

Circuit arrangement. ✓

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The invention relates to a circuit arrangement for operating a discharge lamp, comprising a DC-AC converter provided with

- a branch A having ends suitable for being connected to a DC voltage source and comprising a series circuit of two switching elements for generating a periodic voltage by being conducting and non-conducting alternately with a frequency f , each switching element being shunted by a diode,
- a control circuit coupled to control electrodes of the switching elements for rendering the switching elements conducting and non-conducting alternately with the frequency f ,
- 10 - a load branch B which shunts one of the switching elements and which comprises inductive means L and means for coupling the discharge lamp to the load branch B,
- means M for adjusting the power consumed by the discharge lamp.

Such a circuit is known from European Patent 323676. In this Patent,

15 both the frequency f of the DC-AC converter and the time interval T_t during which each of the switching elements is conducting are presented as parameters by which it is possible to adjust the power consumed by the lamp. It was found that the use of one of these parameters renders it possible to adjust the luminous flux of the lamp over a wide range by comparatively simple electronic auxiliary means. A disadvantage which may

20 arise when the frequency f is used as the parameter is that the relation between the power consumed by the discharge lamp and the frequency f is not unequivocal over the entire range of frequencies which can be set. Especially when the power consumed by the discharge lamp is comparatively low, each value of the frequency f in a certain range of this frequency f can correspond to two lamp power values. This results in an

25 unstable burning of the lamp. It is found for very many discharge lamps in practice, especially compact fluorescent lamps, that it is not possible for this reason to adjust comparatively low values of the power consumed by the discharge lamp. In other words, the range over which the discharge lamp can be dimmed is limited.

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It should be noted that European Patent 482705 describes a possible solution to this problem. This solution, however, is comparatively complicated and expensive.

An important disadvantage connected with the use of the time interval T_t as a parameter is that, depending on the dimensions of the discharge lamp, the power consumed by the discharge lamp is a very steep function of the time interval T_t in a certain range. This means in practice that additional control measures are necessary for adjusting the power consumed by the discharge lamp by means of the time interval T_t in this range. These additional control means also render the use of this parameter comparatively complicated and expensive.

The invention has for its object *inter alia* to provide a circuit arrangement with which the power consumed by a discharge lamp operated by means of the circuit arrangement can be adjusted over a comparatively wide range by comparatively simple means.

According to the invention, this object is achieved in that the means M comprise

- means M_p for adjusting the value of the difference $T_t - T_d$, in which T_t is a time interval during which one of the switching elements is conducting during a half cycle of the periodic voltage, and T_d is a time interval during which a diode is conducting during this same half cycle of the periodic voltage.

It was found for discharge lamps of various types that there is an unequivocal relation between the parameter $T_t - T_d$ and the power consumed by the discharge lamp. In addition, the power consumed by the discharge lamp is a function of the parameter $T_t - T_d$ which is not excessively steep. As a result it is possible to adjust the luminous flux of the discharge lamp over a comparatively wide range with the use of $T_t - T_d$.

An advantageous embodiment of a circuit arrangement according to the invention is characterized in that the means M_p comprise

- means for generating a signal S_1 which is a measure for $T_t - T_d$,



- means for generating a signal S2 which is a measure for a desired value of $T_t - T_d$,
- means for rendering the signal S1 substantially equal to the signal S2.

In this advantageous embodiment of a circuit arrangement according to the invention, the means Mp are realised in a comparatively simple manner.

A further advantageous embodiment of a circuit arrangement according to the invention is characterized in that the means for generating the signal S2 comprise

- means for generating a signal P1 which is a measure for the power consumed by the discharge lamp, and
- 10 - means for generating a signal P2 which is a measure for a desired value of the power consumed by the discharge lamp.

It is possible with this further advantageous embodiment of a circuit arrangement according to the invention to control the power consumed by the discharge lamp at a substantially constant level, independently of ambient parameters such as, for
15 example, the ambient temperature.

Embodiments of a circuit arrangement according to the invention will be explained in more detail with reference to a drawing, in which

20 Fig. 1 is a diagram of a circuit arrangement according to the invention;
Fig. 2 shows a portion of the circuit arrangement of Fig. 1 in greater detail;

Fig. 3 is a diagram of a further circuit arrangement according to the invention;

25 Fig. 4 shows the time-dependent behaviour of currents and voltages present in the circuit arrangement of Fig. 1 during lamp operation; and

Fig. 5 shows the power consumed by a compact fluorescent lamp as a function of a parameter $T_t - T_d$ for a few temperatures. The compact fluorescent lamp was operated on a circuit arrangement as shown in Fig. 1 and the parameter $T_t - T_d$ was
30 used for adjusting this power.

In Fig. 1a, A denotes a branch provided with ends suitable for being



- connected to a DC voltage source and comprising a series circuit of two switching elements Q1, Q2 for generating a periodic voltage by being conducting and non-conducting alternately with a frequency f , each switching element being shunted by a diode D1, D2. The ends of branch A are connected to a voltage source DC. B is a load
- 5 branch which shunts the switching element Q2 and which comprises inductive means L and means K1 and K2 for coupling the discharge lamp to the load branch B. A discharge lamp La, shown as a compact fluorescent lamp, is coupled to the load branch B through the means K1 and K2. The discharge lamp La is shunted by a capacitor C1. The load branch B also comprises a capacitor C2 connected in series with the lamp.
- 10 Control electrodes of switching elements Q1 and Q2 are coupled to control circuit I for rendering the switching elements alternately conducting with the frequency f . An input of control circuit I is coupled to an output T0 of means Mp for adjusting the value of the difference $T_t - T_d$, in which T_t is a time interval during which one of the switching elements is conducting during a half cycle of the periodic voltage and T_d is a time
- 15 interval during which a diode is conducting during the same half cycle of the periodic voltage. The means Mp are built up from circuit portions II and III, an ohmic resistor R1 and an variable resistor R2. Ohmic resistor R1 and variable resistor R2 together form means for generating a signal S2 which is a measure for a desired value of $T_t - T_d$. Circuit portion III forms means for generating a signal S1 which is a measure for $T_t -$
- 20 T_d . Circuit portion II forms means for rendering the signals S1 and S2 substantially equal to one another. A series circuit of ohmic resistor R1 and variable resistor R2 shunts branch A. A common junction point of ohmic resistor R1 and variable resistor R2 is connected to an input T5 of circuit portion II. Respective inputs T7a and T7b of circuit portion III are interconnected by ohmic resistor RL which is connected in series
- 25 with the inductive means L of the load branch B. An output of circuit portion III is connected to a further input T6 of circuit portion II. The said output T0 of the means Mp is also an output of circuit portion II. Output T0 of circuit portion II is connected to an input T8 of circuit portion III.

The operation of the circuit arrangement shown in Fig. 1a is as follows.

- 30 The control circuit I renders the switching elements Q1 and Q2 conducting and non-conducting alternately with a frequency f during lamp operation. As a result, a substantially square-wave voltage with frequency f is present at the junction point HB of the two switching elements. This substantially square-wave voltage causes a current Ib



to flow in the load branch B, the polarity of which changes with the frequency f . To prevent a comparatively high power dissipation in the switching elements, the dimensions of the switching arrangement are so chosen that the load branch forms an inductive impedance at the frequency f . The result is that there will be a phase shift
5 between the substantially square-wave voltage and the current I_b . This means that during each half cycle of the substantially square-wave voltage the current I_b first flows through one of the diodes of branch A during a time interval T_d and then through the switching element shunted by the diode during a time interval T_t . It is true for this case that the sum of the time intervals T_t and T_d is equal to a half cycle of the substantially
10 square-wave voltage ($1/2f$). The current I_p changes polarity at the end of the time interval T_d .

A direct current flows through the series arrangement of ohmic resistor R_1 and variable resistor R_2 during lamp operation. As a result of this, a substantially constant DC voltage is present at input T5 of circuit portion II, the value of which
15 depends on the setting of variable resistor R_2 . This substantially constant DC voltage forms the signal S_2 which is a measure for a desired value of T_t - T_d . A signal S_1 which is a measure for T_t - T_d and which is generated by circuit portion III is applied to input T6 of circuit portion II. The moment the signal S_1 is equal to the signal S_2 , the circuit portion II generates a voltage pulse at the output T0. As a result of this voltage pulse,
20 the control circuit I renders the switching element which is conducting at that moment non-conducting. The fact that a switching element of branch A becomes non-conducting coincides substantially in time with a rising or falling edge of the substantially square-wave voltage, so also with the end of a half cycle and the beginning of the next half cycle of the substantially square-wave voltage. It is assured in this way that T_t - T_d is
25 equal to the desired value of T_t - T_d during each half cycle of the substantially square-wave voltage. It is possible to adjust the luminous flux of the discharge lamp L_a over a comparatively wide range by adjusting this desired value by means of the variable resistor R_2 .

Fig. 2 shows more details of the circuit portions II and III. Circuit portion
30 III is built up from an amplifier A and a sawtooth generator B. Inputs T7a and T7b of amplifier A are coupled to ends of ohmic resistor R_L . An output of amplifier A is coupled to an input T9 of sawtooth generator B. A further input of sawtooth generator B is T8. Circuit portion II is formed by amplifier C. An output of sawtooth generator B



is connected to an input T6 of amplifier C. T5 is a further input of amplifier C to which the signal S2 is applied during lamp operation. An output T0 of amplifier C is connected to input T8 of sawtooth generator B. As is shown in Fig. 1, output T0 is also connected to an input of control circuit I.

5 The operation of the circuit components shown in Fig. 2 is as follows. A voltage pulse is present at output T0 at the beginning of every half cycle of the substantially square-wave voltage. This voltage pulse is used, through input T8 of sawtooth generator B, for rendering the amplitude of the sawtooth-shaped voltage generated by sawtooth generator B substantially equal to zero. Then the amplitude of
10 the sawtooth-shaped voltage decreases linearly as a function of time during the time interval Td. At the end of the time interval Td, the current Ib changes polarity. This polarity change is accompanied by a polarity change of the voltage across ohmic resistor RL. This polarity change, which marks the beginning of Tt, is passed on to input T9 of sawtooth generator B through amplifier A. After this polarity change, the amplitude of
15 the sawtooth-shaped voltage rises linearly during the time interval Tt. Thus the amplitude of the sawtooth-shaped voltage is a measure for Tt-Td and forms the signal S1 which is present at input T6 of amplifier C. Signal S2 is present at input T5 of amplifier C. When the amplitude of signal S1 becomes equal to the amplitude of signal S2, the output T0 of amplifier C changes from low to high. As described above, this
20 renders the amplitude of the sawtooth-shaped voltage substantially equal to zero. The amplitude of signal S2 is now higher again than that of signal S1, and the output T0 of amplifier C changes from high to low.

Fig. 3 shows a circuit arrangement which differs from the circuit arrangement shown in Fig. 1 only in the construction of the means for generating the
25 signal S2. These means in the circuit arrangement shown in Fig. 3 are formed by circuit portions IV, V and VI. Circuit portion V forms means for generating a signal P1 which is a measure for the power consumed by the discharge lamp La. Circuit portion VI forms means for generating a signal P2 which is a measure for a desired value of the power consumed by the discharge lamp La. Circuit portion IV forms means for
30 generating signal S2, which is a measure for a desired value of Tt-Td, in dependence on signal P1 and signal P2. Input T1 of circuit portion V is so coupled to the discharge lamp La (in a manner not shown) that a signal is present at input T1 during lamp operation which is a measure for the lamp current. Input T2 of circuit portion V is so



coupled to the discharge lamp La (in a manner not shown) that a signal is present at input T2 during lamp operation which is a measure for lamp voltage. An output of circuit portion V is connected to an input T3 of circuit portion IV. An output of circuit portion VI is connected to a further input T4 of circuit portion IV. An output of circuit
5 portion IV is connected to input T5 of circuit portion II.

The operation of the circuit arrangement shown in Fig. 3 is as follows. During lamp operation, circuit portion V generates a signal P1 which is a measure for the power consumed by the discharge lamp La. This signal P1 is applied to input T3 of circuit portion IV. Simultaneously, the further input T4 of circuit portion IV receives a
10 signal P2 generated by circuit portion VI which is a measure for a desired value of the power consumed by the discharge lamp La. Using signal P1 and signal P2, circuit portion IV generates a signal S2 which is a measure for a desired value of $T_t - T_d$. The amplitude of signal S2 is such that the power consumed by the discharge lamp is substantially equal to the desired power consumed by the discharge lamp La. It is thus
15 ensured that the power consumed by the discharge lamp La is controlled at a desired value. If the desired value of the power consumed by the discharge lamp La is adjustable, it is possible to adjust the luminous flux of the discharge lamp La over a very wide range as desired. Owing to the unequivocal relation between the parameter $T_t - T_d$ and the power consumed by the discharge lamp La, it is possible to have the
20 discharge lamp operate in a stable manner even at a comparatively low desired value of the consumed power. The operation of the further portions of the circuit arrangement shown in Fig. 3 is similar to the operation of corresponding portions of the circuit arrangement shown in Fig. 1.

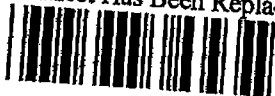
In Fig. 4, Vhb is the substantially square-wave voltage which is present at
25 the junction point of the two switching elements Q1 and Q2 during lamp operation. Ib is the current which flows in the load branch as a result of this voltage. The time intervals T_d and T_t are also shown in the first half cycle of Vhb. Below this, the signal shapes of S1 and S2 are shown against to the same time base. The signals St1 and St2 are control signals by which the switching elements Q1 and Q2 are rendered conducting and non-
30 conducting. The relevant switching element is conducting when St1 or St2 is not equal to zero. It is visible that the action of rendering a switching element non-conducting (falling edge of St1 or St2) substantially coincides with the moment signal S1 is equal to signal S2 and with a rising or falling edge of Vhb. Each switching element is made



conducting while the diode shunting the switching element is in the conducting state (during T_d). This is shown hatched in Fig. 4.

Fig. 5 shows the power consumed by a discharge lamp in dependence on the parameter T_t-T_d and for a number of ambient temperatures. The discharge lamp is a
5 compact fluorescent lamp of the PL type. It is first of all apparent that there is an unequivocal relation between the parameter T_t-T_d and the power consumed by the discharge lamp L_a , in particular also at low power levels. It is also evident that the ambient temperature has only a slight influence on the relation between the parameter T_t-T_d and the consumed power.

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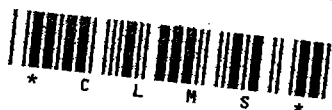
CLAIMS:



1. A circuit arrangement for operating a discharge lamp, comprising a DC-AC converter provided with
- a branch A having ends suitable for being connected to a DC voltage source and comprising a series circuit of two switching elements for generating a periodic voltage by being conducting and non-conducting alternately with a frequency f ,
5 each switching element being shunted by a diode,
 - a control circuit coupled to control electrodes of the switching elements for rendering the switching elements conducting and non-conducting alternately with the frequency f ,
 - 10 - a load branch B which shunts one of the switching elements and which comprises inductive means L and means for coupling the discharge lamp to the load branch B,
 - means M for adjusting the power consumed by the discharge lamp,
characterized in that the means M comprise
 - 15 - means M_p for adjusting the value of the difference $T_t - T_d$, in which T_t is a time interval during which one of the switching elements is conducting during a half cycle of the periodic voltage, and T_d is a time interval during which a diode is conducting during this same half cycle of the periodic voltage.
2. A circuit arrangement as claimed in Claim 1, characterized in that the
20 means M_p comprise
- means for generating a signal S_1 which is a measure for $T_t - T_d$,
 - means for generating a signal S_2 which is a measure for a desired value of $T_t - T_d$,
 - means for rendering the signal S_1 substantially equal to the signal S_2 .
- 25 3. A circuit arrangement as claimed in Claim 2, characterized in that the means for generating the signal S_2 comprises
- means for generating a signal P_1 which is a measure for the power consumed by the discharge lamp, and



means for generating a signal P2 which is a measure for a desired value of the power consumed by the discharge lamp.



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