



- (51) International Patent Classification:
H02M 7/48 (2007.01) *H02M 1/44* (2007.01)
- (21) International Application Number:
PCT/US2012/028829
- (22) International Filing Date:
12 March 2012 (12.03.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/451,823 11 March 2011 (11.03.2011) US
- (71) Applicant (for all designated States except US): **UTAH STATE UNIVERSITY RESEARCH FOUNDATION** [US/US]; 1695 Research Park Way, North Logan, Utah 84341 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **SEALY, Kyle Devro** [US/US]; 646 South 600 East, River Heights, Utah 84321 (US). **SHARP, Bryan Thomas** [US/US]; 1644 Ensign Court, Cottonwood Heights, Utah 84121 (US). **WU, Hunter** [NZ/US]; 700 North 1200 East, Bullen Hall, Room 209, Logan, US 84322 (US). **GILCHRIST, Aaron** [US/US]; 1174 East 1900 North, Logan, Utah 84341 (US).
- (74) Agent: **KARREN, J. Scott**; Holland & Hart LLP, P.O. Box 11583, 222 S. Main Street, Suite 2200, Salt Lake City, Utah 84110 (US).
- (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.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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))

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
- with information concerning authorization of rectification of an obvious mistake under Rule 91.3 (b) (Rule 48.2(i))

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR CONTROLLING LCL CONVERTERS USING ASYMMETRIC VOLTAGE CANCELLATION TECHNIQUES

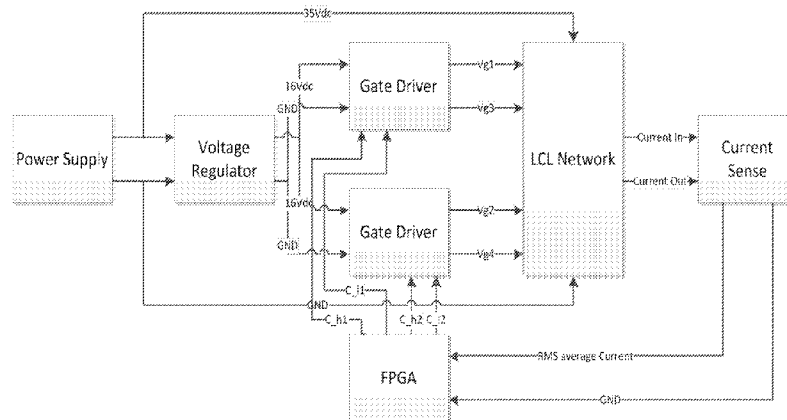


Fig. 37

(57) Abstract: A method and apparatus for LCL resonant converter control utilizing Asymmetric Voltage Cancellation is described. The methods to determine the optimal trajectory of the control variables are discussed. Practical implementations of sensing load parameters are included. Simple PI, PID and fuzzy logic controllers are included with AVC for achieving good transient response characteristics with output current regulation.

WO 2012/125590 A3



(88) Date of publication of the international search report:
27 December 2012

Previous Correction:
see Notice of 8 November 2012

(15) Information about Correction:

A. CLASSIFICATION OF SUBJECT MATTER***H02M 7/48(2007.01)i, H02M 1/44(2007.01)i***

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)

H02M 7/48; H02M 3/335; G05F 5/00; G05F 1/00; G01R 1/02; G05F 1/56

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: "converter", "inverter", "resonant", "AVC(asymmetric voltage cancellation)", "harmonic distortion", "trajectory", "LCL(inductor capacitor inductor)", "impedance"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4661897 A (Allied Corp) 28 Apr. 1987 see the abstract, claims 1-15, and figures 1-14	1-20
A	US 2008-0203992 A1 (Jaber Abu Qahouq et. al) 28 Aug. 2008 see the abstract, claims 1-25, and figures 1-7	1-20
A	US 2009-0267582 A1 (Exar Corp) 29 Oct. 2009 see the abstract, claims 1-22, and figures 1-14	1-20
A	US 6448745 B1 (Dialog Semiconductor GmbH) 10 Sep. 2002 see the abstract, claims 1-25, and figures 1-7	1-20
A	US 7148669 B2 (The Regents of the University of Colorado) 12 Dec. 2006 see the abstract, claims 1-20, and figures 1-14	1-20

 Further documents are listed in the continuation of Box C. 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

23 OCTOBER 2012 (23.10.2012)

Date of mailing of the international search report

24 OCTOBER 2012 (24.10.2012)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan
City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

BAE, Jin Yong

Telephone No. 82-42-481-8503



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/028829

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4661897 A	28.04.1987	US 4641232 A US 4661897 A	03.02.1987 28.04.1987
US 2008-0203992 A1	28.08.2008	CN 101252311 A CN 101252311 C TW 200900896 A US 2010-0117616 A1 US 7652459 B2 US 8026706 B2	27.08.2008 27.08.2008 01.01.2009 13.05.2010 26.01.2010 27.09.2011
US 2009-0267582 A1	29.10.2009	CN 102016742 A EP 2279468 A1 US 8085024 B2 WO 2009-134661 A1	13.04.2011 02.02.2011 27.12.2011 05.11.2009
US 6448745 B1	10.09.2002	None	
US 7148669 B2	12.12.2006	US 2005-168198 A1	04.08.2005