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(21) International Application Number: PCT/IB96/01244 (22) International Filing Date: 18 November 1996 (18.11.96) (30) Priority Data: 08/569,898 8 December 1995 (08.12.95) US (71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE). (72) Inventors: GU, Wen-Jian; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). LIU, Rui; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: EVERS, Johannes, H., M.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).		(81) Designated States: CN, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: BALLAST SYSTEM The diagram shows a ballast system for a lamp. It starts with an AC input (22) connected to a series of three blocks (24, 26, 28). Block 28 is connected to a transformer (40) and a feedback loop (42). The transformer (40) is connected to a high-frequency converter (32). The high-frequency converter (32) is connected to a lamp (68). A feedback signal (i) is taken from the lamp (68) and fed back into the high-frequency converter (32). A control signal (B) is also fed into the high-frequency converter (32).		
(57) Abstract A ballast system for a lamp which includes a rectifier for rectifying AC input power having a first frequency (e.g., 50 or 60 Hz), to thereby produce a pulsating DC current, a DC-DC converter for converting the pulsating DC current into a substantially constant (low percent ripple) DC voltage, and, a high-frequency transformer-linked DC-AC converter for converting the constant DC voltage into an AC output current for driving the lamp, the AC output current having a second frequency (e.g., 25-50 kHz) which is higher than the first frequency. The ballast system further includes a first control circuit for operating the DC-DC converter at a first switching frequency, and a second control circuit for operating the high-frequency transformer-linked DC-AC converter at a second switching frequency (e.g., > 1 MHz) which is preferably at least ten times higher than the second frequency (i.e., the lamp current frequency).		

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Ballast system.

The present invention relates to a ballast system for operating a lamp, comprising

a rectifier for rectifying AC input power to thereby produce a pulsating DC current;

5 a DC-DC converter for converting said pulsating DC current into a substantially constant DC voltage;

a DC-AC converter for converting said substantially constant DC voltage into an AC output current for driving the lamp.

10

Such a ballast system is known from EP 0323676. Electronic ballast lamps (EBLs) are in widespread use. In general, an EBL is a discharge lamp, e.g., a fluorescent lamp, which is coupled to an electronic ballast circuit (system) which converts an AC line voltage into a high frequency AC output voltage for operating the lamp, and which
15 utilizes a lamp current feedback signal to regulate the sinusoidal lamp current.

With reference now to Fig. 1, there can be seen a block diagram of a conventional electronic ballast system 20 which receives its power from a utility AC line 22, e.g., from a standard 60 Hz residential outlet. The ballast system 20 includes an EMI filter 24 which filters out high-frequency noise from the ballast circuit. The AC power from the utility line is rectified by a rectifier 26, which produces a pulsating DC output. The pulsating
20 DC output from the rectifier 26 is smoothed out by a high-frequency power factor correction (PFC) boost converter 28, which produces a smooth DC output with highly attenuated (i.e., low percent) ripple. The PFC boost converter 28 functions to hold constant at near zero the phase angle between the current and voltage waveforms of the pulsating DC output from the rectifier 26, to thereby provide a near-unity power factor (pf). In general, to meet industry
25 requirements, a gas discharge lamp ballast should draw power from the power line with a power factor of at least 90% and harmonic distortion of less than 20%. The smooth DC output from the PFC boost converter 28 is then converted by a high-frequency DC-AC inverter 30 into a high-frequency (e.g., 25-50 kHz) AC voltage which is delivered to the

lamp 32 for ignition thereof. Since the input power of the system is relatively low frequency and the output power is relatively high frequency, a bulk capacitor C_e is provided in the PFC boost converter 28 for energy storage, to thereby balance the input and output power.

Isolation between the AC utility line input and the lamp load is provided by the inverter 30.

5 A control circuit A is utilized to control the switching frequency of the PFC converter, to thereby coarsely regulate the DC output from the PFC boost converter 28, and a control circuit B is utilized to control the switching frequency of the high-frequency DC-AC inverter 30, to thereby regulate the output power applied to the lamp 32. Since a fluorescent lamp acts as an antenna at high frequencies, the lamp current frequency is limited to about 100
10 kHz in order to prevent emission of excessive EMI radiation from the lamp. Typically, gas discharge lamps are operated at a frequency of 50 kHz.

The conventional ballast system described above has at least one major shortcoming. Namely, the switching frequency of the DC-AC inverter are limited by the above-stated constraint on the lamp current frequency. This limitation on the switching
15 frequency of the DC-AC inverter requires that magnetic components (e.g, inductors and isolation transformer), and other reactive elements (e.g., capacitors) be designed for < 50-100 kHz frequency, thereby imposing an unduly high lower limit on the size and weight of such components, thus unduly limiting the achievable miniaturization of the ballast system.

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The invention aims to provide an electronic ballast system for a lamp comprising a DC-AC converter which overcomes the above-described major shortcoming of conventional ballast systems.

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A ballast system as described in the opening paragraph is therefore according to the invention characterized in that the DC-AC converter comprises

means I for generating a first high frequency voltage with frequency f out of said substantially constant DC voltage, comprising first switching means and control circuitry
30 for generating a first control signal for switching said first switching means at frequency f ;
a high frequency transformer comprising a primary winding, coupled to the means I, and a secondary winding;

means II for generating a second high frequency voltage comprising second switching means coupled to said secondary winding;

control circuitry for generating a second control signal for switching said second switching means at frequency f and for controlling and modulating a phase shift between said first control signal and said second control signal at the frequency of said AC output current, and

5 a junction node at which said second high frequency voltage is present during operation, and

demodulating means coupled to said junction node for generating said AC output current out of said second high frequency voltage.

Since the frequency of the the lamp current through a lamp operated by a ballast system according to the present invention is equal to the modulation frequency and is not determined by the frequency f , this frequency f can have a relatively high value. Because of this relatively high switching frequency f , a significant reduction in size and weight of reactive components comprised in the DC-AC converter can be realized.

The frequency of said AC output current is preferably in the order of 10 kHz.

Preferably said first switching means comprises a first pair of switches and said second switching means comprises a second pair of switches. Very good results have been obtained with such a ballast system, wherein the DC-AC converter comprises first and second rails between which said substantially constant DC voltage is present during operation;

20 a first switch and a second switch connected in series between said first and second rails forming the first switching means;

a first capacitor and a second capacitor connected in series between said first and second rails, in parallel with said first pair of switches, and

25 wherein said primary winding has first and second terminals, and said secondary winding has first and second terminals, and a center tap;

a third switch connected between said first terminal of said secondary winding and a junction node, and a fourth switch connected between said second terminal of said secondary winding and said junction node, said third and fourth switches forming the second pair of switches, and

30 wherein said demodulating means comprises an inductor connected between said junction node and a first output node, and a capacitor connected between said first output node and a second output node, said inductor and capacitor forming an L-C low-pass filter;

wherein said first terminal of said primary winding is connected to first node

intermediate said first and second switches, said second terminal of said primary winding is connected to a second node intermediate said first and second capacitors, and said center tap of said secondary winding is connected to said second output node; and,

wherein said first control signal during operation switches said first pair of
5 switches in opposite phase at frequency f , and said second control signal switches said second pair of switches in opposite phase at frequency f , with said first and second pairs of switches being switched at a controlled phase shift with respect to each other.

The demodulating means preferably comprise inductive means and capacitive means.

10 Good results have been obtained in case the frequency f was chosen at least ten times the frequency of said AC output current and preferably higher than 1 MHz.

In a ballast system according to the present invention the lamp current can be controlled during operation in case the ballast system comprises

means for generating a lamp current feedback signal;

15 means for adjusting the phase shift between the first and second control signal in dependency of the current feedback signal in a manner to regulate the lamp current.

In order to ignite the lamp it is advantageous if said control circuitry modulates the phase shift between the first control signal and the second control signal at a lamp ignition frequency for ignition of the lamp, and after ignition modulates the phase shift
20 between the first control signal and the second control signal at the frequency of said AC output current.

In case the ballast system is powered from a DC-supply, such as a battery, the rectifier can be dispensed with. Depending on the amplitude of the DC voltage supplied by the DC-supply, the DC-DC converter can also be dispensed with.

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These and various other features and advantages of the present invention will be readily understood with reference to the following detailed description taken in conjunction with the accompanying drawings, in which:

30 Fig. 1 is a block diagram of a conventional electronic ballast system;

Fig. 2 is a block diagram of an electronic ballast system which constitutes a preferred embodiment of the present invention;

Fig. 3 is a schematic diagram of the high-frequency transformer linked DC-AC converter of the ballast system of the preferred embodiment of the present invention

depicted in Fig. 2;

Fig. 4 is a diagram of the operating waveforms of the high-frequency transformer linked DC-AC converter depicted in Fig. 3;

Fig. 5 is a diagram depicting the relationship between the duty ratio and
5 output voltage of the high-frequency transformer linked DC-AC converter depicted in Fig. 3;
and,

Fig. 6 is a diagram depicting the gain of the L-C filter of the ballast system of the present invention depicted in Fig. 3 as a function of frequency.

10

With reference now to Fig. 2, there can be seen a block diagram of an electronic ballast system 40 which constitutes a presently preferred embodiment of the present invention. In overview, the ballast system 40 of the present invention includes the same elements as the conventional ballast system 20 depicted in Fig. 1, except that the
15 standard DC-AC inverter 30 used in the conventional ballast is replaced with a high-frequency (HF) transformer-linked DC-AC converter 42. The operation of the HF transformer-linked DC-AC converter 42 is controlled by the control circuit B to generate a well-regulated, high-frequency (e.g., 25-50 kHz) sinusoidal (AC) current for driving the lamp 32. The HF transformer-linked DC-AC converter 42 is similar to the converter
20 disclosed in U.S. Patent Number 3,517,300, issued to W. McMurray, and the converter disclosed in an article by K. Harada, H. Sakamoto, and M. Shoyama, entitled "Phase-Controlled DC-AC Converter with High-Frequency Switching", *IEEE Transactions on Power Electronics*, Vol. 3, No. 4, October 1988. However, the HF transformer-linked DC-AC converter 42 disclosed in both of these references is configured and controlled in such a
25 manner as to generate low-frequency (50-60 Hz) output power, and to regulate the output voltage, as opposed to the output current. In this regard, the McMurray converter is just used as an inverter, and the Harada et al. converter is used in an uninterruptible power supply (UPS) system. As such, these references do not suggest a converter having a configuration suitable for use in an electronic lamp ballast.

30

With reference now to Fig. 3, the HF transformer-linked DC-AC converter 42 of the preferred embodiment of the present invention is configured as follows. A first pair of switches Q1 and Q2 are connected in series between terminals 44 and 46. A pair of capacitors 48, 50 are connected in series between the terminals 44 and 46, in parallel with the first pair of switches Q1, Q2. A first terminal 52 of the primary winding 54 of a

transformer T is connected to a node A intermediate the first and second switches Q1 and Q2, and a second terminal 56 of the primary winding 54 of the transformer T is connected to a node B intermediate the capacitors 48 and 50. A switch Q3 is connected between a first terminal 58 of the secondary winding 62 of the transformer T and a node F, and a switch Q4 is connected between a second terminal 60 of the secondary winding 62 and the node F. The secondary winding 62 of the transformer T is center-tapped, with the center tap 64 being connected to a first output terminal 76. The switches Q3 and Q4 constitute a second pair of switches. The transformer T preferably has a turns ratio of $N1:N2:N3 = N:1:1$. Of course, the particular value for N which is selected will depend upon the desired voltage transformation. An inductor L is connected between the node F and a second output terminal 74, and a capacitor C is connected between the first output terminal 74 and the second output terminal 76. The inductor L and capacitor C constitute a low-pass filter.

The operation of the ballast system 40 of the present invention will now be described. More particularly, as with the conventional ballast system, the AC power (e.g., 50 or 60 Hz) from the utility line is rectified by the rectifier 26, e.g., a half-bridge or full-bridge rectifier, which produces a pulsating DC output. The pulsating DC output from the rectifier 26 is smoothed out by the PFC converter 28, which, under the control of the control circuit A, produces a smooth (constant) DC output with highly attenuated (i.e., low percent) ripple.

With additional reference now to Fig. 4, the HF transformer-linked DC-AC converter 42, under the control of the control circuit B, generates a well-regulated, high-frequency (e.g., 25-50 kHz) sinusoidal (AC) current for driving the lamp 32. More particularly, the first pair of switches Q1 and Q2 are alternately turned on and off, in complementary fashion, i.e., in opposite phase, and the second pair of switches Q3 and Q4 are also turned on and off in opposite phase. Each of the switches Q1-Q4 is operated at a duty ratio of 50% (0.5). The first pair of switches Q1 and Q2 and the second pair of switches Q3 and Q4 are switched at a selected phase shift with respect to each other, i.e., the switching phase between the two pairs of switches is shifted. When the switches Q1 and Q3 are turned on, or the switches Q2 and Q4 are turned on, a positive voltage V_i/N appears at the node F. When the switches Q1 and Q4 are turned on, or the switches Q2 and Q3 are turned on, a negative voltage $-V_i/N$ appears at the node F. The ratio of the period DTs when the switches Q1 and Q3 are turned on (or the switches Q2 and Q4 are turned on), to the switching period T_s , is hereby defined as the "phase-shift duty ratio D", as illustrated in Fig. 4. (The voltage at node F is referred to as " V_f "). The voltage V_f is filtered by the L-C low-

pass filter (L,C) to produce a DC output voltage V_o at the output terminal. The value of the output voltage V_o is determined by the following equation (1):

$$(1) \quad V_o (\text{DC}) = (2D-1)V_i/N.$$

In order to convert the output voltage V_o from a DC voltage to a sinusoidal (AC) voltage for powering the lamp 32, the control circuit B functions in a manner explained hereinafter to sinusoidally modulate the phase-shift duty ratio D at a frequency which is lower than the cut-off frequency (f_{co}) of the L-C filter. The value of the modulated phase-shift duty ratio D is determined by the following equation (2):

$$(2) \quad D = D_m \sin (wt) + 0.5,$$

where D_m is the maximum duty ratio.

The value of the resultant sinusoidal output voltage V_o (AC) is determined by the following equation (3):

$$(3) \quad V_o (\text{AC}) = (2D_m V_i/N) \sin (wt).$$

Fig. 5 illustrates the relationship between the phase-shift duty ratio D and the output voltage V_o .

The control circuit B operates in the following manner. More particularly, the control circuit B produces control signals for switching the switches Q1-Q4 on and off in the above-described manner at a very high switching frequency, e.g., > 1 MHz. A partial waveform of one of these control signals, labelled "B", is shown in Fig. 2. The phase-shift duty ratio D of these control signals is modulated by the control circuit B in accordance with a reference signal F_{ref} generated by a reference signal generating circuit 68. The frequency of the reference signal F_{ref} is the same as the desired lamp current frequency, e.g., 25 kHz. The control circuit B compares a lamp current feedback signal i with the reference signal F_{ref} and, in response to any detected frequency/phase/amplitude error therebetween, adjusts the phase shift duty ratio D of the control signals in a manner to correct the error. By thus modulating the phase-shift duty ratio D of the switches Q1-Q4, a well-regulated output current is produced at the desired operating frequency for the lamp 32.

In accordance with another aspect of the present invention, for ignition of the lamp 32, the frequency of the reference signal F_{ref} is preferably set at a frequency close to the cut-off frequency f_{co} (e.g., 250 kHz) of the L-C filter, and the phase-shift duty ratio D of the switches Q1-Q4 is preferably modulated at a frequency close to the cut-off frequency f_{co} of the L-C filter. Under these conditions, due to the resonance characteristics of the L-C filter, a high voltage is produced at the output terminals 74 and 76 to ignite the lamp 32. By monitoring the lamp current feedback signal i , the control circuit B can detect

when lamp ignition occurs. When the control circuit B detects that lamp ignition has occurred, the frequency of the reference signal f_{ref} is set to a lower frequency to modulate the phase-shift duty ratio D of the switches Q1-Q4, and thereby produce a sinusoidal lamp current having a lower frequency (e.g., 25 kHz), for steady-state operation of the lamp 32.

5 This aspect of the present invention is graphically depicted in Fig. 6, which illustrates the gain of the L-C circuit as a function of frequency, and particularly, at an exemplary lamp ignition modulation frequency (250 kHz), at an exemplary steady-state modulation frequency (25 kHz), and at an exemplary switching frequency (2.5 MHz) of the DC-AC converter 42.

With reference again to Fig. 4, an alternative technique for igniting the
10 lamp 32 will now be described. More particularly, for lamp ignition purposes, the switches Q1-Q4 can be switched on and off at a lamp ignition switching frequency (e.g., 125 kHz) equal to one-half the cut-off frequency f_{co} (e.g., 250 kHz) of the L-C filter, while maintaining the phase-shift duty ratio D fixed at 50%. As can be seen in Fig. 4, using this lamp ignition technique, the voltage V_f across the node F is a square-wave voltage at twice
15 the lamp ignition switching frequency, i.e., at $2 \times (1/2 f_{co}) = f_{co}$. Under these conditions, due to the resonance characteristics of the L-C filter, a high voltage is produced at the output terminals 74 and 76 to ignite the lamp 32. When the control circuit B detects that lamp ignition has occurred, the switching frequency of the DC-AC converter 42 is set to a higher frequency (e.g., 2.5 MHz) well above the cut-off frequency f_{co} of the L-C filter, and the
20 phase-shift duty ratio D of the switches Q1-Q4 is modulated at a lower frequency (e.g., 25 kHz), to thereby produce a sinusoidal lamp current having a lower frequency (e.g., 25 kHz), for steady-state operation of the lamp 32.

Since the switching frequency of the DC-AC converter 42 can be much higher than the lamp current frequency without increasing the EMI radiation from the lamp
25 32, the size of the transformer T and L-C low pass filter can be designed for very high frequency operation, thus greatly reducing the size and weight of these components. In general, the switching frequency of the DC-AC converter 42 should be significantly higher than both the cut-off frequency f_{co} of the L-C filter and the duty ratio modulation frequency, whereby the output voltage V_o can be derived like a buck-type converter.

30 As will be readily appreciated by those skilled in the art, the switches Q1-Q4 are preferably solid state switches, e.g., metal-oxide-semiconductor field effect transistor (MOSFET) switches, and the control circuit B is preferably a solid state electronic control circuit. Further, because the lamp current is bi-directional, the switches Q3 and Q4 should also be directional, e.g., each of the switches Q3 and Q4 can be implemented with a pair of

diode quads in combination with a MOSFET. Additionally, if the magnetizing inductance of the transformer T is sufficiently reduced (and thus, the magnetizing current sufficiently increased), the DC-AC converter 42 can be designed to be operated with zero-voltage-switching in order to reduce switching losses and switching noise. In this connection, zero-
5 voltage-switching can be realized by providing a short time interval ("dead time") during which both the switches Q1 and Q2 are turned off. Other techniques, including soft-switching, can also be employed in order to improve the efficacy of the ballast system.

CLAIMS:

1. A ballast system for operating a lamp, comprising
a rectifier for rectifying AC input power to thereby produce a pulsating DC
current;
a DC-DC converter for converting said pulsating DC current into a substantially
5 constant DC voltage;
a DC-AC converter for converting said substantially constant DC voltage into
an AC output current for driving the lamp,
characterized in that the DC-AC converter comprises
means I for generating a first high frequency voltage with frequency f out of
10 said substantially constant DC voltage, comprising first switching means and control circuitry
for generating a first control signal for switching said first switching means at frequency f ;
a high frequency transformer comprising a primary winding, coupled to the
means I, and a secondary winding;
means II for generating a second high frequency voltage comprising
15 second switching means coupled to said secondary winding;
control circuitry for generating a second control signal for switching said
second switching means at frequency f and for controlling and modulating a phase shift
between said first control signal and said second control signal at the frequency of said AC
output current, and
20 a junction node at which said second high frequency voltage is present during
operation, and
demodulating means coupled to said junction node for generating said AC
output current out of said second high frequency voltage.
2. A ballast system as claimed in claim 1, wherein the frequency of said AC
25 output current is in the order of 10 kHz.
3. A ballast system as claimed in claim 1 or 2, wherein said first switching
means comprises a first pair of switches and said second switching means comprises a second
pair of switches.
4. A ballast system as claimed in claim 1, 2 or 3, wherein said demodulating

means comprise inductive means and capacitive means.

5. A ballast system as claimed in one or more of the previous claims, wherein the frequency f is at least ten times the frequency of said AC output current.

6. A ballast system as claimed in one or more of the previous claims,

5 wherein frequency f is higher than 1 MHz.

7. A ballast system as claimed in one or more of the previous claims, wherein the ballast system further comprises

means for generating a lamp current feedback signal;

means for adjusting the phase shift between the first and second control signal

10 in dependency of the current feedback signal in a manner to regulate the lamp current.

8. The ballast system as claimed in claim 3, wherein the DC-AC converter comprises

first and second rails between which said substantially constant DC voltage is present during operation;

5 a first switch and a second switch connected in series between said first and second rails forming the first switching means;

a first capacitor and a second capacitor connected in series between said first and second rails, in parallel with said first pair of switches, and

10 wherein said primary winding has first and second terminals, and said secondary winding has first and second terminals, and a center tap;

a third switch connected between said first terminal of said secondary winding and a junction node, and a fourth switch connected between said second terminal of said secondary winding and said junction node, said third and fourth switches forming the second pair of switches, and

15 wherein said demodulating means comprises an inductor connected between said junction node and a first output node, and a capacitor connected between said first output node and a second output node, said inductor and capacitor forming an L-C low-pass filter;

20 wherein said first terminal of said primary winding is connected to first node intermediate said first and second switches, said second terminal of said primary winding is connected to a second node intermediate said first and second capacitors, and said center tap of said secondary winding is connected to said second output node; and,

wherein said first control signal during operation switches said first pair of switches in opposite phase at frequency f , and said second control signal switches said second pair of switches in opposite phase at frequency f , with said first and second pairs of

- 25 switches being switched at a controlled phase shift with respect to each other.
9. The ballast system as claimed in one or more of the previous claims, wherein said control circuitry modulates the phase shift between the first control signal and the second control signal at a lamp ignition frequency for ignition of the lamp, and after
- 30 signal at the frequency of said AC output current.

2/4

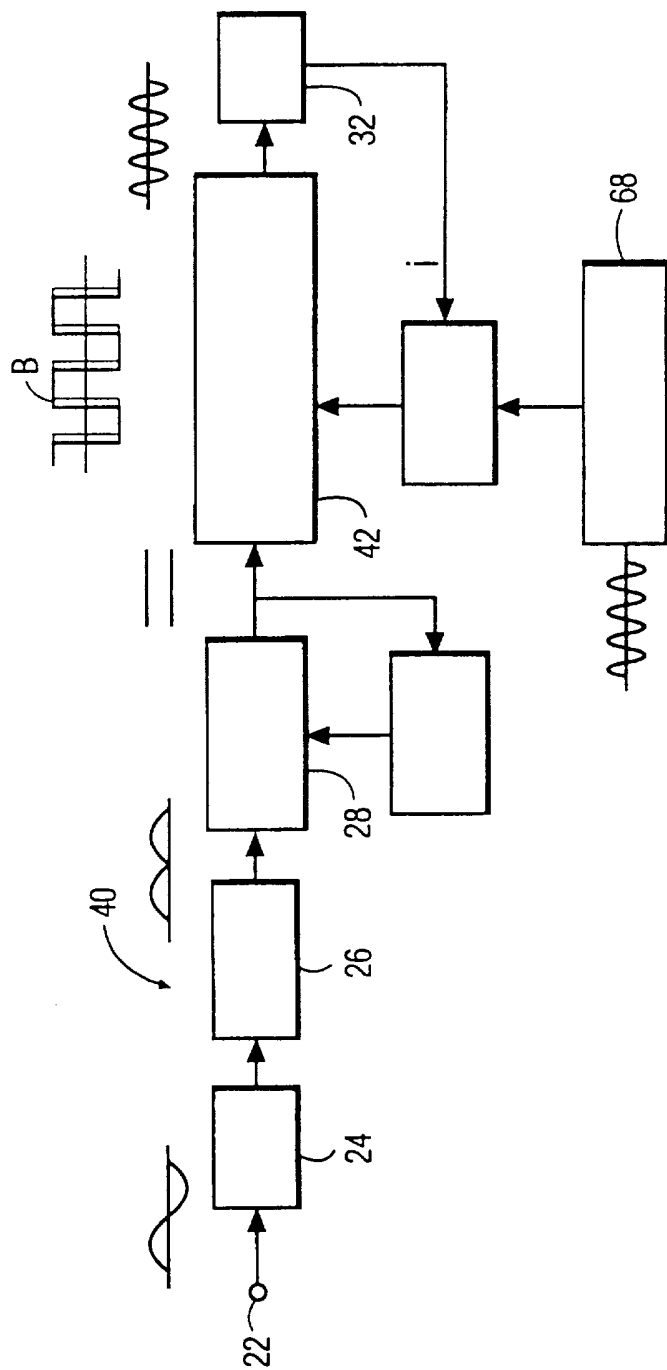


FIG. 2

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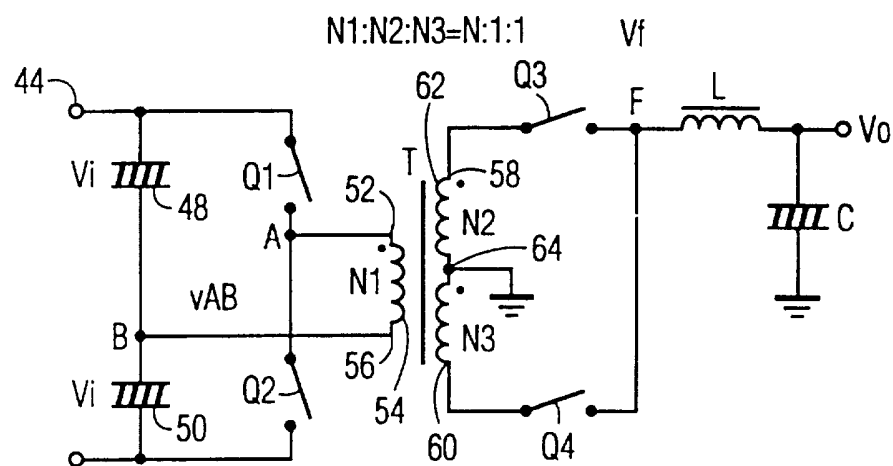


FIG. 3

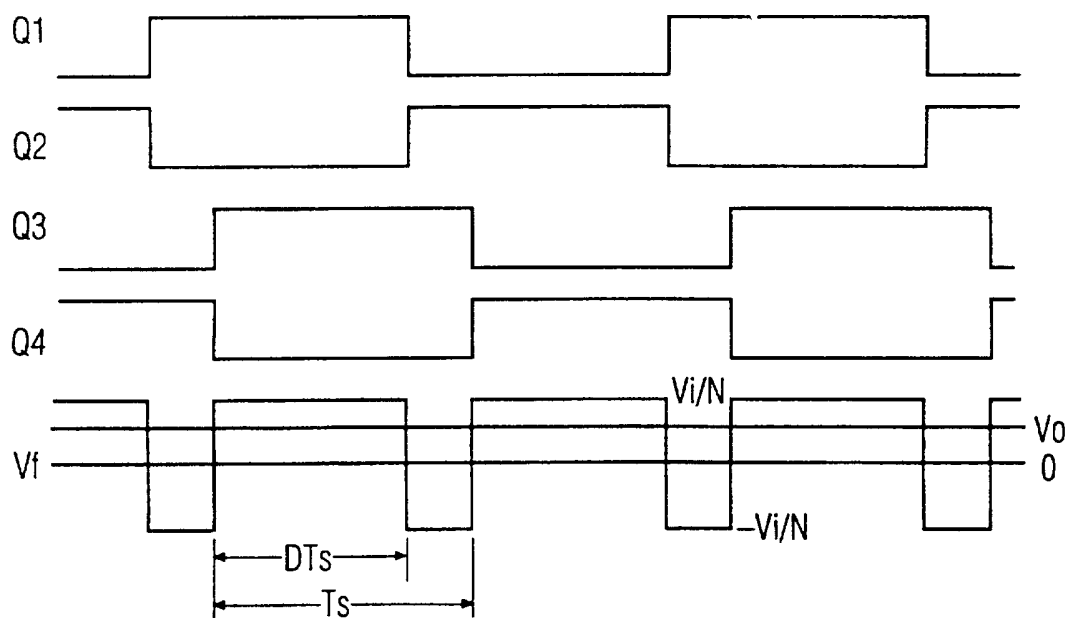


FIG. 4

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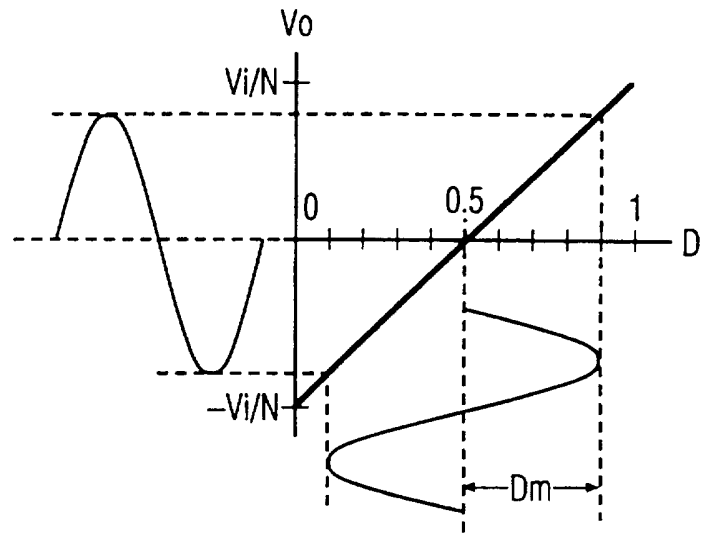


FIG. 5

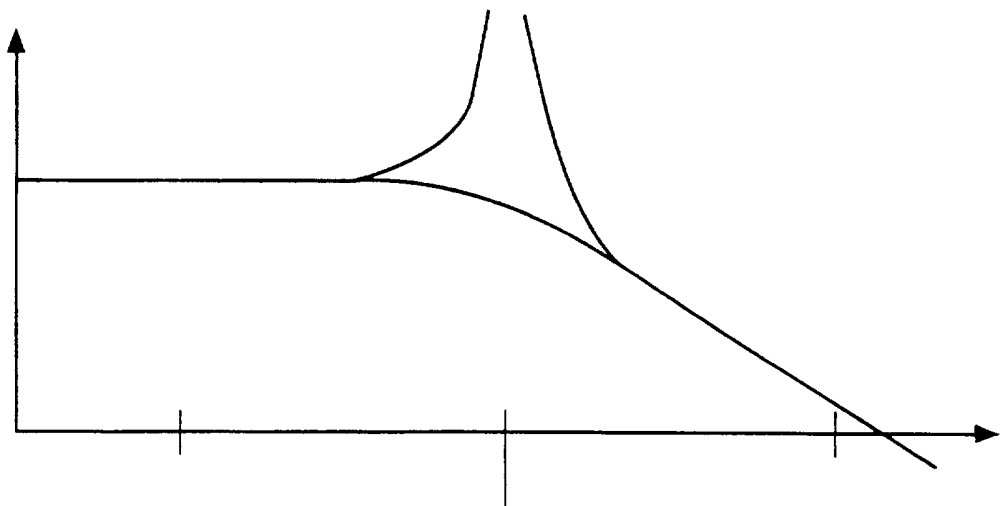


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 96/01244

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H05B 41/29

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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IPC6: H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5371440 A (R. LIU ET AL.), 6 December 1994 (06.12.94), see the whole document --	1-9
A	US 5150014 A (L. KASTELEIN), 22 Sept 1992 (22.09.92), figures 1,2, abstract --	1-9
A	US 5175474 A (T. KAKITANI ET AL.), 29 December 1992 (29.12.92), figure 3, abstract -- -----	1-9

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	5371440	A	06/12/94	NONE	
US	5150014	A	22/09/92	EP 0439861 A	07/08/91
				JP 4212296 A	03/08/92
				NL 9000202 A	16/08/91
US	5175474	A	29/12/92	CA 2052443 A	27/03/92
				DE 69108163 D,T	06/07/95
				EP 0478306 A,B	01/04/92
				JP 4138066 A	12/05/92
				KR 9409518 B	14/10/94