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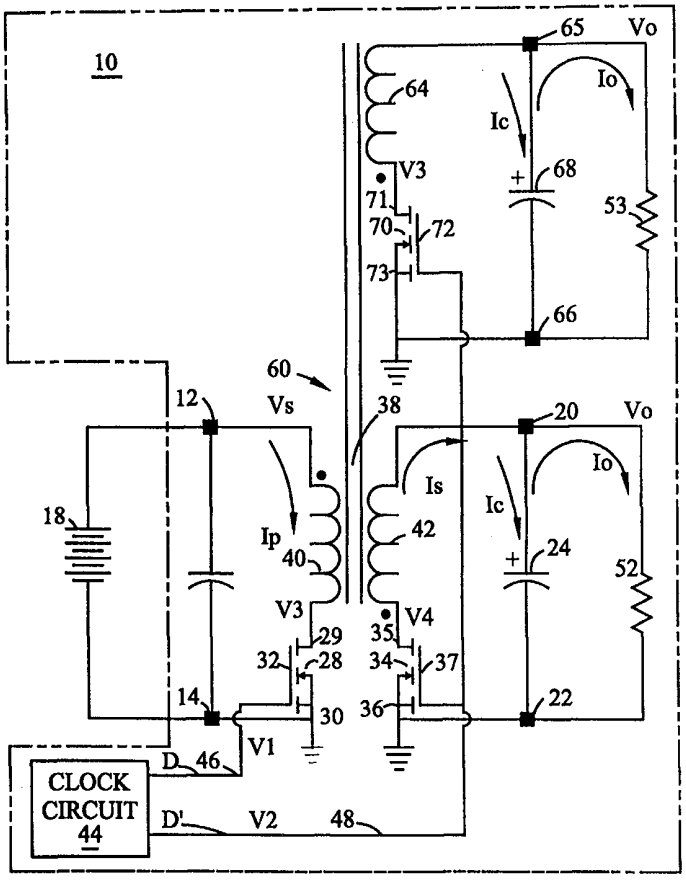
(54) Title: A BI-DIRECTIONAL DC-TO-DC POWER CONVERTER

(57) Abstract

A multi-output, multi-directional power converter (10) has an input bi-directional switch (30) and at least a first output bi-directional switch (36), a coupled inductor (38) having an input winding (40) and at least one output winding (42). The coupled inductor input winding (40) is connected in series with the input voltage source (18) and an input bi-directional switch (28). Each coupled inductor output winding is connected in series with a corresponding output voltage source such as a capacitor (24) and its respective output bi-directional switch (34). A clock circuit (44) provides a first and second control signal V1, V2. In an alternative embodiment, a resonant transition control means (204, 206) senses the coupled inductor (170) input and output winding currents and the output voltage Vo and adjusts the clock frequency to provide operation in a resonant transition mode.



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INTERNATIONAL SEARCH REPORT

In ional Application No
PCT/US 99/16951

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02M3/335 H02J7/02

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02M

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 3 986 097 A (WOODS GORDON DOUGLAS) 12 October 1976 (1976-10-12) column 1, line 45 - line 62; figure 1 column 2, line 47 -column 4, line 6	1-4 5
Y	US 5 594 629 A (STEIGERWALD ROBERT L) 14 January 1997 (1997-01-14) column 2, line 40 -column 3, line 39; figures 1,2	5
A	PATENT ABSTRACTS OF JAPAN vol. 013, no. 450 (E-830), 11 October 1989 (1989-10-11) & JP 01 174265 A (MITSUBISHI ELECTRIC CORP), 10 July 1989 (1989-07-10) abstract	1-4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 1999	09/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	GENTILI, L

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/16951

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-5

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 99/16951

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-5

   A bidirectional power converter using field effect transistors as input and output bidirectional switches

2. Claim : 6

   A bidirectional power converter with a control circuit comprising a clock, a latch, output voltage and input current sensing means, and means for setting and resetting the latch.

3. Claim : 7

   A bidirectional power converter with means for adjusting the clock frequency and provide operation in a resonant transition mode

4. Claims: 8-21

   A bidirectional power converter comprising first and second output bidirectional switch, a coupled inductor with at least two output windings, each output winding being coupled in series with a corresponding output voltage source and a respective bidirectional switch conduction channel, one of such output voltage sources comprising a capacitor or a battery.

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No
PCT/US 99/16951

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3986097 A	12-10-1976	NONE	
US 5594629 A	14-01-1997	NONE	
JP 01174265 A	10-07-1989	NONE	