement information is utilized in the operation of a control block AI in such a manner that the lamp LL can be supplied in a stable fashion with a power proportional to the voltage between control lines CO1 and CO2 for regulating the light output of the lamp. The power supplied to the lamp load LL by the halfbridge-connected transistor circuit TR1 and TR2 consists of two components: an actual lamp power, which sustains a light-generating discharge in the lamp, and a filament power, which is used for heating the lamp cathodes. Other components of the load circuit experience power losses as well. Especially at lower regulation levels, the power consumed by a lamp discharge being low, the power of cathode incandescence constitutes a considerable portion of the power of the entire circuit.

A problem with the ballast shown in fig. 1 is the measurement of a load power in such a manner that the actual lamp power can be measured at a sufficient accuracy without the power required by incandescence having a significant effect on the measuring result.

An object of the invention is to resolve this problem involving measuring technology and to provide a ballast of the type defined in the preamble of claim 1, wherein the inaccuracy factors associated with the measurement of a lamp power can be sufficiently eliminated.

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

The operation of the invention will now be described in more detail with reference made to the accompanying drawings, in which

fig. 1 shows a prior art as described above and

fig. 2 shows a ballast according to one embodiment

of the invention, most of whose functions have already been described in reference to fig. 1. As an addition to the former, there are so-called free-wheel diodes V2 and V3, which allow forward passage for the current of the oscillating circuit whenever either transistor TR1 or TR2 in parallel therewith has cut off the circuit current in the opposite direction.

The effective energy consumed by the halfbridge TR1 - TR2 transfers primarily to a load circuit C2, L2, LL, and C3. As a result of the symmetrical operation of the circuit, the current through either supply of the halfbridge is proportional to the energy consumed by the load circuit, if the supply voltage of the halfbridge is maintained constant.

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

Thus, the load circuit is constituted by an inductance or coil L2, a lamp LL, and capacitors C2, C3. As for these, the lamp LL is the only one to consume effective power. The energy consumed by the lamp LL is divided into an energy input required by the lamp discharge and an energy consumed by filaments. In terms of the output of light, 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 is higher than 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 10...20 % light level. When it is desirable to adjust to a light level lower than this, the effect of the filament power must be eliminated from a measuring signal. This can be done by measuring e.g. a voltage existing across one of the cathodes of the lamp LL, as set forth in the Applicant's patent application "Measurement of a lamp power in a regulable electronic ballast". As for these measuring methods, a problem is how to achieve a sufficient accuracy, since there are losses also in other circuit elements, such as ignition capacitors, lamp inductances, and switching transistors.

An object of this invention is to introduce a circuit connection for a ballast, whereby the power of a low-pressure discharge lamp, especially a fluorescent lamp, can be measured in such a way that said inaccuracy factors in the measurement can be eliminated. This is performed by feeding through a lamp a separate direct-current signal, which is used for producing a direct-voltage signal proportional to the effective resistance of the lamp. Said direct current through a lamp brings about a further advantage that the dark stripes visible on the surface of the lamp bulb, or a so-called striation effect, at lower regulation levels and especially at lower operating temperatures, can be avoided.

A lamp power measurement by means of a DC-sig-

nal according to the invention will now be described in even more detail.

Fig. 2 of the drawing illustrates one embodiment of the above-described measuring principle. In this case, the total power of a load circuit is measured by using a resistance R2, the voltage produced thereby and proportional to the current of a halfbridge TR1 - TR2 being filtered with elements R3 and C4 as well as being conducted to an oscillator block A1. For the sake of clarity, the operation of the oscillator block A1 is here divided in two sections, whereof a sub-block II handles the processing of measuring signals and a sub-block I the control of the halfbridge transistors TR1 and TR2. A resistance R4 is used for developing a direct-current component in an alternating current passing through the lamp LL. Thus, across the lamp develops also a direct-voltage component, which is proportional to the effective resistance of the lamp. The direct voltage is measured by means of circuit elements R5, R6 and C5 and this measuring signal is likewise conducted to the sub-block II of the oscillator circuit A1. Here is formed a difference between said measuring signals, 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 perform its control function in such a manner that the control of the halfbridge TR1 - TR2 through the sub-block I guarantees a stable lighting regulation function for the ballast, as planned.

At a maximum regulation level the lamp has a substitution resistance of about 275 ohms, at a 50 % light level about 600 ohms, and at a 5 % light level about 14 kilo-ohms. When the direct current component supplied to a lamp is 1,5 mA, the result will be a direct voltage of about 20 V across the lamp. Thus, the direct voltage measurement has a wide dynamic range and the measuring signal can be readily utilized in the control block of a ballast.

By means of a circuit system of the invention, the regulation of a light level at low light levels can be made considerably more accurate than by using conventional power measurement. The Applicant's patent FI 65524 describes how said direct current component through a low-pressure discharge lamp can be used for avoiding a so-called striation effect, which is a serious problem in controllable and dimmable ballasts. In addition, this patent discloses a variety of ways of producing a direct current component. The undeniable strength of this invention lies in the fact that one and the same direct current signal can be used to gain two major benefits in terms of the operation of regulable ballasts, namely an accurate regulation and an unstreaked output of light from the lamp.

It is evident for a skilled person that the invention is not limited solely to the described embodiments but is equally well adaptable to numerous other frequency-regulation based ballast circuits, e.g. multiple-lamp ballast versions. In particular, the technology applied in

switching transistors used in the halfbridge has no significance regarding the usefulness of the described circuit, i.e. in this context, useful components include a.o. a bipolar transistor and various designs of field effect transistors. It is also obvious that the control signal of the oscillator A1 in the circuit CO1 - CO2 can be digital as well, the sub-block II including necessary circuit elements for processing digital information, e.g. by means of a programmable micro-controller.

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rent measuring elements (R5, R6, C5) are connected between said resistance (R4) and the lamp (LL).

Claims

1. A controllable or dimmable electronic ballast for a low-pressure discharge lamp, especially a fluorescent lamp, comprising

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- at least one halfbridge inverter (TR1, TR2, V2, V3) or a corresponding AC-source, which supplies power to a load circuit,
- a load circuit, including 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 adjusting the frequency of the inverter or a corresponding AC-source for regulating the light output of the lamp,
- elements (R2, R3, C4) for measuring a current proportional to the load circuit power and for conducting the measurement information ($U_{meas.}$) to the regulation or control block; and
- elements (R4) for producing a direct current passing through the lamp,

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characterized in that the device further includes elements (R5, C5, R6) for measuring the direct current passing through the lamp and for feeding the measurement information to the regulation or control block (A1/I, II) for using the same in controlling the regulation of the light output of the lamp.

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2. A ballast as set forth in claim 1, **characterized** in that a measuring signal proportional to the lamp power is produced as difference between said pieces of measurement information.

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3. A ballast as set forth in claim 1 or 2, **characterized** in that each of said current measuring elements includes at least one resistance (R2; R6) and at least one capacitor (C4; C5) connected in parallel with the resistance.

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4. A ballast as set forth in any of claims 1-3, **characterized** in that the element producing the direct current passing through the lamp is a resistance (R4), which is connected in parallel with a capacitor (C2) included in the load circuit, and that the direct cur-

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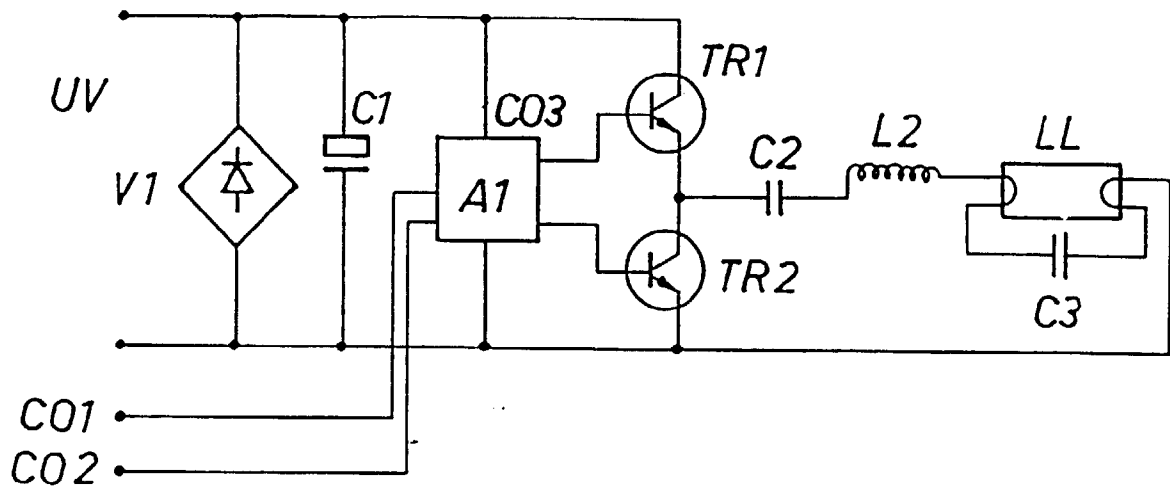


Fig.1

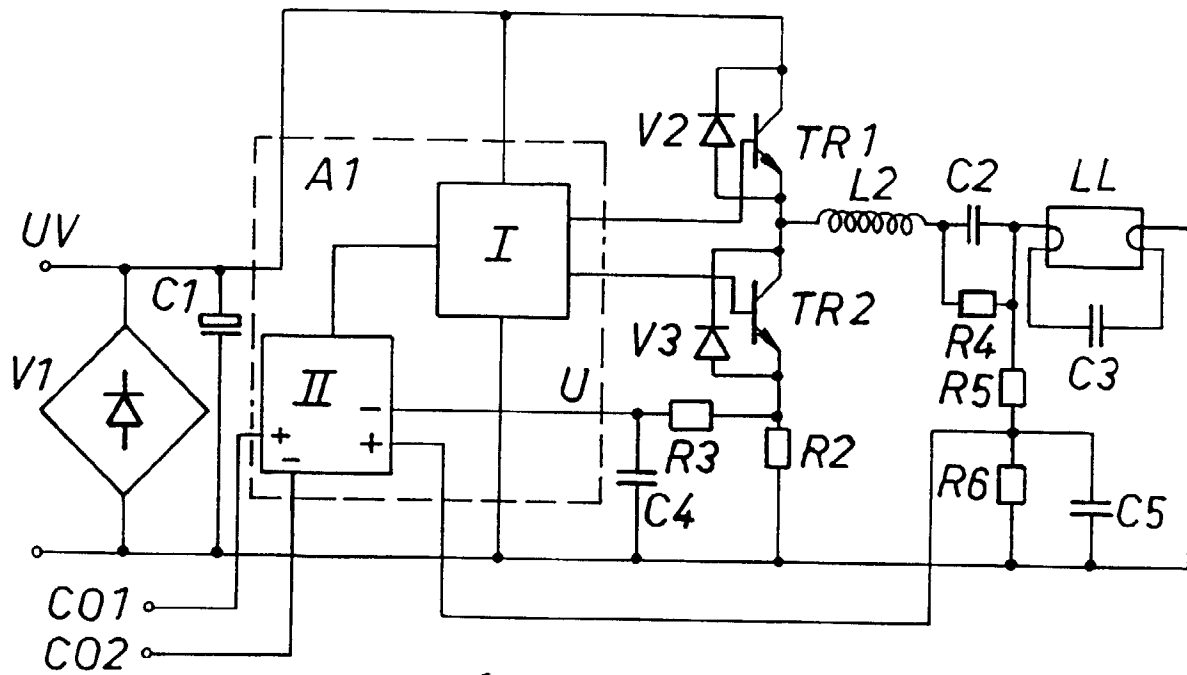


Fig. 2



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 66 0149

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	EP 0 422 255 A (SIEMENS AG) * column 2, line 16 - column 6, line 11; figures 1-4 *	1-4	H05B41/00 H05B41/392
X,P	WO 97 01945 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) * page 1, line 17 - page 2, line 30; figure 1 *	1	
A	EP 0 589 081 A (KNOBEL LICHTTECH) * column 2, line 41 - column 3, line 38; figures 1-3 *	1	
A	GB 2 246 034 A (LUTRON ELECTRONICS CO) * abstract; figures 5C,11 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H05B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21 April 1998	Examiner Speiser, P
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