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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
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Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: HYSTERETIC CURRENT MODE CONTROLLER FOR A BIDIRECTIONAL CONVERTER WITH LOSSLESS INDUCTOR CURRENT SENSING

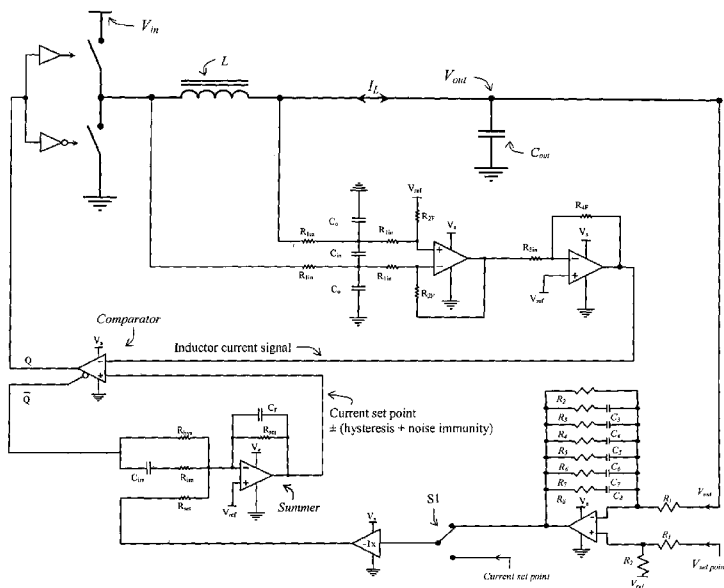


Figure 12. Hysteretic current mode controlled bidirectional converter

(57) Abstract: A system and circuit for achieving bidirectional hysteretic current mode control of a converter. The system comprises a summer that provides a constant hysteresis and has added switching noise immunity, a comparator, a lossless inductor current sense means and a converter. A circuit using the inductors internal resistance for sensing the current through an inductor in a lossless manner is described. The circuit preserves both DC and dynamic current information while incorporating the RC time constant, difference amplifier and signal amplification, all using only one amplifier. This circuit provides excellent common mode and differential noise immunity, while still having a high bandwidth and small group delay of the current signal. A method to accomplish stability of a current mode controlled converter when closing the loop to control the output voltage with very high accuracy and gain is described.

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Published:

- *with international search report (Art. 21(3))*
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INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER IPC: G01R 19/00 (2006.01); H02M 3/158 (2006.01) 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) G01R, 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 practicable, search terms used) WPI, EPODOC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DALLAGO, E. et al. "Lossless Current Sensing in Low-Voltage High-Current DC/DC Modular Supplies", IEEE Transactions on Industrial Electronics, December 2000 (12.2000), Vol.47, No.6, pages 1249-1252, ISSN 0278-0046, XP011023747 section III.	1-8
A	US 6356461 B1 (JACOBS, M.E.) 12 March 2002 (12.03.2002) abstract, figs. 2, 3.	1-8
A	SIMÓN-MUELA, A. et al. "Practical Implementation of a High-Frequency Current-Sense Technique for VRM", IEEE Transactions on Industrial Electronics, September 2008 (09.2008), Vol.55, No.9, pages 3221-3230, ISSN 0278-0046, XP011229651 sections I, II, IV.	1-8
A	WO 2008094232 A1 (LINEAR TECHNOLOGY CORPORATION) 07 August 2008 (07.08.2008) abstract, figs. 7, 10.	1-8
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.		<input checked="" type="checkbox"/> See patent family annex.
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance		"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
"E" earlier application or patent but published on or after the international filing date		"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		"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
"O" document referring to an oral disclosure, use, exhibition or other means		"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed		
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C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009146643 A1 (OSTROM, K.A. et al.) 11 June 2009 (11.06.2009) abstract, figs. 2, 3, 5.	1-8
A	US 2004004470 A1 (YOSHIDA, S. et al.) 08 January 2004 (08.01.2004) abstract, fig. 4.	1-8
A	US 2007035281 A1 (KUROIWA, H. et al.) 15 February 2007 (15.02.2007) abstract, figs. 1, 11.	1-8
A	WO 2006112991 A2 (RAYTHEON COMPANY) 26 October 2006 (26.10.2006) abstract, figs. 1-3.	1-8

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 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 No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

Group I: Claims 1 and 2

Group I invention is directed to a lossless inductor current sensing and signal amplification circuit. The said circuit comprises the technical features as defined in the subject matter of claims 1 and 2. The particular circuit for which protection is sought is shown in Fig. 2.

Group II: Claims 3 to 6

Group II invention is directed to a system for achieving bidirectional hysteretic current mode control with constant hysteresis. The said system comprises the technical features as defined in the subject matter of claims 3 and 4. The configuration of the particular system for which protection is sought is shown in Fig. 5.

It is considered that the features introduced in claims 5 and 6 are not related to a further additional invention. Accordingly, the special technical features introduced in dependent claims 5 and 6 are considered to be related to further implementation specific details of the technical feature "summer", which has already been defined in the subject matter of independent claim 3, wherein the said technical feature "summer" is preferably implemented as a summer circuit with added switching noise immunity. The specific configuration of the said summer circuit is shown in Fig. 6.

Furthermore, it is perceived that the subject matter of independent claim 3 refers to the technical feature of "a means to measure the current in said inductor", however, no further indication is given in the subject matter of said independent claim 3 that said technical feature "a means to measure the current in said inductor" is identical to the lossless inductor current sensing and signal amplification circuit according to the subject matter of independent claim 1.

Consequently, it is considered that said generic technical feature "a means to measure the current in said inductor" may be represented by any known technical solution being applicable for measuring current in an inductor and is not particularly restricted to the single proposed solution according to Group I invention to measure current in an inductor according to the subject matter of independent claim 1.

Group III: Claims 7 and 8

Although the subject matter of independent claim 7 has been drafted to be of the method category, it is considered that the subject matter of independent claim 7 is of an apparatus category. This is true, because there are only technical features contained in the subject matter of said independent claim 7 which are straightforwardly directed to a current mode controlled converter being specifically configured to attain stability when closing the loop to control the output voltage when using a very high gain.

Consequently, Group III invention is directed to a current mode controlled converter. The said current mode controlled converter comprises the technical features as defined in the subject matter of claims 7 and 8. The configuration of the said current mode controlled converter is shown in Fig. 10 and Fig. 12, respectively.

As the special technical feature common to Group I invention is neither present in Group II invention nor in Group III invention and the special technical feature common to Group II invention is neither present in Group I invention nor in Group III invention and the special technical feature common to Group III invention is neither present in Group I invention nor in Group II invention it is considered that the group of inventions are not so linked as to form a single general inventive concept and, therefore, the requirement of unity of invention is not met.

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 additional fees, this Authority did not invite payment of additional fees.

INTERNATIONAL SEARCH REPORT

International application No.

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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 only those claims for which fees were paid, specifically claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT / ZA 2012/000006

Patent document cited in search report			Patent family member(s)			Publication date
US	B1	6356461	US	B1	6356461	2002-03-12
WO	A1	2008094232	EP	A1	2123122	2009-11-25
			US	A1	2008180075	2008-07-31
			WO	A1	2008094232	2008-08-07
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			US	A1	2004004470	2004-01-08
			JP	A	2004064994	2004-02-26
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WO	A2	2006112991	EP	A2	1889135	2008-02-20
			US	A1	2006232226	2006-10-19
			IL	A	184486	2010-12-30
			WO	A2	2006112991	2006-10-26
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			JP	A	2007049845	2007-02-22