AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT for the District of Delaware
PLAINTIFF Tigo Energy Inc.		DEFENDANT SMA Solar Technology America LLC

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,823,218	Sept. 2, 2014	Tigo Energy Inc.
2	8,933,321	Jan. 13, 2015	Tigo Energy Inc.
3	9,584,021	Feb. 28, 2017	Tigo Energy Inc.
4	9,966,848	May 8, 2018	Tigo Energy Inc.
5	10,256,770	Apr. 9, 2019	Tigo Energy Inc.
6	10,333,405	Jun. 25, 2019	Tigo Energy Inc.

In the above---entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above---entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1---Upon initiation of action, mail this copy to Director Copy 3---Upon termination of action, mail this copy to Director
Copy 2---Upon filing document adding patent(s), mail this copy to Director Copy 4---Case file copy

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/822,227	02/28/2017	9584021	108144-201502/US (TGY015)	4926

64494 7590 02/08/2017

GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 1 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Mordechay AVRUTSKY, Alfei Menashe, ISRAEL;
Tigo Energy, Inc., Los Gatos, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

OK TO ENTER: /J.A.G/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Mordechay Avrutsky	Examiner:	Jeffrey Gblende
Serial No.:	14/822,227	Group Art Unit:	2838
Filed:	August 10, 2015	Confirmation:	4926
Title:	Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module		

AMENDMENT UNDER 37 CFR 1.312

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Please kindly enter the following amendments and consider the following remarks/arguments:

Amendments to the Claims are reflected in the list of claims that begins on page 2 of this paper;

Remarks/Arguments begin on page 7 of this paper.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)	4926

64494 7590 02/03/2017

GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

EXAMINER	
GBLENDE, JEFFREY A	

ART UNIT	PAPER NUMBER
2838	

NOTIFICATION DATE	DELIVERY MODE
02/03/2017	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

gtipmail@gtlaw.com
clairt@gtlaw.com
rupickd@gtlaw.com

Response to Rule 312 Communication	Application No.	Applicant(s)
	14/822,227	AVRUTSKY, MORDECHAY
	Examiner	Art Unit
	JEFFREY GBLENDE	2838

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address –

1. ☒ The amendment filed on *28 December 2016* under 37 CFR 1.312 has been considered, and has been:

a) ☒ entered.

b) ☐ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.

Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.

/JEFFREY GBLENDE/
Primary Examiner, Art Unit 2838

PART B – FEE(S) TRANSMITTAL

Complete and send this form, together with the applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22314-1450
or Fax **(571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note Use Block 1 for any change of address)

64494
GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago IL 60601

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Junchao Zhang	(Depositor's Name)
/Junchao Zhang/	(S-signature)
December 28, 2016	(Date)

APPLICATION NO	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO	CONFIRMATION NO
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)	4926

TITLE OF INVENTION:

APPLN: TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	Small	$480	$0	$0	$480	02/21/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS

1. Change of correspondence address or indication of "Fee Address" (37CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered attorney or agent. If no name is listed, no name will be printed

1. Greenberg Traurig, LLP
2.
3.

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)
PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

1a. NAME OF ASSIGNEE: TIGO ENERGY, INC.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): LOS GATOS, CA

Please check the appropriate assignee categories (will not be printed on the patent): ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☑ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies

4b. Payment of Fees(s): **(Please first reapply and previously paid fee shown above)**
☐ A check is enclosed
☐ Payment be credit card. Form PTO-2038 is attached
☑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-2638 (enclose an extra copy of this form)

5. Change of Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /John P. Ward/ Date December 28, 2016

Typed or printed name John P. Ward Registration No. 40,216

SMA Solar Technology America, LLC, Ex. 1006

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Mordechay Avrutsky	Examiner:	Jeffrey Gblende
Serial No.:	14/822,227	Group Art Unit:	2838
Filed:	August 10, 2015	Confirmation:	4926
Title:	Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module		

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Applicant respectfully provides the following comments on the Statement of Reasons for Allowance that was provided in the Notice of Allowability mailed in the subject application.

Applicant assumes that the claims are to be interpreted based on the features recited in the claims rather than any paraphrases provided in the Statement of Reasons for Allowance, and the Statement of Reasons for Allowance is to be taken in light of the exact features recited in the claims. The claims should not be interpreted to include the features that are not explicitly recited in the claims. Any paraphrases in the Statement of Reasons for Allowance should not be used in a way to narrow the scope of the claims.

Respectfully submitted,

Date: December 28, 2016

/John P. Ward/

John P. Ward
Reg. No. 40,216

GREENBERG TRAURIG, LLP
CUSTOMER NUMBER **64494**
Phone: (650) 328-8500
Fax: (650) 328-8508

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Mordechay Avrutsky	Examiner:	Jeffrey Gblende
Serial No.:	14/822,227	Group Art Unit:	2838
Filed:	August 10, 2015	Confirmation:	4926
Title:	Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module		

AMENDMENT UNDER 37 CFR 1.312

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Please kindly enter the following amendments and consider the following remarks/arguments:

Amendments to the Claims are reflected in the list of claims that begins on page 2 of this paper;

Remarks/Arguments begin on page 7 of this paper.

CLAIMS

1. (Original) A method to supply power, the method comprising:

providing a power supply having a first stage and a second stage, wherein the first stage converts power from a direct current input into a first output, and the second stage powered by the first output has a second output for a micro-controller;

connecting the first output of the first stage to a switchable load to consume at least a portion of the first output while disabling the second stage in supplying the second output to the micro-controller;

determining whether the first output from the first stage powering the switchable load is above a threshold during a time period in which the second output to the micro-controller is disabled; and

in response to a determination that the first output from the first stage powering the switchable load is above the threshold during the time period in which the second output to the micro-controller is disabled,

disconnecting the switchable load from the first output of the first stage; and

instructing the second stage to enable the second output to the micro-controller using power from the first output of the first stage.

2. (Original) The method of claim 1, wherein the switchable load comprises:

a resistive device; and

a switching device connected to the resistive device, wherein the switching device is configured to be turned on to be connected to the first output to consume the portion of the first output and turned off to be disconnected from the first stage.

3. (Original) The method of claim 2, wherein the disconnecting of the switchable load from the first output of the first stage comprises sending a first signal to the switching device to turn off the switching device.

4. (Original) The method of claim 3, further comprising:

generating the first signal based on the determining of whether the first output from the first stage powering the switchable load is above the threshold; and

delaying the first signal to generate a second signal to the second stage, the second signal enabling the second output to the micro-controller.

5. (Original) The method of claim 4, further comprising:
providing a control circuit comprising:
a hysteresis amplifier configured to receive the first output of the first stage and generate the first signal; and
a delay circuit to generate the second signal according to the first signal.

6. (Original) The method of claim 3, wherein the switching device includes one of: a field effect transistor (FET), a metal-oxide-semiconductor field-effect-transistor (MOSFET), and a bipolar junction transistor.

7. (Original) The method of claim 6, wherein when the switch device is turned on, the switchable load and an input of the second stage are connected in parallel to the first output of the first stage.

8. (Original) The method of claim 1, wherein the first stage comprises a first step-down converter; and the second stage comprises a second step-down converter.

9. (Original) The method of claim 1, wherein the disconnecting is performed prior to the instructing of the second stage to enable the second output to the micro-controller.

10. (Original) A system to supply power, the system comprising:
a power source to provide a direct current input;
a first stage power converter configured to convert the direct current input into a first output;
a second stage power converter configured to be powered by the first output to generate a second output;
a micro-controller powered by the second output;
a switchable load; and
a control circuit powered by the first output and configured to
connect the first output to the switchable load to consume at least a portion of the first output while disabling the second stage power converter in supplying

the second output to the micro-controller;

determine whether a voltage of the first output powering the switchable load is above a threshold during a time period in which the second output to the micro-controller is disabled; and

in response to the voltage being above the threshold during the time period in which the second output to the micro-controller is disabled, disconnect the switchable load from the first output of the first stage power converter and signal the second stage power converter to enable the second output to the micro-controller using power from the first output of the first stage power converter.

11. (Original) The system of claim 10, wherein the control circuit comprising:

a hysteresis amplifier configured to receive the first output and generate a first control signal for the switchable load; and

a delay circuit to generate a second control signal for the second stage power converter by delaying the first signal.

12. (Original) The system of claim 11, wherein in response to the voltage going above the threshold:

the first control signal causes the switchable load to be disconnected from the first output of the first stage power converter; and

the second control signal causes the second stage power converter to enable the second output to the micro-controller.

13. (Original) The system of claim 12, wherein the micro-controller is configured to maximize power generated by the power source.

14. (Original) The system of claim 13, wherein the power source comprises a photovoltaic panel; the first stage power converter comprises a first step-down converter; and the second stage power converter comprises a second step-down converter.

15. (Original) The system of claim 12, wherein the switchable load comprises:

a resistive device; and

a switching device connected to the resistive device, wherein the switching device is configured to be turned on to be connected to the first output to consume the portion of the first output and turned off to be disconnected from the first stage, and

wherein the first control signal is connected to control the switching device.

16. (Original) The system of claim 15, wherein the switching device includes one of: a field effect transistor (FET), a metal-oxide-semiconductor field-effect-transistor (MOSFET), and a bipolar junction transistor.

17. (Original) The system of claim 16, wherein when the switch device is turned on, the switchable load and an input of the second stage are connected in parallel to the first output of the first stage.

18. (Original) A system to supply power, the system comprising:

a photovoltaic panel to provide a direct current input;

a first stage power converter connected to the photovoltaic panel to generate a first output from the direct current input;

a second stage power converter connected to convert the first output to a second output;

a micro-controller;

a power absorption circuit; and

a control circuit coupled with the first stage power converter and the second stage power converter, the control circuit powered by the first output to control the second stage power converter, wherein

when the second stage power converter is disabled in providing the second output to the micro-controller, the control circuit monitors a voltage of the first output powering the power absorption circuit and signals the second stage power converter to continue disabling the providing of the second output to the micro-controller during a time period in which the voltage is below a threshold;

when the voltage is above the threshold, the control circuit signals the second stage power converter to enable the providing of the second output to the

micro-controller.

19. (Original) The system of claim 18, wherein the power absorption circuit includes a capacitor coupled to the first output; and the threshold allows the capacitor to power the second stage to operate the micro-controller for a predetermined period of time even without the output of the first stage.

20. (Currently Amended) The system of claim 18, wherein the power absorption circuit comprises a switchable load; and the control circuit signals the switchable load to be in a first state to consume a portion of the first output when the voltage is below the threshold and to be in a second state not to consume a portion of the first output when the voltage is above the threshold.

REMARKS

The above amendments correct informalities and typographical errors in the claims. No new matter is added.

Authorization is hereby provided to charge any fees which may be required for the present filing, or credit any overpayment, to Deposit Account No. 50-2638.

Respectfully submitted,

Date: December 28, 2016

/Lehua Wang/
Lehua Wang
Reg. No. 48,023

GREENBERG TRAURIG, LLP
CUSTOMER NUMBER **64494**
Phone: (650) 328-8500
Fax: (650) 328-8508

Electronic Patent Application Fee Transmittal

Application Number:	14822227
Filing Date:	10-Aug-2015
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	Mordechay AVRUTSKY
Filer:	John Patrick Ward/Junchao Zhang
Attorney Docket Number:	108144-201502/US (TGY015)

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	480	480

SMA Solar Technology America, LLC, Ex. 1006

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**480**

SMA Solar Technology America, LLC, Ex. 1006

Electronic Acknowledgement Receipt

EFS ID:	27922432
Application Number:	14822227
International Application Number:	
Confirmation Number:	4926
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	Mordechay AVRUTSKY
Customer Number:	64494
Filer:	John Patrick Ward/Junchao Zhang
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-201502/US (TGY015)
Receipt Date:	28-DEC-2016
Filing Date:	10-AUG-2015
Time Stamp:	20:03:05
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$480
RAM confirmation Number	122916INTEFSW00007906502638
Deposit Account	502638
Authorized User	YIJIE SHEN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

SMA Solar Technology America, LLC, Ex. 1006

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	108144-201502_IssueFee.PDF	155332 fd9ecea0efe4de97617446911ccbf861b919d5d5	no	2
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	108144-201502_CommentsonStatement.pdf	75314 bd8a953d46e3261b697144142d627dca92ce6cb6	no	1
Warnings:					
Information:					
3		108144-201502_312Amendment.pdf	92638 5dff7ef90fdfa43a8bfbddc6320010c486cbdb23	yes	7

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment after Notice of Allowance (Rule 312)	1	1
Claims	2	6
Applicant Arguments/Remarks Made in an Amendment	7	7

Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30689 fdd591ece1ab3ab0ae3e329ad547bfa8a27eb042	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	353973		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

64494 7590 11/18/2016

GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

EXAMINER	
GBLENDE, JEFFREY A	
ART UNIT	PAPER NUMBER
2838	

DATE MAILED: 11/18/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)	4926

TITLE OF INVENTION: SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	02/21/2017

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

64494 7590 11/18/2016
GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)	4926

TITLE OF INVENTION: SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	02/21/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
GBLENDE, JEFFREY A	2838	323-282000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

SMA Solar Technology America, LLC, Ex. 1006

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)	4926

64494 7590 11/18/2016

GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

EXAMINER	
GBLENDE, JEFFREY A	
ART UNIT	**PAPER NUMBER**
2838	

DATE MAILED: 11/18/2016

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

SMA Solar Technology America, LLC, Ex. 1006

Notice of Allowability	Application No. 14/822,227	Applicant(s) AVRUTSKY, MORDECHAY	
	Examiner JEFFREY GBLENDE	Art Unit 2838	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the application filed on 8/10/2015* .
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-20*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☒ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/JEFFREY GBLENDE/
Primary Examiner, Art Unit 2838

Examiner's Comment

Allowable Subject Matter

1. Claims 1-20 are allowed.

2. The following is an examiner's statement of reasons for allowance:

Regarding claim 1, the prior art fails to teach or disclose a method to supply power, the method comprising: connecting the first output of the first stage to a switchable load to consume at least a portion of the first output while disabling the second stage in supplying the second output to the micro-controller; determining whether the first output from the first stage powering the switchable load is above a threshold during a time period in which the second output to the micro-controller is disabled; and in response to a determination that the first output from the first stage powering the switchable load is above the threshold during the time period in which the second output to the micro-controller is disabled, disconnecting the switchable load from the first output of the first stage; and instructing the second stage to enable the second output to the micro-controller using power from the first output of the first stage.

Regarding claim 10, the prior art fails to teach or disclose a system to supply power, the system comprising: a control circuit powered by the first output and configured to connect the first output to the switchable load to consume at least a portion of the first output while disabling the second stage power converter in supplying the second output to the micro-controller; determine whether a voltage of the first output powering the switchable load is above a threshold during a time period in which the

second output to the micro-controller is disabled; and in response to the voltage being above the threshold during the time period in which the second output to the micro-controller is disabled, disconnect the switchable load from the first output of the first stage power converter and signal the second stage power converter to enable the second output to the micro-controller using power from the first output of the first stage power converter.

Regarding claim 18, the prior art fails to teach or disclose a control circuit coupled with the first stage power converter and the second stage power converter, the control circuit powered by the first output to control the second stage power converter, wherein when the second stage power converter is disabled in providing the second output to the micro-controller, the control circuit monitors a voltage of the first output powering the power absorption circuit and signals the second stage power converter to continue disabling the providing of the second output to the micro-controller during a time period in which the voltage is below a threshold; when the voltage is above the threshold, the control circuit signals the second stage power converter to enable the providing of the second output to the micro-controller.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

Conclusion

3. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure:

Bandholz et al. (US 2010/0117614) discloses tuning a switching power supply comprising a switchable load.

Forman et al. (US 2006/0176031) discloses a dual output switching regulator and a method of operation.

Zanchi et al. (US 2011/0148388) discloses a radiation tolerant circuit comprising a flying capacitor circuit.

Negoi (US 2008/0100233) disclose an apparatus comprising a charge pump and flying capacitor circuit.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JEFFREY GBLENDE whose telephone number is (571)270-5472. The examiner can normally be reached on Monday - Friday 8:00am - 5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Monica Lewis can be reached on 571-272-1838. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status

information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JEFFREY GBLENDE/
Primary Examiner, Art Unit 2838

Notice of References Cited	Application/Control No. 14/822,227	Applicant(s)/Patent Under Reexamination AVRUTSKY, MORDECHAY	
	Examiner JEFFREY GBLENDE	Art Unit 2838	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2010/0117614 A1	05-2010	Bandholz; Justin P.	H02M3/156	323/283
*	B	US-2006/0176031 A1	08-2006	Forman; Dustin D.	H02M3/158	323/267
*	C	US-2011/0148388 A1	06-2011	Zanchi; Alfio	G11C27/024	323/313
*	D	US-2008/0100233 A1	05-2008	Negoi; Andy C.	H02M3/07	315/299
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 4926

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/822,227	08/10/2015	323	2838	108144-201502/US (TGY015)

APPLICANTS
Tigo Energy, Inc., Los Gatos, CA;

INVENTORS
Mordechay AVRUTSKY, Alfei Menashe, ISRAEL;

**** CONTINUING DATA ***************************
This application is a CON of 12/787,205 05/25/2010 PAT 9143036
which claims benefit of 61/275,734 09/02/2009
and claims benefit of 61/336,743 01/26/2010

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
08/21/2015

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /JEFFREY A GBLENDE/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		ISRAEL	6	20	3

ADDRESS

GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601
UNITED STATES

TITLE

SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

FILING FEE RECEIVED		
800	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14822227	AVRUTSKY, MORDECHAY
	Examiner	Art Unit
	JEFFREY GBLENDE	2838

CPC- SEARCHED		
Symbol	Date	Examiner
See attached EAST search history	11/7/2016	JG

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor name search	11/7/2016	JG
See attached EAST search history	11/7/2016	JG

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	Interference search history attached	11/7/2016	JG

	/J.G./ Primary Examiner.Art Unit 2838

Page 32 of 219 SMA Solar Technology America, LLC, Ex. 1006

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4719553		1988-01-12	Hinckley	
	2	5235266		1993-08-10	Schaffrin	
	3	5268832		1993-12-07	Kandatsu	
	4	5604430		1997-02-18	Decker, et al.	
	5	5903138		1999-05-11	Hwang, et al.	
	6	5923158		1999-07-13	Kurokami, et al.	
	7	6275016		2001-08-14	Ivanov	
	8	6448489		2002-09-10	Kimura, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	9	6650031		2003-11-18	Goldack	
	10	6844739		2005-01-18	Kasai, et al.	
	11	6894911		2005-05-17	Telefus, et al.	
	12	6984970		2006-01-10	Capel	
	13	7061214		2006-06-13	Mayega, et al.	
	14	7202653		2007-04-10	Pai	
	15	7248946		2007-07-24	Bashaw, et al.	
	16	7256566		2007-08-14	Bhavaraju, et al.	
	17	7276886		2007-10-02	Kinder, et al.	
	18	7518346		2009-04-14	Prexl, et al.	
	19	7560915		2009-07-14	Ito, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	20	7595616		2009-09-29	Prexl, et al.	
	21	7605498		2009-10-20	Ledenev, et al.	
	22	7719140		2010-05-18	Ledenev, et al.	
	23	7821281		2010-10-26	Chen	
	24	8004866		2011-08-23	Bucella, et al.	
	25	9143036		2015-09-22	Avrutsky	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050017701		2005-01-27	Hsu, Chih-Yuan	
	2	20050040800		2005-02-24	Sutardja, Sehat	
	3	20050057214		2005-03-17	Matan, Stefan	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	4	20050057215		2005-03-17	Matan, Stefan	
	5	20060001406		2006-01-05	Matan; Stefan	
	6	20060174939		2006-08-10	Matan; Stefan	
	7	20060185727		2006-08-24	Matan; Stefan	
	8	20070001653		2007-01-04	Xu; Peng	
	9	20070273351		2007-11-29	Matan; Stefan	
	10	20070278861		2007-12-06	Chih-Hong Lou, et al.	
	11	20080121272		2008-05-29	David A. Besser, et al.	
	12	20080122449		2008-05-29	David A. Besser, et al.	
	13	20080122518		2008-05-29	David A. Besser, et al.	
	14	20080179949		2008-07-31	David A. Besser, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	15	20080191560		2008-08-14	David A. Besser, et al.	
	16	20080191675		2008-08-14	David A. Besser, et al.	
	17	20080303503		2008-12-11	Wolfs; Peter	
	18	20100013452		2010-01-21	BENJAMIM TANG, et al.	
	19	20110031946		2011-02-10	Patrick K. Egan, et al.	
	20	20110050190		2011-03-03	AVRUTSKY; Mordechay	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2005262278	AU		2005-07-12	Central Queensland University et al.		☐
	2	19961705	DE		2001-07-05	SMA Regelsysteme GmbH		☐
	3	4232356	DE		1994-03-31	Inst Solare Energieversorgungs		☐

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(**Not for submission under 37 CFR 1.99)**

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	4	1388774	EP		2004-02-11	CIT Alcatel		☐
	5	2249147	ES		2006-03-16	Fundacion Robotiker		☐
	6	2003012569	WO		2003-02-13	Stichting Energie et al.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	ALONSO, R. et al., "A New Distributed Converter Interface for PV Panels," 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, pp. 2288-2291, June 6-10, 2005.	☐
	2	ALONSO, R. et al., "Experimental Results of Intelligent PV Module for Grid-Connected PV Systems," 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, pp. 2297-2300, September 4-8, 2006.	☐
	3	BASSO, Tim, "IEEE Standard for Interrconnecting Distributed Resources With the Electric Power System," IEEE PES Meeting, June 9, 2004.	☐
	4	Boostbuck.com, "The Four Boostbuck Topologies," located at http://www.boostbuck.com/TheFourTopologies.html, 2003.	☐
	5	ENSLIN, Johan H.R., et al., "Integrated Photovoltaic Maximum Power Point Tracking Converter," IEEE Transactions on Industrial Electronics, Vol. 44, No. 6, pp. 769-773, December 1997.	☐
	6	GAUTAM, Nalin K. et al., "An Efficient Algorithm to Simulate the Electrical Performance of Solar Photovoltaic Arrays," Energy, Vol. 27, No. 4, pp. 347-361, 2002.	☐

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(**Not for submission under 37 CFR 1.99)**

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

	7	International Patent Application No. PCT/US2010/046272, International Search Report and Written Opinion, March 31, 2011.	☐
	8	LINARES, Leonor et al., "Improved Energy Capture in Series String Photovoltaics via Smart Distributed Power Electronics," 24th Annual IEEE Applied Power Electronics Conference and Exposition, pp. 904-910, February 15, 2009.	☐
	9	NORDMANN, T. et al., "Performance of PV Systems Under Real Conditions," European Workshop on Life Cycle Analysis and Recycling of Solar Modules, The "Waste" Challenge, Brussels, Belgium, March 18-19, 2004.	☐
	10	PALMA, L. et al., "A Modular Fuel Cell, Modular DC-DC Converter Concept for High Performance and Enhanced Reliability," 38th IEEE Power Electronics Specialists Conference (PESC'07), pp. 2633-2638, June 17, 2007.	☐
	11	QUASCHNING, V. et al., "Cost Effectiveness of Shadow Tolerant Photovoltaic Systems," Euronsun 96, pp. 819-824, September 16, 1996.	☐
	12	ROMAN, Eduardo, et al., "Intelligent PV Module for Grid-Connectred PV Systems," IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, pp. 1066-1073, August 2006.	☐
	13	URIARTE, S. et al., "Energy Integrated Management System for PV Applications," 20th European Photovoltaic Solar Energy Conference, June 6, 2005.	☐
	14	WALKER, G. R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," 33rd IEEE Power Electronics Specialists Conference (PESC'02), Vol. 1, pp. 24-29, 2002.	☐
	15	WALKER, Geoffrey R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," IEEE Transactions on Power Electronics, Vol. 19, No. 4, pp. 1130-1139, July 2004.	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/JEFFREY A GBLENDE/	Date Considered	11/07/2016

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Meng Sui/	Date (YYYY-MM-DD)	2015-12-01
Name/Print	Meng Sui	Registration Number	62633

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.A.G/

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	45	("20050017701" | "20050040800" | "20050057214" | "20050057215" | "20060001406" | "20060174939" | "20060185727" | "20070001653" | "20070273351" | "20070278861" | "20080121272" | "20080122449" | "20080122518" | "20080179949" | "20080191560" | "20080191675" | "20080303503" | "20100013452" | "20110031946" | "20110050190" | "4719553" | "5235266" | "5268832" | "5604430" | "5903138" | "5923158" | "6275016" | "6448489" | "6650031" | "6844739" | "6894911" | "6984970" | "7061214" | "7202653" | "7248946" | "7256566" | "7276886" | "7518346" | "7560915" | "7595616" | "7605498" | "7719140" | "7821281" | "8004866" | "9143036").PN.	US-PGPUB; USPAT	OR	OFF	2016/11/03 17:03
S2	8	(("7202653") or ("20050040800")).PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:35
S3	2861	mppt near2 track$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:39
S4	71591	(G05F1/00| G05F1/10| G05F1/12| G05F1/46| G05F1/455| G05F1/445| H02M5/2573| G05F1/66| H02M1/081| H02M5/293| H02M7/12| H05B39/048| B23K11/24| G05F1/40| G05F1/42| G05F1/462| G05F1/52| G05F1/56| H02M3/10| H02M3/125| H02M3/13| H02M3/135| H02M3/145| H02M3/15| H02M3/155| G05F1/563| G05F1/61| G05F1/614| H02M2001/0045| H02M2001/007| G05F1/575| G05F1/465| G05F1/468| H02M3/156| H02M3/158| H02M3/1588| H02M2003/1566| H02M3/1582| H02M2003/1557| H04B2215/069).CLAS,CCLS,CPC,CPCL.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:43
S5	56286	(H02M3/07| H02M3/073| H02M7/10| H02M7/103| H02M7/106| H02M3/1582| H02M3/1584| H02M3/285| H02M3/33561| H02M7/49| H02J3/46|	US-PGPUB; USPAT; USOCR; FPRS;	OR	OFF	2016/11/03 18:44

		H02J3/38| H02M7/06| H02M7/153| H02M1/088| H02M7/19| H02M7/08| H02M7/17| H02M2001/007| H02M7/493| H02M7/53806| H02M7/5381).CLAS,CCLS,CPC,CPCL.	EPO; JPO; DERWENT; IBM_TDB			
S6	36	(("AVRUTSKY") near3 ("Mordechay")).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2016/11/03 18:44
S7	861970	first near2 (stage or phase or converter or regulator)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:49
S8	727991	second near2 (stage or phase or converter or regulator)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:50
S9	6233	((switch$1able$1 near load) or (switch$4 near3 series near3 load))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:50
S10	48	S7 same S8 same S9	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:51
S11	380	(S7 same S8) and S9	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:52
S12	332	S11 not S10	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 18:52
S13	594	(S4 or S5) and S9	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:07
S14	724	(switch$1able$1 near load)	US-PGPUB; USPAT; USOCR; FPRS;	OR	OFF	2016/11/03 19:07

			EPO; JPO; DERWENT; IBM_TDB			
S15	25	(S4 or S5) and S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:07
S16	48478	(switch$4 near load)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:10
S17	2872	(S4 or S5) and S16	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:10
S18	2645	(switch$4 near2 series near2 load)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:11
S19	273	(S4 or S5) and S18	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/03 19:11
S20	1155	(switch$1able$1 near2 load)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:00
S21	71591	(G05F1/00| G05F1/10| G05F1/12| G05F1/46| G05F1/455| G05F1/445| H02M5/2573| G05F1/66| H02M1/081| H02M5/293| H02M7/12| H05B39/048| B23K11/24| G05F1/40| G05F1/42| G05F1/462| G05F1/52| G05F1/56| H02M3/10| H02M3/125| H02M3/13| H02M3/135| H02M3/145| H02M3/15| H02M3/155| G05F1/563| G05F1/61| G05F1/614| H02M2001/0045| H02M2001/007| G05F1/575| G05F1/465| G05F1/468| H02M3/156| H02M3/158| H02M3/1588| H02M2003/1566| H02M3/1582| H02M2003/1557| H04B2215/069).CLAS,CCLS,CPC,CPCL.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:01
S22	56286	(H02M3/07| H02M3/073| H02M7/10|	US-PGPUB;	OR	OFF	2016/11/04

		H02M7/103| H02M7/106| H02M3/1582| H02M3/1584| H02M3/285| H02M3/33561| H02M7/49| H02J3/46| H02J3/38| H02M7/06| H02M7/153| H02M1/088| H02M7/19| H02M7/08| H02M7/17| H02M2001/007| H02M7/493| H02M7/53806| H02M7/5381).CLAS,CCLS,CPC,CPCL.	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			09:01
S23	59	(S21 or S22) and S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:01
S24	9175	load near2 dump$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:47
S25	126	(S21 or S22) and S24	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:47
S26	848632	(connect$4 or coupl$4) near3 capacit$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:58
S27	861970	first near2 (stage or phase or converter or regulator)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:59
S28	727991	second near2 (stage or phase or converter or regulator)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:59
S29	12073	S27 same S28 same S26	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 09:59
S30	46003	(dis$1connect$4 or de$1coupl$4) near3 capacit$4	US-PGPUB; USPAT; USOCR; FPRS;	OR	OFF	2016/11/04 10:00

			EPO; JPO; DERWENT; IBM_TDB			
S31	74831	(dis$1connect$4 or remov$4) near3 capacit$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 10:00
S32	465	S27 same S28 same S31	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 10:01
S33	2749	flying near capacit$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 10:16
S34	217	S27 same S28 same S33	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2016/11/04 10:16

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S35	11285	(G05F1/00| G05F1/10| G05F1/12| G05F1/46| G05F1/455| G05F1/445| H02M5/2573| G05F1/66| H02M1/081| H02M5/293| H02M7/12| H05B39/048| B23K11/24| G05F1/40| G05F1/42| G05F1/462| G05F1/52| G05F1/56| H02M3/10| H02M3/125| H02M3/13| H02M3/135| H02M3/145| H02M3/15| H02M3/155| G05F1/563| G05F1/61| G05F1/614| H02M2001/0045| H02M2001/007| G05F1/575| G05F1/465| G05F1/468| H02M3/156| H02M3/158| H02M3/1588| H02M2003/1566| H02M3/1582| H02M2003/1557| H04B2215/069).CLAS,CCLS,CPC,CPCL.	US-PGPUB	OR	OFF	2016/11/04 10:37
S36	7985	(H02M3/07| H02M3/073| H02M7/10| H02M7/103| H02M7/106| H02M3/1582| H02M3/1584| H02M3/285| H02M3/33561| H02M7/49| H02J3/46| H02J3/38| H02M7/06| H02M7/153| H02M1/088| H02M7/19| H02M7/08| H02M7/17| H02M2001/007| H02M7/493| H02M7/53806| H02M7/5381).CLAS,CCLS,CPC,CPCL.	US-PGPUB	OR	OFF	2016/11/04 10:37
S37	252757	first near2 (stage or phase or converter or	US-	OR	OFF	2016/11/04

		regulator)	PGPUB			10:38
S38	214379	second near2 (stage or phase or converter or regulator)	US-PGPUB	OR	OFF	2016/11/04 10:38
S39	1183	((switch$1able$1 near load) or (switch$4 near3 series near3 load))	US-PGPUB	OR	OFF	2016/11/04 10:38
S40	4261975	threshold or reference	US-PGPUB	OR	OFF	2016/11/04 10:38
S41	2405289	(comparator or comparing or compared or amplif$5)	US-PGPUB	OR	OFF	2016/11/04 10:38
S42	0	(S37 same S38 same S39 same S40 same S41).clm.	US-PGPUB	OR	OFF	2016/11/04 10:46
S43	1	(S37 same S38 same S39 same S40).clm.	US-PGPUB	OR	OFF	2016/11/04 10:48

11/ 4/ 2016 1:53:12 PM
C:\ Users\ jgblende\ Documents\ EAST\ Workspaces\ 14822227.wsp

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14822227	AVRUTSKY, MORDECHAY
	Examiner	**Art Unit**
	JEFFREY GBLENDE	2838

CPC							
Symbol						**Type**	**Version**
H02M		3	/	158		F	2013-01-01
H02M		3	/	07		I	2013-01-01
H02M		1	/	36		A	2013-01-01
H02M		2001	/	007		A	2013-01-01
H02M		2001	/	008		A	2013-01-01
Y02E		10	/	56		A	2013-01-01
			/				
			/				
			/				
			/				
			/				
			/				
			/				
			/				
			/				

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/JEFFREY GBLENDE/ Primary Examiner.Art Unit 2838	11/07/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	10	3

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14822227	AVRUTSKY, MORDECHAY
	Examiner	**Art Unit**
	JEFFREY GBLENDE	2838

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
		H	0	2	M	3 / 07 (2006.01.01)						
CROSS REFERENCE(S)												
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)											

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/JEFFREY GBLENDE/ Primary Examiner.Art Unit 2838	11/07/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	10	3

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14822227	AVRUTSKY, MORDECHAY
	Examiner	**Art Unit**
	JEFFREY GBLENDE	2838

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE

(Assistant Examiner) (Date)

Total Claims Allowed: 20

/JEFFREY GBLENDE/
Primary Examiner.Art Unit 2838 11/07/2016

(Primary Examiner) (Date)

O.G. Print Claim(s)	O.G. Print Figure
10	3

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)

CONFIRMATION NO. 4926

64494
GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

PUBLICATION NOTICE



Title:SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

Publication No.US-2015-0349644-A1
Publication Date:12/03/2015

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14822227
Filing Date	2015-08-10
First Named Inventor	MORDECHAY AVRUTSKY
Art Unit	2838
Examiner Name	
Attorney Docket Number	108144-201502/US (TGY015)

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4719553		1988-01-12	Hinckley	
	2	5235266		1993-08-10	Schaffrin	
	3	5268832		1993-12-07	Kandatsu	
	4	5604430		1997-02-18	Decker, et al.	
	5	5903138		1999-05-11	Hwang, et al.	
	6	5923158		1999-07-13	Kurokami, et al.	
	7	6275016		2001-08-14	Ivanov	
	8	6448489		2002-09-10	Kimura, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	9	6650031		2003-11-18	Goldack	
	10	6844739		2005-01-18	Kasai, et al.	
	11	6894911		2005-05-17	Telefus, et al.	
	12	6984970		2006-01-10	Capel	
	13	7061214		2006-06-13	Mayega, et al.	
	14	7202653		2007-04-10	Pai	
	15	7248946		2007-07-24	Bashaw, et al.	
	16	7256566		2007-08-14	Bhavaraju, et al.	
	17	7276886		2007-10-02	Kinder, et al.	
	18	7518346		2009-04-14	Prexl, et al.	
	19	7560915		2009-07-14	Ito, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	20	7595616		2009-09-29	Prexl, et al.	
	21	7605498		2009-10-20	Ledenev, et al.	
	22	7719140		2010-05-18	Ledenev, et al.	
	23	7821281		2010-10-26	Chen	
	24	8004866		2011-08-23	Bucella, et al.	
	25	9143036		2015-09-22	Avrutsky	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050017701		2005-01-27	Hsu, Chih-Yuan	
	2	20050040800		2005-02-24	Sutardja, Sehat	
	3	20050057214		2005-03-17	Matan, Stefan	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	4	20050057215		2005-03-17	Matan, Stefan	
	5	20060001406		2006-01-05	Matan; Stefan	
	6	20060174939		2006-08-10	Matan; Stefan	
	7	20060185727		2006-08-24	Matan; Stefan	
	8	20070001653		2007-01-04	Xu; Peng	
	9	20070273351		2007-11-29	Matan; Stefan	
	10	20070278861		2007-12-06	Chih-Hong Lou, et al.	
	11	20080121272		2008-05-29	David A. Besser, et al.	
	12	20080122449		2008-05-29	David A. Besser, et al.	
	13	20080122518		2008-05-29	David A. Besser, et al.	
	14	20080179949		2008-07-31	David A. Besser, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	15	20080191560		2008-08-14	David A. Besser, et al.	
	16	20080191675		2008-08-14	David A. Besser, et al.	
	17	20080303503		2008-12-11	Wolfs; Peter	
	18	20100013452		2010-01-21	BENJAMIM TANG, et al.	
	19	20110031946		2011-02-10	Patrick K. Egan, et al.	
	20	20110050190		2011-03-03	AVRUTSKY; Mordechay	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2005262278	AU		2005-07-12	Central Queensland University et al.		☐
	2	19961705	DE		2001-07-05	SMA Regelsysteme GmbH		☐
	3	4232356	DE		1994-03-31	Inst Solare Energieversorgungs		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	4	1388774	EP		2004-02-11	CIT Alcatel		☐
	5	2249147	ES		2006-03-16	Fundacion Robotiker		☐
	6	2003012569	WO		2003-02-13	Stichting Energie et al.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	ALONSO, R. et al., "A New Distributed Converter Interface for PV Panels," 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, pp. 2288-2291, June 6-10, 2005.	☐
	2	ALONSO, R. et al., "Experimental Results of Intelligent PV Module for Grid-Connected PV Systems," 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, pp. 2297-2300, September 4-8, 2006.	☐
	3	BASSO, Tim, "IEEE Standard for Interrconnecting Distributed Resources With the Electric Power System," IEEE PES Meeting, June 9, 2004.	☐
	4	Boostbuck.com, "The Four Boostbuck Topologies," located at http://www.boostbuck.com/TheFourTopologies.html, 2003.	☐
	5	ENSLIN, Johan H.R., et al., "Integrated Photovoltaic Maximum Power Point Tracking Converter," IEEE Transactions on Industrial Electronics, Vol. 44, No. 6, pp. 769-773, December 1997.	☐
	6	GAUTAM, Nalin K. et al., "An Efficient Algorithm to Simulate the Electrical Performance of Solar Photovoltaic Arrays," Energy, Vol. 27, No. 4, pp. 347-361, 2002.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

	7	International Patent Application No. PCT/US2010/046272, International Search Report and Written Opinion, March 31, 2011.	☐
	8	LINARES, Leonor et al., "Improved Energy Capture in Series String Photovoltaics via Smart Distributed Power Electronics," 24th Annual IEEE Applied Power Electronics Conference and Exposition, pp. 904-910, February 15, 2009.	☐
	9	NORDMANN, T. et al., "Performance of PV Systems Under Real Conditions," European Workshop on Life Cycle Analysis and Recycling of Solar Modules, The "Waste" Challenge, Brussels, Belgium, March 18-19, 2004.	☐
	10	PALMA, L. et al., "A Modular Fuel Cell, Modular DC-DC Converter Concept for High Performance and Enhanced Reliability," 38th IEEE Power Electronics Specialists Conference (PESC'07), pp. 2633-2638, June 17, 2007.	☐
	11	QUASCHNING, V. et al., "Cost Effectiveness of Shadow Tolerant Photovoltaic Systems," Euronsun 96, pp. 819-824, September 16, 1996.	☐
	12	ROMAN, Eduardo, et al., "Intelligent PV Module for Grid-Connectred PV Systems," IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, pp. 1066-1073, August 2006.	☐
	13	URIARTE, S. et al., "Energy Integrated Management System for PV Applications," 20th European Photovoltaic Solar Energy Conference, June 6, 2005.	☐
	14	WALKER, G. R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," 33rd IEEE Power Electronics Specialists Conference (PESC'02), Vol. 1, pp. 24-29, 2002.	☐
	15	WALKER, Geoffrey R. et al., "Cascaded DC-DC Converter Connection of Photovoltaic Modules," IEEE Transactions on Power Electronics, Vol. 19, No. 4, pp. 1130-1139, July 2004.	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	14822227
	Filing Date	2015-08-10
	First Named Inventor	MORDECHAY AVRUTSKY
	Art Unit	2838
	Examiner Name	
	Attorney Docket Number	108144-201502/US (TGY015)

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Meng Sui/	Date (YYYY-MM-DD)	2015-12-01
Name/Print	Meng Sui	Registration Number	62633

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Mordechay Avrutsky	Examiner:	
Serial No.:	14/822,227	Group Art Unit:	2838
Filed:	August 10, 2015	Confirmation:	4926
Title:	Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module		

NOTICE OF RELATED APPLICATIONS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Applicant is hereby providing notice that the subject patent application is related to the following U.S. patent applications. Applicant respectfully requests the Examiner to consider the related applications and the prosecution histories of these related applications, such as the current claims, Office Actions and Notices of Allowance, etc.

1.	Title:	Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module		
	Serial No.:	12/787,205	Filed on:	May 25, 2010
	Inventor(s):	Mordechay AVRUTSKY	Docket No.:	108144-201501/US (TGY015)
	Examiner:	Jeffrey Gblende	Art Unit:	2838
	Patent No.:	9,143,036	Issue Date:	September 22, 2015

Respectfully submitted,

Date: December 1, 2015

/Meng Sui/

Meng Sui
Reg. No. 62,633

GREENBERG TRAURIG, LLP
CUSTOMER NUMBER **64494**
Phone: (650) 328-8500
Fax: (650) 328-8508

(12) STANDARD PATENT (11) Application No. **AU 2005262278 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
A device for distributed maximum power tracking for solar arrays

(51) International Patent Classification(s)
G05F 1/67 (2006.01) ***H02M 3/04*** (2006.01)

(21) Application No: **2005262278** (22) Date of Filing: **2005.07.12**

(87) WIPO No: **WO06/005125**

(30) Priority Data

(31) Number	(32) Date	(33) Country
2004903833	**2004.07.13**	**AU**

(43) Publication Date: **2006.01.19**
(44) Accepted Journal Date: **2009.03.26**

(71) Applicant(s)
Central Queensland University;Queensland State Department of Public Works

(72) Inventor(s)
Wolfs, Peter

(74) Agent / Attorney
Wynnes Patent & Trade Mark Attorneys, Level 3, Waterfront Place 1 Eagle Street, Brisbane, QLD, 4000

(56) Related Art
EP 1388774
US 5604430
WO 2003/012569

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 January 2006 (19.01.2006)

PCT

(10) International Publication Number
WO 2006/005125 A1

(51) International Patent Classification[7]: G05F 1/67, H02M 3/04

(21) International Application Number: PCT/AU2005/001017

(22) International Filing Date: 12 July 2005 (12.07.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2004903833 13 July 2004 (13.07.2004) AU

(71) Applicants *(for all designated States except US)*: **CENTRAL QUEENSLAND UNIVERSITY** [AU/AU]; CQ Mail Centre, Rockhampton, QLD 4702 (AU). **QUEENSLAND STATE DEPARTMENT OF PUBLIC WORKS** [AU/AU]; 80 George Street, Brisbane, QLD 4000 (AU).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **WOLFS, Peter** [AU/AU]; C/- Central Queensland University, CQ Mail Centre, Rockhampton, QLD 4702 (AU).

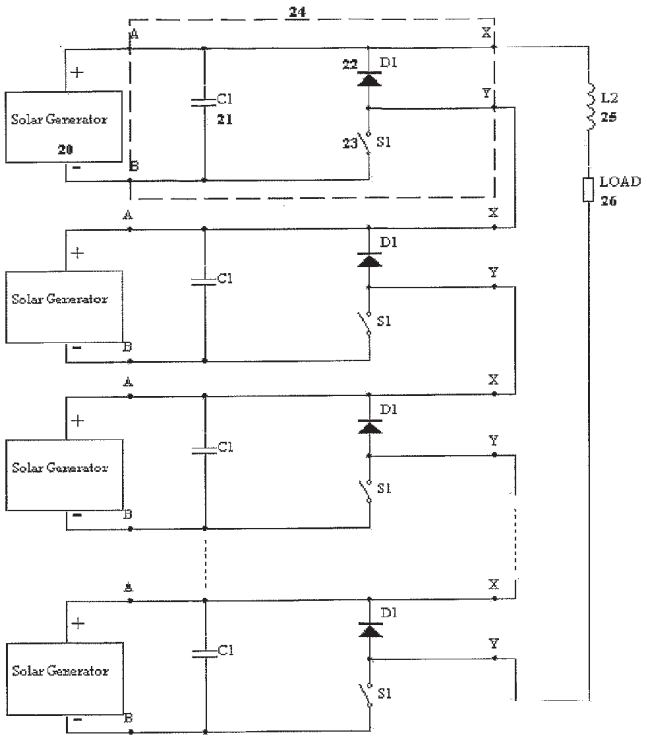
(74) Agent: **WYNNE, Ewen, Cardinal**; Wynnes Patent & Trade Mark Attorneys, Level 3, Waterfront Place, 1 Eagle Street, Brisbane, QLD 4121 (AU).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: A DEVICE FOR DISTRIBUTED MAXIMUM POWER TRACKING FOR SOLAR ARRAYS



(57) Abstract: The present invention is a system for providing power from solar cells whereby each cell or cell array is allowed to produce its maximum available power and converted by an operatively connected DC/DC converter. Each cell or cell array has its own DC/DC converter. In one form the system for providing power from solar cells includes one or more solar generators wherein each of said solar generators has one to nine solar cells; a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other; an inductor operatively connected to the series connected maximum power trackers; and means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

WO 2006/005125 A1

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A DEVICE FOR DISTRIBUTED MAXIMUM POWER TRACKING FOR SOLAR ARRAYS

FIELD OF INVENTION

The present invention relates to solar cell technology and in particular to maximum power tracking converters. The present invention has particular but not exclusive application for use in vehicles that are at least in part electrically powered by solar cells. Reference to solar powered vehicles is by means of example only and the present invention has application in other areas.

BACKGROUND OF THE INVENTION

A solar cell is a device able to convert incident light to electrical power. Many solar cells are typically grouped to form an array of solar cells. To collect the electrical power from the solar cells, groups of cells are either directly connected in series or in parallel. Where the cells are connected in series, they must have identical currents but if the cells are connected in parallel they must operate with identical voltages. An individual cell will produce maximum power at a unique cell voltage and current which will vary from cell to cell. The combination of voltage and current that allows a cell to produce its maximum power is termed the maximum power point. The maximum power point varies with cell illumination and temperature. Connection of the cells in series forces cells to have identical current while connection in parallel forces cells to have identical voltage. Direct connection in series or parallel results in failure to collect all the available electrical power from the solar cells in the array and at least some of the cells will operate at a condition other than at their maximum power points.

To obtain the maximum available power from a group of solar cells connected in an array or sub-array, a maximum power tracking device is used. Maximum power tracking devices are DC to DC power converters that allow an array or sub-array to operate at their maximum power point. A DC to DC converter can transform a power input at a certain voltage and current to be transformed to a DC power output at a differing voltage and current. A key feature of all maximum power trackers is a control device that determines the point of maximum power for the connected solar cells and acts to adjust the DC to DC converter performance to adjust the cell voltage or current to extract the maximum available power.

However there are a number of problems or disadvantages associated with the use of a single maximum power device to control the voltage or current of an array or sub-array of solar cells.

Where solar cells are used to power vehicles, the vehicles are usually aerodynamically designed with curved surfaces and also have limited surface area in which to mount the solar cells. Consequently arrays of cells are mounted on the curved surfaces but the variation of the angle of incidence of light on the different cells within the array on the curved surface causes variation in the available optical power. Furthermore, cells in an array may be subjected to variable light levels due to shadowing by foreign objects such as trees and buildings between the cell and the source of illumination.

Because of differences in optical illumination, cell temperatures may vary within arrays causing some cells to be hotter than other cells. Arrays may be cooled partially by air flow or by the use of a cooling fluid in an illumination concentrator system. These mechanisms however may not provide uniform cooling to all cells.

The available power from each cell within an array will vary due to the variations in illumination and temperature. In these cases, the maximum power conditions of different cells within the array will differ at any one point of time. Furthermore the maximum power conditions of some cells within the array will vary differently over time compared with others. As well these variations are not predictable. In addition changes to the maximum power conditions of cells can vary rapidly thereby requiring a relatively quick response time.

Currently maximum power tracking devices are directly electrically connected to an array of solar cells. A single maximum power tracking device is currently used to control the available power from an array of between ten to several hundred cells.

OBJECT OF THE INVENTION

It is an object of the present invention to provide an alternate maximum power tracking device that overcomes at least in part one or more of the above mentioned problems or disadvantages.

SUMMARY OF THE INVENTION

The present invention arises from the realization that each cell at any one particular time point will have a unique maximum power point defined by a specific cell voltage and specific current at which the cell will produce its maximum available power. Furthermore the invention was developed from the realization that it is not possible for every cell in an array to operate at its maximum power point if the array is formed by the direct electrical interconnection of cells. With this in mind and taking advantage of recent advances in low voltage electronics, maximum power tracking

devices for very small groups of directly connected cells or for single solar cells were developed to provide a solution to optimizing the electrical power from the array.

In one aspect the present invention broadly resides in a system for providing power from solar cells including

one or more solar generators wherein each of said solar generators has one to nine solar cells;

a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other;

an inductor operatively connected to the series connected maximum power trackers; and

means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

The maximum power tracker preferably includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point.

Preferably the control means makes observations of solar generator voltage, and observations of the change in energy storage capacitor voltage during the buck converter switch off time and observations of the duration of the buck converter switch off time to infer solar generator power to adjust the buck converter duty cycle to extract maximum power from the connected solar generator.

In one preferred embodiment, the switching operations of the DC/DC converter are synchronized in frequency by the use of a synchronizing signal.

Preferably each solar generator includes one solar cell. Preferably each solar generator includes one solar cell and each solar cell is connected to its own dedicated maximum power tracker so that the tracker responds to its connected solar cell.

Preferably the system uses a single inductor.

Load means includes devices that use or store the electrical power.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the present invention can be more readily understood and put into practical effect, reference will now be made to the accompanying drawings wherein:

Figure 1 is a diagrammatic view of a simplified Buck type DC/DC converter with solar generator and load;

Figure 2 is a diagrammatic view of an alternative embodiment of a simplified Buck type DC/DC converter with solar generator and load;

Figure 3 is a diagrammatic view of a solar generator with a Buck type DC/DC converter without an inductor;

Figure 4 is a diagrammatic view of an alternative embodiment of a solar generator with a Buck type DC/DC converter without an inductor;

Figure 5 is a diagrammatic view of the interconnection of a plurality of Buck type DC/DC converters without inductors, corresponding plurality of solar generators, one inductor and a load; and

Figure 6 is a diagrammatic view of a preferred embodiment of the single cell MPPT converter;

Figure 7 is a graphical representation of the control signals and gate signals for MOSFETs;

Figure 8 is a graphical representation of a no load 2kHz waveforms, top MOSFET gate waveform; top MOSFET gate drive referred to ground, bottom MOSFET gate waveform to ground, output terminal to ground (from top to bottom);

Figure 9 is a graphical representation of an unloaded 20kHz waveforms, Traces top to bottom, output terminal, bottom MOSFET gate, top MOSFET gate, all referred to ground;

Figure 10 is a graphical representation of a loaded 20kHz waveforms, traces top to bottom, output terminal, bottom MOSFET gate, top MOSFET gate, all referred to ground;

Figure 11 is a graphical representation of input voltage, current and power at 10kHz (from top to bottom);

Figure 12 is a graphical representation of output current, voltage and power at 10kHz (from top to bottom);

Figure 13 is a table of equipment for efficiency measurement; and

Figure 14 is a table of converter efficiency at different frequencies.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figure 1 there is shown a simplified buck type DC/DC converter 10 connected to a solar generator 11 and load 12. The solar generator 11 can be a solar cell or several cells. The buck type DC/DC converter 10 includes a capacitor 13 which serves as an energy storage element, a controlled switching

device 14, a diode or a controlled device acting as a synchronous rectifier 15 and an output inductor 16. An alternative arrangement for the buck type DC/DC converter 10 is shown in Figure 2.

A buck type DC/DC converter can be controlled to operate the solar generator at its maximum power point while producing an adjustable level of output current. The solar generator and maximum power tracker will be referred to as a solar generator /MPPT. Many solar generators/MPPT can be series connected. Each DC/DC converter will then have an identical output current but they can be individually controlled to allow each solar generator to operate at their maximum power point.

A conventional buck converter uses an output inductor to provide energy storage that is necessary for current filtering. An important feature of this invention is that the many inductors would normally be required, one for each solar generator/MPPT, and this can be replaced by a single inductor which will perform the energy storage and filtering function for many series connected solar generator/MPPT. The MPPT device can be produced as an inductor free device.

Figure 3 shows an inductorless DC/DC buck converter with a solar generator while Figure 4 shows an alternate embodiment.

Many solar generators/MPPT devices that utilize inductor free DC/DC buck converters can be series connected with a single inductor to supply power to an electrical load. The series connection of the solar generators/MPPT devices forces each inductorless DC/DC buck converter to supply an identical output current. Each converter operates with a constant current load.

The controlled switching device operates alternates between an open and closed state. The average portion of time that the switch is closed is the switch duty

cycle. Closure of the controlled switching device causes the load current to be supplied from the solar generator and the energy storage capacitor. When the controlled switch is open, the load current transfers to the diode or synchronous rectifier device while the solar generator current replenishes the charge within energy storage capacitor.

The duty cycle of the controlled switching device will determine the average current withdrawn from the energy storage capacitor. The energy storage capacitor will adjust its voltage in response to the difference in the current supplied by the solar generator and the current withdrawn to by the controlled switch. The switching device will be controlled by a device that adjusts the controlled switch duty cycle to maintain the solar generator voltage at the maximum power point.

With respect to Figure 5 there is shown a solar generator 20 connected to a capacitor 21, diode 22 and control switch 23. The capacitor 21, diode 22 and control switch 23 forms the inductorless DC/DC converter 24. Several solar generators 20 are connected in series via their dedicated inductorless DC/DC converters 24. Each solar generator 20 has its own inductorless DC/DC converters 24. After the last inductorless DC/DC converters 24, there is an inductor 25 to filter the current prior to reaching the load 26. The inductor 25 can be smaller in terms of magnetic energy shortage measured as $\frac{1}{2} LI^2$,where L is the inductance value in Henry and I is the inductor current, in Amperes, than the total combined set of inductors that are normally used with each buck DC/DC converter. The use of a smaller inductor and only one inductor reduces cost and weight and increases the efficiency in providing maximum power from the solar cells. In the preferred embodiment the solar generator consists of a solar generator which is a single high performance solar cell.

With reference to Figure 6, there is shown a DC to DC converter 30 in the formed by MOSFETs Q1 and Q2 (31 and 32 respectively), and the energy storage capacitor 33. No filter inductor is required. In this preferred embodiment MOSFET Q1 (31) is a synchronous rectifier implementation of the diode device and MOSFET Q2 (32) is the buck converter controlled switch element. In the preferred embodiment the output terminals of the solar generator/MPPT device are the the drain terminal of Q1, point X and the junction of the source terminal of Q1 and the drain terminal of Q2, point Y.

The control element of the maximum power device is a microprocessor. In this preferred embodiment, an ultra-low power Texas Instruments MSP430 microprocessor 34 which is capable of operation at a supply voltage of 1.8V. This allows direct operation from a dual junction cell which typically produces 2V. If other cell types are used with lower cell voltages, a power conditioning device may be required to develop a higher voltage supply to allow the control element to be operated from a single cell. For example, silicon cells typically produce 0.4V and a voltage boosting converter would be required to generate a voltage high enough to operate a microprocessor control element.

An alternate embodiment is possible where the solar generator/MPPT device output terminals are the junction of Q1 and Q2, point Y, and the source of Q2. In this case Q1 is the controlled switch element and Q2 is the diode element implemented as a synchronous rectifier.

The gate drive voltage for the MOSFETS Q1 and Q2 is derived by charge pump circuit. In the preferred implementation a multiple stage charge pump circuit formed by diodes D_1 to D_4 , devices 35-38, and their associated capacitors 39-42.

The MOSFETS Q1 and Q2 are driven by a gate driver circuit. In the preferred embodiment a comparator, 43, forms the driver circuit. As this circuit delivers a higher gate to source voltage to device Q2 than Q1, Q2 achieves a lower turn on resistance. In the preferred embodiment Q2 is the controlled switching device as this arrangement minimises power losses.

Resistors 44 and 45 form a voltage divider network which is used to perform voltage observations of solar generator voltage using a analogue to digital converter within the microprocessor 34. An important feature of the maximum power tracking method is the measurement of cell voltage magnitude, the and measurement of the change in cell voltage during periods when the controlled switch, 32, is open and the measurement of the time that the controlled switch is open to infer cell power. This may be used as an input to a maximum power tracking method that will control the DC-DC converter duty cycle to allow the solar generator to operate at maximum power.

In order to secure high efficiency in the solar generator/MPPT, low switching frequencies are preferred. In the preferred embodiment switching frequencies will be below 20 kHz. At very low switching frequencies the ripple voltage on capacitor C1 will increase. The voltage ripple will cause the cell to deviate from its maximum power point. An optimum switching frequency range will exist. In the preferred embodiments the switching frequency will be adjusted to maximise the energy delivered by the solar generator/MPPT.

A plurality of solar generator/MPPT may be configured within a large array to switch at the same frequency and with a relative phase relationship that provides improved cancellation of switching frequency voltage components in the output voltage waveforms of the solar generator/MPPT combinations. This allows a smaller

inductor to provide filtering of the load current. Such synchronisation may be provided by auxiliary timing signals that are distributed within an array or by other means.

In some embodiments the solar generator/MPPT devices within an array may not switch at the same frequency. The combined output voltage of large number of asynchronously switching series connected buck converters will follow a binomial distribution. The average output voltage of the group of n solar generator/MPPT devices, with an input voltage V_{in} and a duty cycle d, increases linearly with n while the switching ripple or the distortion voltage, V_{dist}, rises as $\sqrt{n}$.

$$V_{dist} = V_{in}\sqrt{n(d - d^2)} \qquad (1)$$

Likewise the average volt second area, A, for a shared filter inductor follows an $\sqrt{n}$ relationship.

$$A = \sqrt{n}\frac{V_{in}}{f}(d - d^2) \qquad (2)$$

In a non synchronized embodiment, a larger inductor is required than in an optimally synchronized embodiment. The required inductor is still significantly smaller than the combined plurality of inductors that would be required for conventional buck converters.

A prototype converter was developed to first examine the conversion efficiency of the DC to DC converter stage and its suitability for use with a dual junction single solar cell, with an approximate maximum power point at 2V and

300mA. For these tests the MSP340 was programmed to drive the charge pump circuitry and to operate the buck converter stage at a fixed 50% duty ratio. The experimental circuit is as in Figure 6. A fixed 2V input source voltage was applied and a load consisting of a 2 500μH inductor and a 1.6 Ω resistor was applied. A dead-time of 0.8μS is inserted in each turn-on and turn-off transient to prevent MOSFETs shoot through conduction events.

As gate charging loss was a significant loss contributor, a range of operating frequencies was trialled. Figure 7 shows the control waveforms at 20kHz. The waveforms show the dead times between the top and bottom signals at turn-on and turn-off. All waveforms in this figure are ground referred. The measured no load loss in this condition was 6mW which is approximately twice the expected figure. The gate drive loss is fully developed at no load and we may have additional loss in the charge pump circuitry. Figure 8 shows gate waveforms at 2kHz but a differential measurement is made of V_{gs1} to show the lowering of the gate source voltage to approximately 4V due to elevation of the source at the device turn-on.

The waveforms at 20 kHz without load are shown in Figure 9. Note that the load connection is across terminals X and Y. The lower MOSFET has the higher gate drive voltage and a lower R_{dson}. Figure 10 shows the loaded waveforms. Note the conduction of the MOSFET inverse diodes in the dead time as seen by the 2 μS wide peaks on the leading and trailing pulse top edges on the top trace. The transfer of current to these diodes generates an additional conduction loss of 24mW which reduces efficiency at higher frequencies.

Given circuit losses are around a few percentage points of rating, precise voltage and current measurements are needed if power measurements are used to determine efficiency. A complication is that the output is inductorless and both the

output voltage and current contain significant switching frequency components. It is likely that a significant amount of power is transferred to the combined R-L load at frequencies other than DC.

In order to determine the efficiency of this converter, a new high end oscilloscope was used to measure the input and output power. The internal math function was employed to obtain the instantaneous power from the current and voltage, the mean value of which indicates the average power. The current probe was carefully calibrated before each current measurement, to minimise measurement errors. Figure 13 shows the details of the equipment used in a table format. Figures 11 and 12 show the input and output voltages, current and power. The mean value of measured power is displayed at the right column of the figures.

The efficiencies of the converter obtained are shown in a table in Figure 14. It is seen that the measured efficiency is slightly lower than estimated especially at higher frequencies. One reason is the loss during the dead-time. The on-state voltage drop of the diode is much higher than the MOSFET, and therefore reduces the efficiency of the converter. At 10kHz the dead time loss accounts for 12mW of the observed 30mW. The results do confirm that the circuit is capable of achieving high efficiencies especially if the switching frequency is low.

VARIATIONS

It will of course be realised that while the foregoing has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is herein set forth.

Throughout the description and claims this specification the word "comprise" and variations of that word such as "comprises" and "comprising", are not intended to exclude other additives, components, integers or steps.

CLAIMS

1. A system for providing power from solar cells including

one or more solar generators wherein each of said solar generators has one to nine solar cells;

a maximum power tracker operatively associated with each solar generator, each of said maximum power tracker includes a buck type DC/DC converter without an output inductor, each of said maximum power trackers are operatively connected in series with each other;

an inductor operatively connected to the series connected maximum power trackers; and

means for providing electrical power from the inductor to load means, wherein each of said maximum power trackers is controlled so that the operatively associated solar generator operates at its maximum power point to extract maximum available power.

2. A system as claimed in claim 1 wherein the maximum power tracker includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point.

3. A system as claimed in claim 1 wherein the maximum power tracker includes an energy storage capacitor and a control means for adjusting the buck type DC/DC converter duty cycle so that a connected solar generator operates at its maximum power point; said control means makes observations of solar generator voltage, and observations of the change in energy storage capacitor voltage during the buck

converter switch off time and observations of the duration of the buck converter switch off time to infer solar generator power to adjust the buck converter duty cycle to extract maximum power from the connected solar generator.

4. A system as claimed in any one of the above mentioned claims wherein the switching operations of the DC/DC converter are synchronized in frequency by the use of a synchronizing signal.

5. A system as claimed in any one of the above mentioned claims wherein each solar generator includes one solar cell.

6. A system as claimed in any one of the above mentioned claims wherein each solar generator includes one solar cell and each solar cell is connected to its own dedicated maximum power tracker so that the tracker responds to its connected solar cell.

7. A system as claimed in any one of the above mentioned claims wherein the system uses a single inductor.

8. A system as claimed in any one of the above mentioned claims wherein load means includes devices that use or store the electrical power.

9. A system as substantially described herein with reference to and as illustrated by the accompanying drawings.

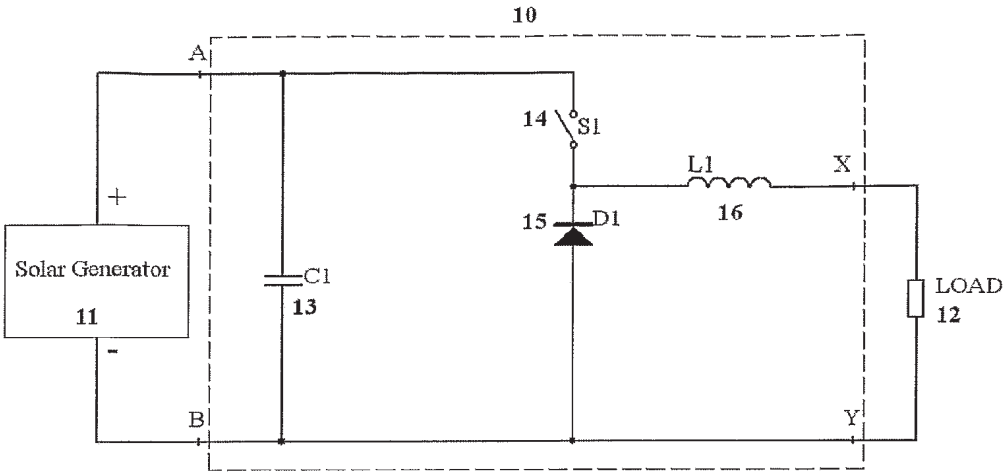


FIGURE 1

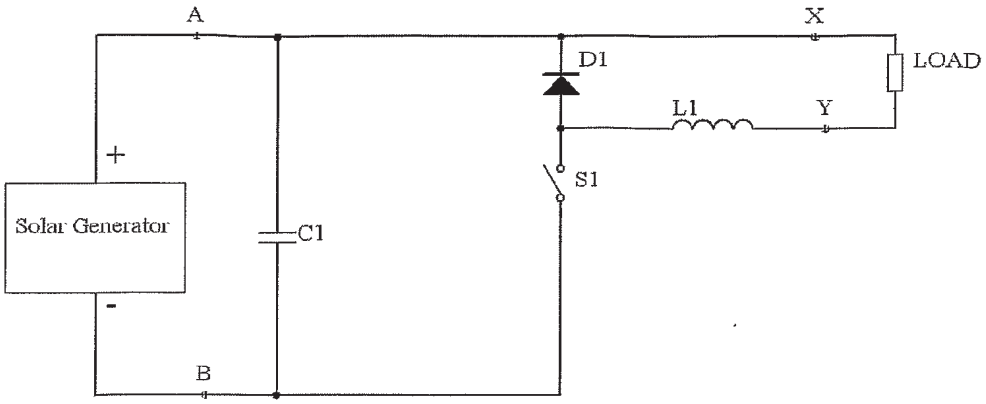


FIGURE 2

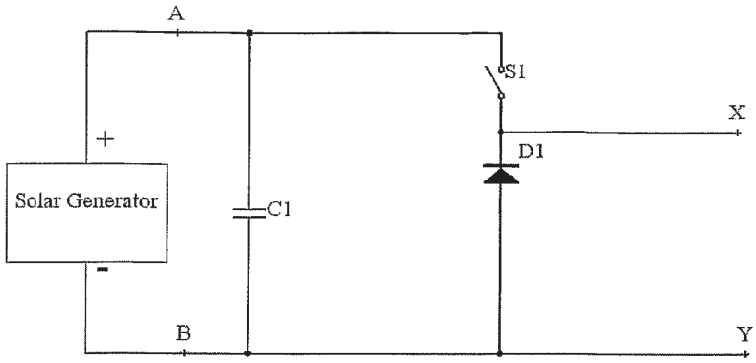


FIGURE 3

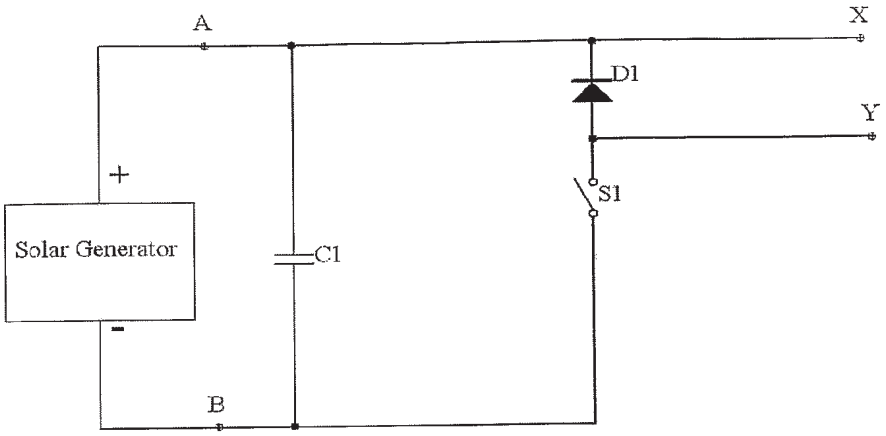


FIGURE 4

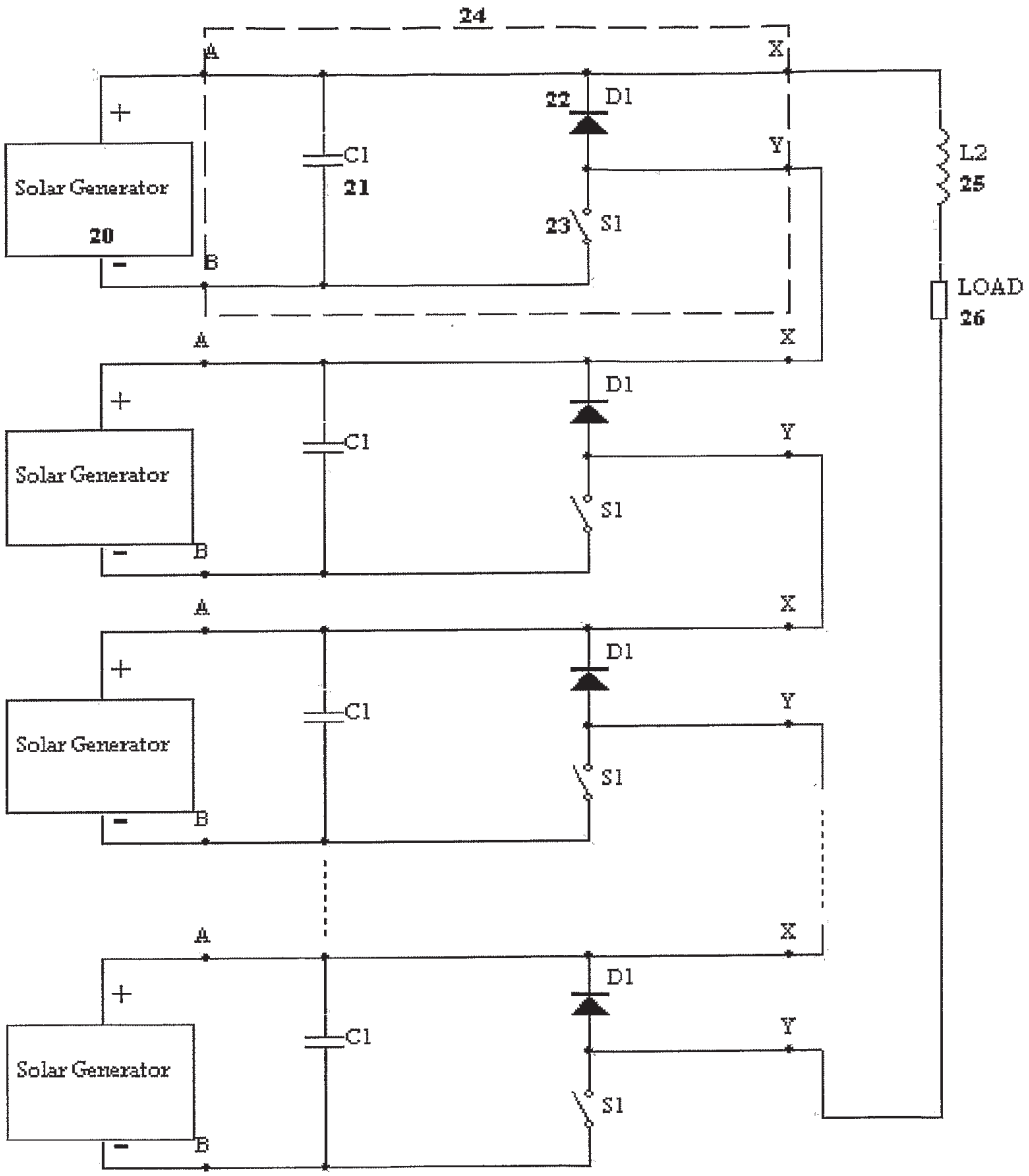

24
A
X
22
D1
Y
L2
25
C1
21
Solar Generator
20
23
S1
B
LOAD
26
A
X
D1
Y
C1
Solar Generator
S1
B
A
X
D1
Y
C1
Solar Generator
S1
B
A
X
D1
Y
C1
Solar Generator
S1
B

FIGURE 5

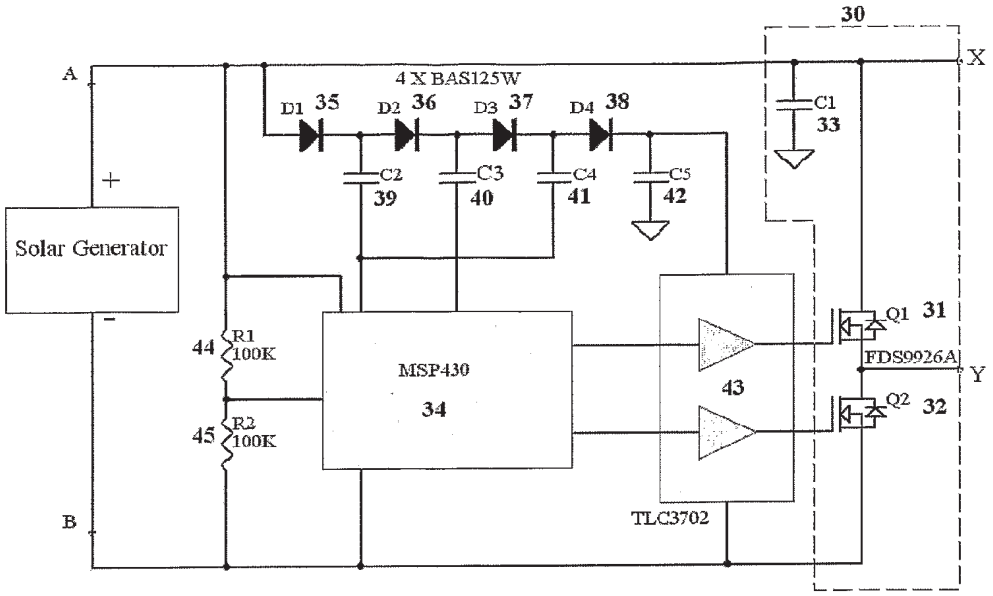

30
A
4 X BAS125W
D1 35
D2 36
D3 37
D4 38
C1
33
X
C2
39
C3
40
C4
41
C5
42
+
Solar Generator
-
R1
44
100K
R2
45
100K
MSP430
34
43
Q1 31
FDS9926A
Y
Q2 32
TLC3702
B

FIGURE 6

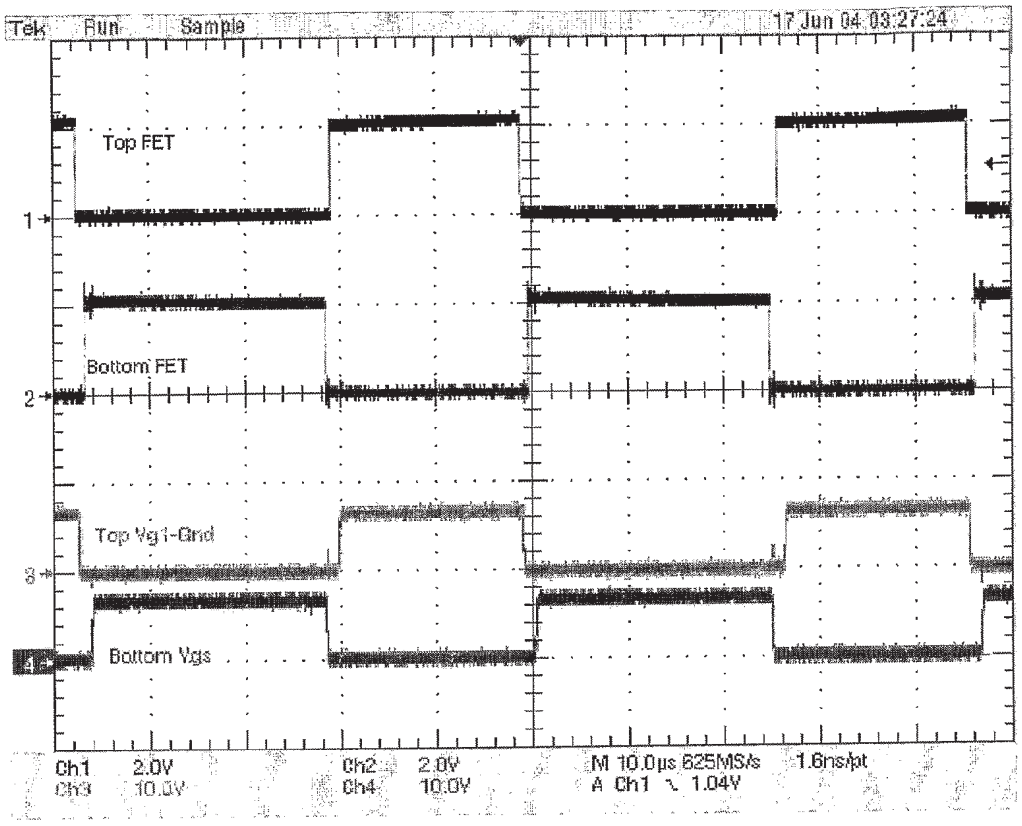

Tek Run Sample 17 Jun 04 03:27:24
Top FET
Bottom FET
Top Vg1-Gnd
Bottom Vgs
Ch1 2.0V
Ch3 10.0V
Ch2 2.0V
Ch4 10.0V
M 10.0µs 625MS/s 1.6ns/pt
A Ch1 1.04V

FIGURE 7

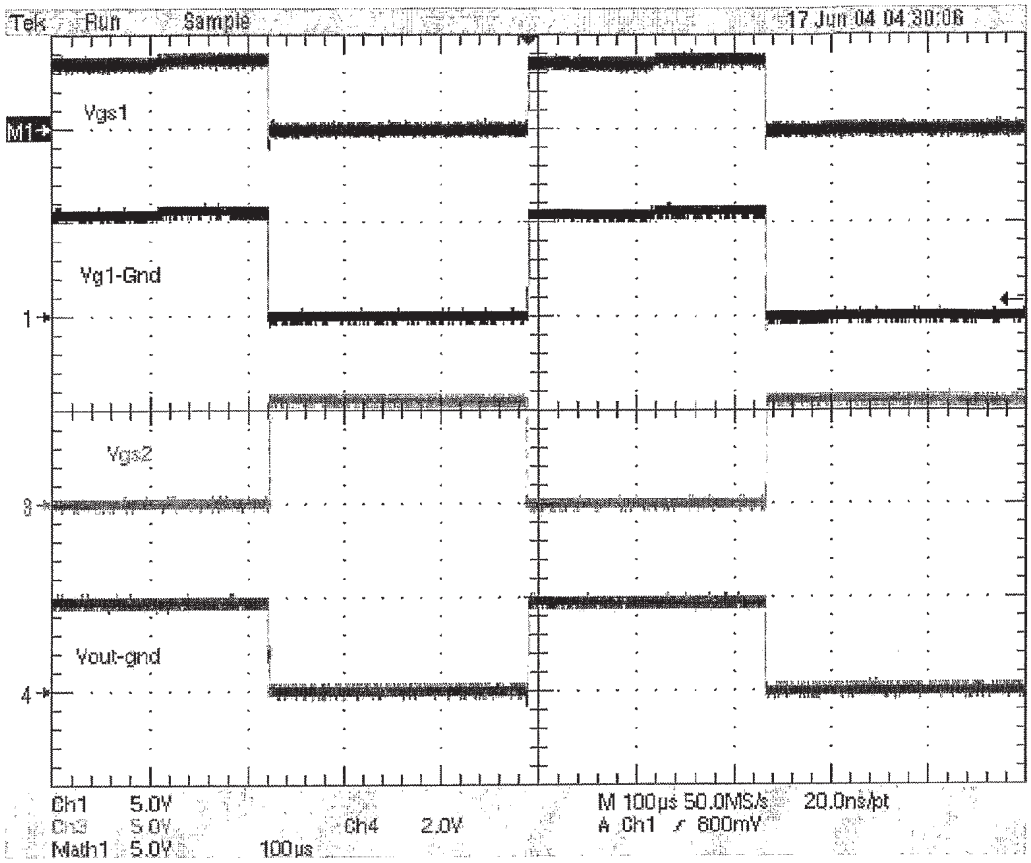

Tek Run Sample 17 Jun 04 04:30:06
Vgs1
Vg1-Gnd
Vgs2
Vout-gnd
Ch1 5.0V
Ch3 5.0V
Math1 5.0V
100µs
Ch4 2.0V
M 100µs 50.0MS/s 20.0ns/pt
A Ch1 ⌿ 600mV

FIGURE 8

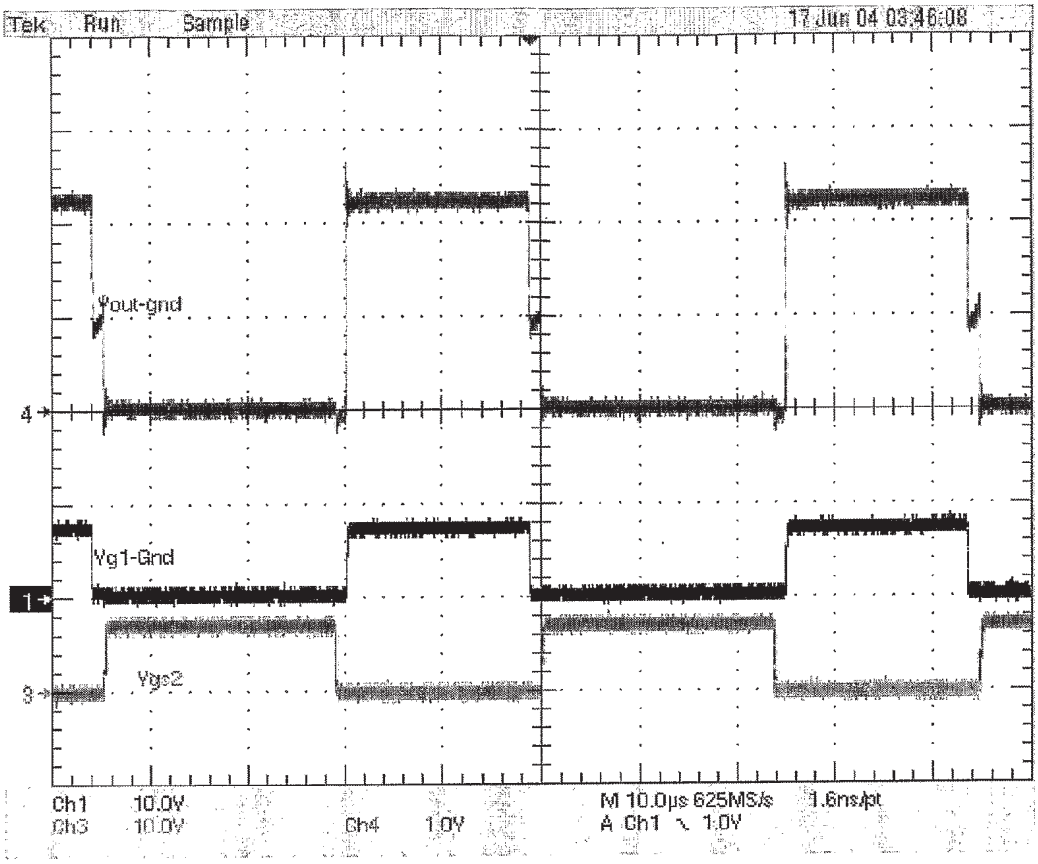

Tek Run Sample
17 Jun 04 03:46:08
Vout-gnd
Vg1-Gnd
Vgs2
4
1
3
Ch1 10.0V
Ch3 10.0V
Ch4 1.0V
M 10.0µs 625MS/s
A Ch1 ∖ 1.0V
1.6ns/pt

FIGURE 9

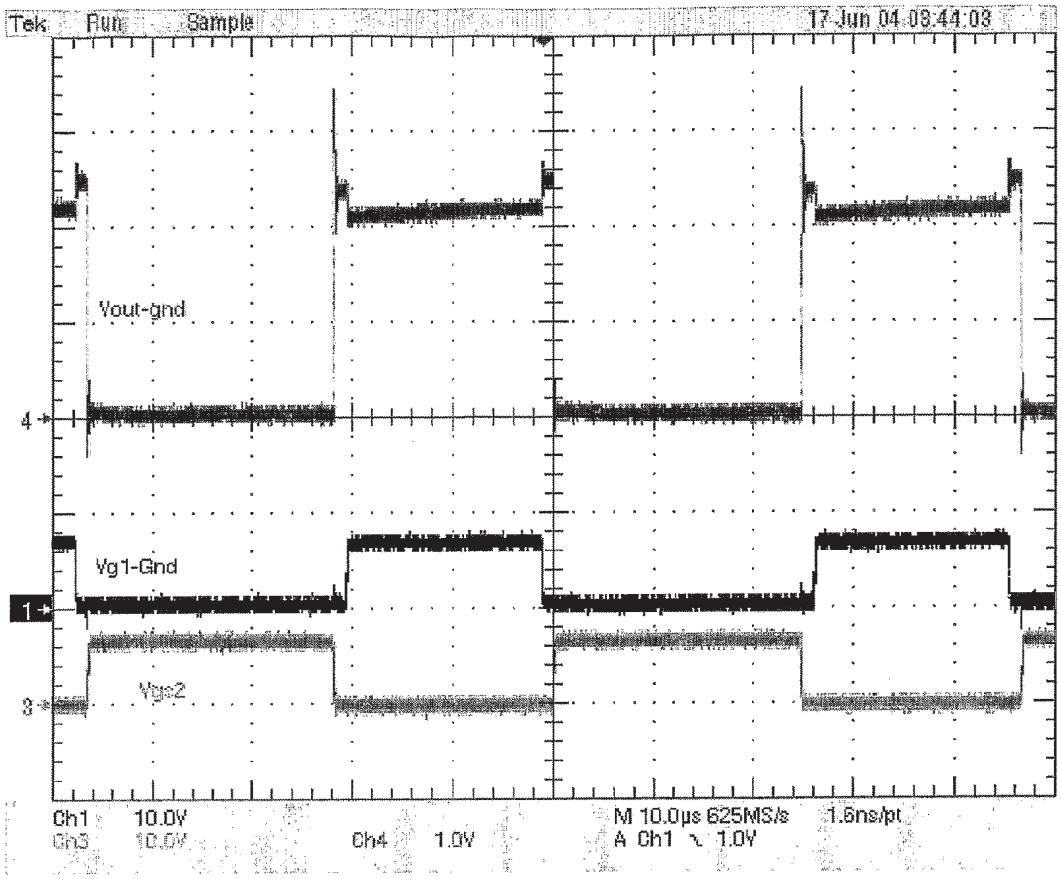

Tek Run: Sample
17-Jun 04 08:44:03
Vout-gnd
Vg1-Gnd
Vgs2
4
1
3
Ch1 10.0V
Ch3 10.0V
Ch4 1.0V
M 10.0µs 625MS/s
A Ch1 ∿ 1.0V
1.6ns/pt

FIGURE 10

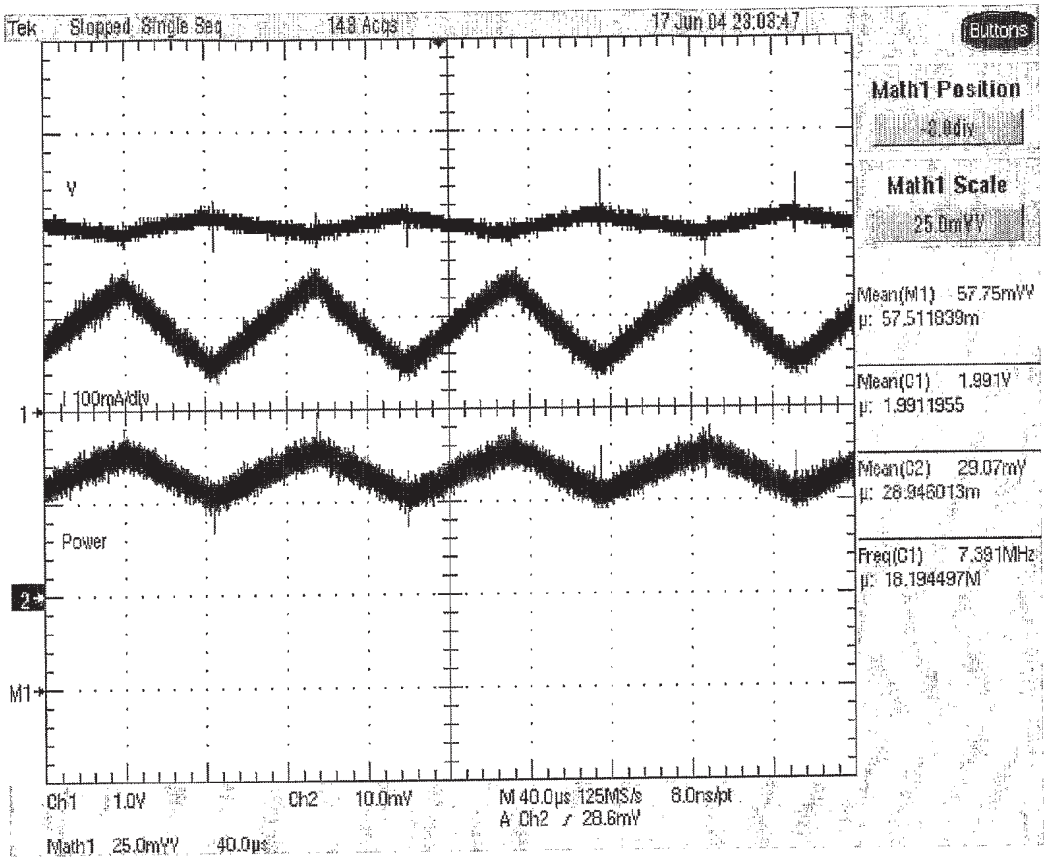

Tek Stopped Single Seq 143 Acqs 17 Jun 04 23:08:47
Buttons
Math1 Position
-2.0div
Math1 Scale
25.0mV/V
V
100mA/div
Power
Mean(M1) 57.75mV/V
μ: 57.511939m
Mean(C1) 1.991V
μ: 1.9911955
Mean(C2) 29.07mV
μ: 28.946013m
Freq(C1) 7.391MHz
μ: 18.194497M
Ch1 1.0V Ch2 10.0mV M 40.0μs 125MS/s 8.0ns/pt
A Ch2 28.8mV
Math1 25.0mV/V 40.0μs

FIGURE 11

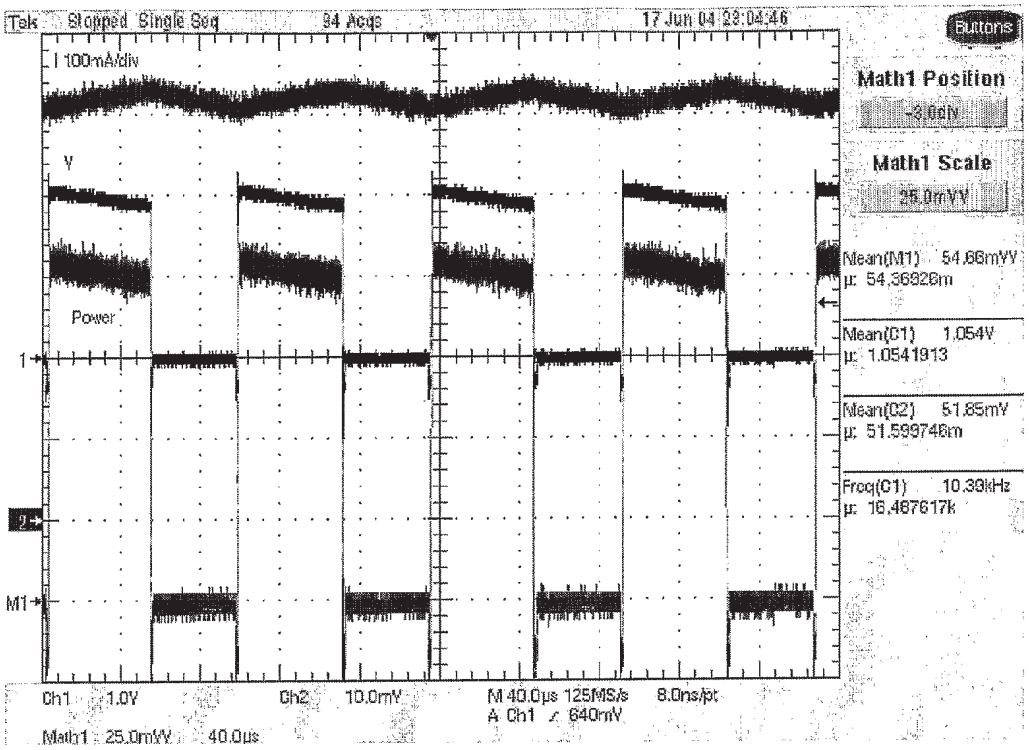

Tek Stopped Single Seq 94 Acqs 17 Jun 04 23:04:46
I 100mA/div
V
Power
1
2
M1
Ch1 1.0V Ch2 10.0mV M 40.0µs 125MS/s 8.0ns/pt
A Ch1 ∠ 640mV
Math1 : 25.0mVV 40.0µs
Buttons
Math1 Position
-3.6div
Math1 Scale
25.0mVV
Mean(M1) 54.66mVV
µ: 54.36926m
Mean(C1) 1.054V
µ: 1.0541913
Mean(C2) 51.85mV
µ: 51.599746m
Freq(C1) 10.39kHz
µ: 16.487617k

FIGURE 12

Name of equipment	Model	Quantity
Current probe	Tektronix AM503B+TM502A	1
Voltage probe	Tektronix P5050	1
Oscilloscope	Tektronics DPO5034	1

FIGURE 13

Frequency (kHz)	Input Power (mW)	Output Power (mW)	Efficiency
2	520	510	98%
10	577	547	95%
20	506	471	93%

FIGURE 14

Power supply system with at least two rectifier-inverter pairs - has voltage from one pair phase-shifted with respect to other pair thus eliminating unwanted harmonics

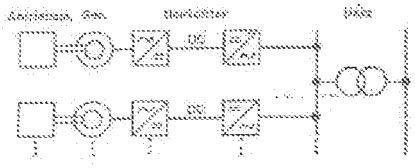
Publication number: DE4232356 (A1)
Publication date: 1994-03-31
Inventor(s): HEIER SIEGFRIED DIPL ING [DE]; KLEINKAUF WERNER PROF DR ING [DE] +
Applicant(s): INST SOLARE ENERGIEVERSORGUNGS [DE] +
Classification:
- international: ***F03D9/00; H02J3/01; H02J3/38; H02J5/00; H02P9/48;*** **F03D9/00; H02J3/01; H02J3/38; H02J5/00; H02P9/00;** (IPC1-7): H02J3/01; H02J3/38; H02N6/00; H02P9/48
- European: F03D9/00C2B; H02J3/01; H02J3/38; H02J5/00; H02P9/48
Application number: DE19924232356 19920926
Priority number(s): DE19924232356 19920926

Also published as:
DE4232356 (C2)

Cited documents:
DE3023195 (A1)
DE2911342 (A1)
DE2317068 (A1)
EP0473257 (A2)
EP0353715 (A2)

Abstract of **DE 4232356 (A1)**

The power source with at least two rectifier-inverter pairs (used as a controllable DC link), typically a wind power plant or photovoltaic plant, has the voltage from one pair phase-shifted with respect to the other pair so as to eliminate totally or partially the harmonics generated. There is a step-up transformer between the output voltage and the Grid. To eliminate or reduce harmonics, the half period of the critical harmonic number is chosen as the displacement in the firing angles. The critical harmonic number lies near the grid frequency. ADVANTAGE - Reduces unwanted harmonics being fed into Grid.



Data supplied from the ***espacenet*** database — Worldwide

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **Patentschrift**

(10) **DE 42 32 356 C 2**

(51) Int. Cl.[6]:
H 02 J 3/01
H 02 J 3/38
H 02 N 6/00
H 02 P 9/48

(21) Aktenzeichen: P 42 32 356.8-32
(22) Anmeldetag: 26. 9. 92
(43) Offenlegungstag: 31. 3. 94
(45) Veröffentlichungstag der Patenterteilung: 9. 1. 97

DE 42 32 356 C 2

Innerhalb von 3 Monaten nach Veröffentlichung der Erteilung kann Einspruch erhoben werden

(73) Patentinhaber:
Institut für Solare Energieversorgungstechnik (ISET) - Verein an der Gesamthochschule Kassel, 34119 Kassel, DE

(74) Vertreter:
Walther, R., Dipl.-Ing.; Walther, H., Dipl.-Ing., Pat.-Anwälte, 34131 Kassel

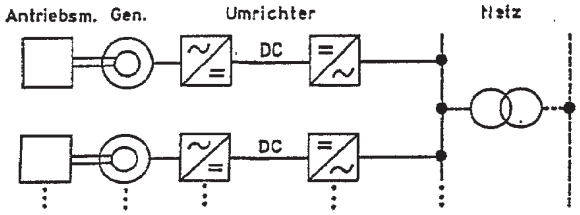
(72) Erfinder:
Heier, Siegfried, Dipl.-Ing., 3507 Baunatal, DE;
Kleinkauf, Werner, Prof. Dr.-Ing., 3500 Kassel, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:

DE 30 23 195 A1
DE-OS 29 11 342
DE-OS 23 17 068
EP 04 73 257 A2
EP 03 53 715 A2
H. PRINZ: Einführung in die Starkstromtechnik, München 1961, S.144-149;

(54) Stromversorgungseinrichtung mit mindestens zwei Stromquellen

(57) Stromversorgungseinrichtung mit mindestens zwei Stromquellen, wobei jede Stromquelle über einen zugeordneten Stromrichter in ein Wechselstromnetz einspeist, dadurch gekennzeichnet, daß zur Herabsetzung der Amplitude einer bestimmten vorhandenen Oberschwingung die Spannung von mindestens einem der Stromrichter mit Hilfe eines Steuerwinkels phasenverschoben zu mindestens einem anderen Stromrichter in das Netz einspeisbar ist.



Systeme mit gemeinsamer Netzkopplung

DE 42 32 356 C 2

SMA Solar Technology America, LLC, Ex. 1006

Beschreibung

Die Erfindung betrifft eine Stromversorgungseinrichtung mit mindestens zwei Stromquellen gemäß dem Oberbegriff des Anspruchs 1.

Stromversorgungseinrichtungen der eingangs genannten Art sind bekannt. Häufig werden Windkraftanlagen in Form von sogenannten Windparks eingesetzt, wobei der Aufbau derartiger Windparks von den herrschenden Windverhältnissen und der Art der Einzelanlagen abhängt. Bei Windkraftanlagen mit Asynchron-Generatoren wird eine direkte Netzkopplung bevorzugt, während bei Synchron-Generatoren meist eine Netzkopplung über einen Frequenzumrichter, bestehend aus einem Gleichrichter mit Gleichstrom-Zwischenkreis und netzgeführtem Wechselrichter, erfolgt. Es werden auch Windkraftanlagen mit Generatoren eingesetzt, die mehrere parallel zueinander angeordnete Statorwicklungen mit entsprechenden Stromrichtern aufweisen. Ein derartiger Generator kann im vorliegenden Fall auch als ein System bestehend aus zwei Maschinen bzw. zwei Einheiten betrachtet werden.

Eine Umrichterspeisung ist dann von Vorteil, wenn das Energieangebot vergleichmäßigt werden soll. So kann z. B. bei böigem Wind über variable Drehzahl mit Hilfe der Schwungmassen als Speicher ein Ausgleich geschaffen werden. Bei einem Windrad mit Umrichter wird die Drehzahl bei schwankender Windgeschwindigkeit derart verändert, daß die vom Wind angebotene Energie besser genutzt, mechanische Anlagenteile entlastet und eine gleichmäßigere Ausgangsleistung abgegeben wird. Das heißt, die Schwungmasse des Windrades wird zur Vergleichmäßigung der Abgabeleistung herangezogen.

Bei Netzeinspeisung über Umrichtersysteme besteht die Gefahr von Netzeinwirkungen. U.a. können Oberschwingungen in das Netz eingebracht werden und Netzresonanzen entstehen. Die Folge ist, daß sich Strom- oder Spannungsüberhöhungen im Netz ergeben, die sich bis zu einzelnen Verbrauchern fortpflanzen und dort zu Beeinträchtigungen führen.

Photovoltaikanlagen oder Batteriespeicher, die Gleichstrom liefern, sind ebenfalls häufig über netzgeführte Wechselrichter mit dem Wechsel- oder Drehstromnetz verbunden und verursachen entsprechende Oberschwingungsprobleme.

Wird ein Netz am Anschlußpunkt eines oder mehrerer Einspeise- oder Verbrauchersysteme betrachtet, so ist für das Verhalten die Gesamtimpedanz der Konfiguration maßgebend, die sich anhand der gegebenen Kombination von ohmschen Widerständen, Induktivitäten und Kapazitäten im Einspeise-, Verteiler- und Verbrauchersystem ermitteln läßt. Entsprechend der Anzahl dieser Einzelelemente, ihrer Anbindung und Größe der Impedanzen ergeben sich u. a. Eigenresonanzwerte im betrachteten Netzteil, die — wie bereits ausgeführt — bei Anregung Strom- oder Spannungsüberhöhungen in den angeschlossenen Bauelementen und Geräten verursachen können. Diese Anregungen treten insbesondere durch Stromrichtereinheiten auf, wie sie in Windkraft- und Photovoltaikanlagen oder Batteriesystemen eingesetzt werden. Derartige Stromumformer erzeugen nichtsinusförmige Strom- und Spannungsverläufe, die neben der Grundschwingungsfrequenz auch höherfrequente Anteile (Oberschwingungen) beinhalten. Es ist auch nicht zu verkennen, daß Oberschwingungen in Erzeuger- und Verbrauchersystemen zusätzliche Verluste und auch Alterungseffekte (z. B. bei Kondensatoren) zur Folge haben.

Nach der DE-OS 23 17 068 werden in einem Verbundnetz bzw. in Teil- oder Inselnetzen störende Oberschwingungen vorwiegend durch Filtereinrichtungen auf ein für Verbraucher- und Erzeugersysteme erträgliches Maß abgebaut.

So ist insbesondere die Anordnung von Filtern zum Abbau der störenden Oberschwingungen zwar die Maßnahme, die nach dem Stand der Technik zu den besten Ergebnissen führt, der Einsatz von Filtern verursacht jedoch zusätzliche Kosten und verliert beim Auftreten von höherfrequenten Resonanzen an Wirksamkeit.

Aus der EP 473 257 A2 ist bekannt, daß zur elektrischen Energieumsetzung z. B. durch Parallelschaltung von mehreren Stromrichterbrücken Netzschwingungen reduziert und Gleichstromversorgungen insgesamt günstiger gestaltet werden können. Die EP 353 715 A2 hat die Unterdrückung von Schwingungen durch Pulsation der Gleichspannung bei Frequenzwandlern zum Inhalt.

Eine Stromversorgungseinrichtung der eingangs genannten Art ist aus der DE 30 23 195 A1 bekannt. Das Ziel dieser Stromversorgungseinrichtung für ein Wechsel- oder Drehstromnetz besteht darin, das Wechsel- oder Drehstromnetz nur gering mit Blindleistung zu belasten. Dies wird mit Hilfe von DC/DC-Wandlern durch große Steuerwinkel erreicht.

Der Erfindung liegt die Aufgabe zugrunde, bei einer Stromversorgungseinrichtung der eingangs genannten Art das Auftreten von unerwünschten Oberschwingungen derart zu vermindern, daß sie keine Gefahr für Verbraucher- und Erzeugersysteme darstellen.

Die Aufgabe wird erfindungsgemäß durch die Merkmale des Anspruchs 1 gelöst. Hierdurch wird erreicht, daß im Gegensatz zu den bekannten Möglichkeiten in vorhandenen oder zu installierenden Systemen eine gezielte Reduzierung von Oberschwingungen und Klirrfaktorwerten erfolgt.

Weitere vorteilhafte Ausführungsformen ergeben sich aus den Unteransprüchen.

Eine besondere Ausführungsform einer Stromversorgungseinrichtung mit mindestens zwei Stromquellen ist z. B. eine Anordnung von Windkraftanlagen mit Wechselrichtern, die derart ausgerüstet sind, daß sie sich mit unterschiedlichen Steuerwinkeln betreiben lassen. Dies kann z. B. dadurch erreicht werden, daß die stromrichterseitige Trafowicklung der einen Stromquelle eine andere Spannungsebene aufweist als die Trafoseite der anderen Stromquelle. Dadurch, daß die Trafos bzw. Trafowicklungen von beispielsweise zwei Windkraftanlagen jeweils eine unterschiedliche Spannungsebene haben, wird erreicht, daß der Stromrichter beispielsweise als Wechselrichter der jeweiligen Windkraftanlage mit einem anderen Steuerwinkel betrieben wird. Die Spannungsebenen der beiden Trafos sind daher so zu wählen, daß eine Auslöschung oder zumindest partielle Überdeckung der durch den jeweiligen Wechselrichter erzeugten Phasen erzielt wird. Zur Auslöschung oder Überdeckung von Phasen bestimmter Oberschwingungen ist die halbe Periodendauer der kritischen Oberschwingungszahl als Phasenverschiebungswinkel geeignet. Bei der Auswahl der Oberschwingungszahl, die ausgelöscht werden soll, ist die kritische Netzfrequenz zu wählen, die besondere Beeinträchtigungen hervorruft, z. B. die Frequenz, die nahe der Netzeigenresonanz- oder Rundsteuerfrequenz liegt.

Nach einer anderen Ausführungsform wird zur Auslöschung oder zumindest partiellen Überdeckung der

SMA Solar Technology America, LLC, Ex. 1006

Phasen von Oberschwingungen bei elektrisch erregten Generatoren die Zwischenkreisspannung entsprechend geändert.

Das heißt, durch die Erregung des Generators wird die Zwischenkreisspannung so geändert, daß sich entsprechende Steuerwinkel ergeben und sich die Phasen der Oberschwingungen des einen Generators mit denen eines weiteren Generators auslöschen bzw. überdecken.

Sowohl bei elektrisch erregten als auch bei permanenterregten Generatoren besteht darüber hinaus die Möglichkeit, daß der Gleichrichter durch die Wahl des Steuerwinkels derart betrieben wird, daß durch eine Einstellung der Zwischenkreisspannung eine Auslöschung oder Überdeckung von Phasen von Oberschwingungen am Wechselrichterausgang erfolgt. Das heißt, soll eine bestimmte Oberschwingung abgebaut werden, muß die Zwischenkreisspannung entsprechend eingestellt bzw. geregelt werden.

Eine weitere Möglichkeit ist dadurch gegeben, die Statorwicklung jeweils zweier Maschinen derart zu wählen, daß durch die unterschiedliche Zwischenkreisspannung einer jeden Maschine eine derartige Steuerwinkeldifferenz erzeugt wird, daß sich die entsprechenden Phasen von Oberschwingungen überdecken oder auslöschen. Das heißt, die Statorwicklung bei zwei Maschinen wird derart gewählt, daß sich die jeweils ergebenden Zwischenkreisspannungen in geeigneter Weise einstellen und hierdurch eine Steuerwinkeldifferenz entsteht, wobei die Differenz so zu wählen ist, daß sich hier die Phasen der Oberschwingungen auslöschen oder zumindest partiell überdecken bzw. in der Summe vermindern, um insbesondere hierdurch den Klirrfaktor zu reduzieren.

Durch die Wahl der Auslegungs-, Steuer- oder Regelungsgrößen ist es möglich, bestimmte Oberschwingungen, Gruppen von Oberschwingungen, sowie den gesamten Oberschwingungsgehalt zu vermindern. Dabei lassen sich durch die Erhöhung der Anzahl von Systemen die Freiheitsgrade erhöhen. Das heißt, durch den Einsatz von z. B. 3 Einheiten ist es möglich, eine Abstimmung auf 2 Oberschwingungen zu erreichen.

In den **Fig.** 1 bis **Fig.** 4 sind Beispiele für Systeme mit Gleich- und Wechselrichter dargestellt.

Zwei oder mehr elektrische Versorgungssysteme können nach **Fig.** 1 von einer gemeinsamen Spannungsebene ausgehend direkt oder über einen Transformator in das Netz einspeisen, bzw. nach **Fig.** 2, 3 und 4 über parallele Zweige getrennt oder magnetisch gekoppelt mit dem Netz verbunden werden. Dabei kann die Verbindung nieder-, mittel- oder hochspannungsseitig geschaffen werden.

Die Konfiguration nach **Fig.** 2 soll im folgenden beispielhaft betrachtet werden. Dabei wird die 25. Oberschwingung ausgewählt, die stark vermindert werden soll, weil im Bereich der 25. Oberschwingung die Netzeigenresonanzfrequenz besteht. Somit ergibt sich ein Differenzwinkel von $360°/2 \times 25 = 7{,}2°$ für die Ansteuerung. Wechselrichter, die auch bei ca. 10% Spannungsschwankung vor sogenanntem "Kippen" geschützt werden, lassen sich bei einem Ansteuerwinkel von etwa 140° sicher betreiben. Somit wird der Wechselrichter der ersten Stromquelle mit 140° und die zweite Stromquelle mit 132,8° betrieben. Um diesen Zustand z. B. im Nennbetrieb zu erhalten, sind die Übersetzungsverhältnisse der Transformatoren mit ca. 12% Unterschied zu wählen. Die Gesamtblindleistung erhöht sich dadurch um ca. 12%. Dabei wird die 25. Oberschwingung um 95%, die 23. um etwa 87% bis hin zur 11. um ungefähr 20% vermindert. Ohne wesentliche Zusatzkosten wird dadurch der Filteraufwand erheblich verringert.

Patentansprüche

1. Stromversorgungseinrichtung mit mindestens zwei Stromquellen, wobei jede Stromquelle über einen zugeordneten Stromrichter in ein Wechselstromnetz einspeist, **dadurch gekennzeichnet,** daß zur Herabsetzung der Amplitude einer bestimmten vorhandenen Oberschwingung die Spannung von mindestens einem der Stromrichter mit Hilfe eines Steuerwinkels phasenverschoben zu mindestens einem anderen Stromrichter in das Netz einspeisbar ist.
2. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jedem Stromrichter ein Transformator nachgeschaltet ist, dessen stromrichterseitige Wicklungen unterschiedliche Spannungsebenen aufweisen.
3. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jeder Stromrichter aus einem Gleichrichter und einem diesem nachgeschalteten Wechselrichter besteht, wobei der Gleichrichter zur Veränderung der Gleichstrom-Zwischenkreisspannung mit Hilfe seines Steuerwinkels steuer- oder regelbar ist.
4. Stromversorgungseinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Ausgangsspannung der mindestens zwei Stromquellen änderbar bzw. regelbar ist.

Hierzu 1 Seite(n) Zeichnungen

Nummer: DE 42 32 356 C2
Int. Cl.[6]: H 02 J 3/01
Veröffentlichungstag: 9. Januar 1997

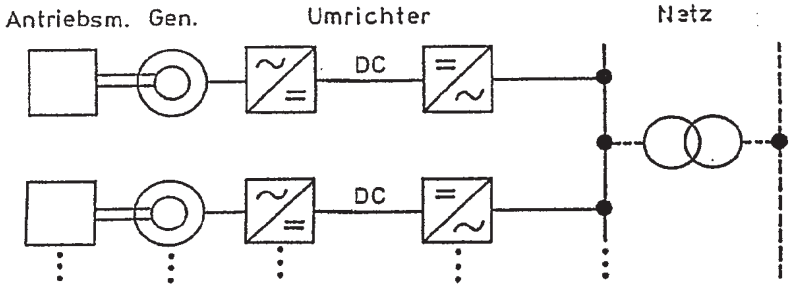


Fig. 1

Systeme mit gemeinsamer Netzkopplung

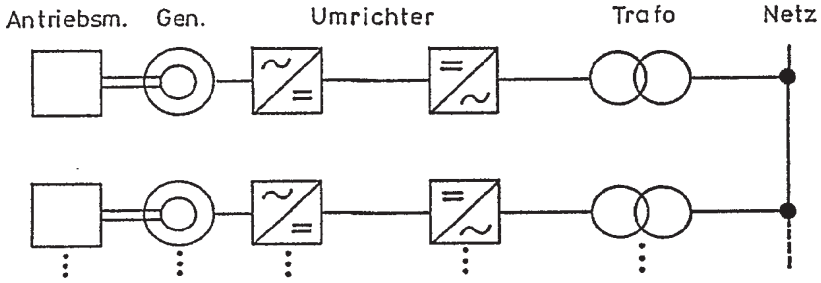


Fig. 2

Systeme mit getrennter Netzkopplung

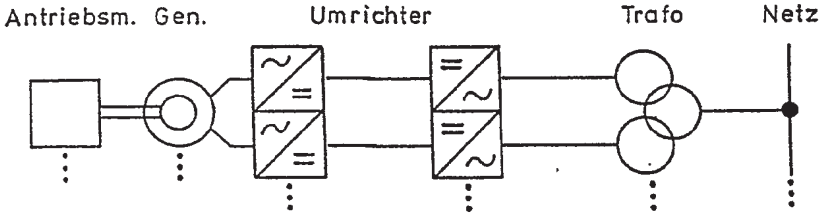


Fig. 3

Systeme mit galvanisch getrennten Zweigen (auch räumlich bzw. elektrisch versetzt)

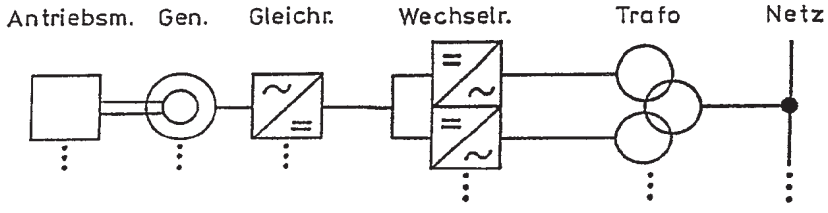


Fig. 4

Systeme mit getrennten Wechselrichterzweigen

602 162/99

SMA Solar Technology America, LLC, Ex. 1006

Arrangement for decentralized supply of regenerative energy performs voltage regulation at combination point for controlled improvement of quality of electrical supply

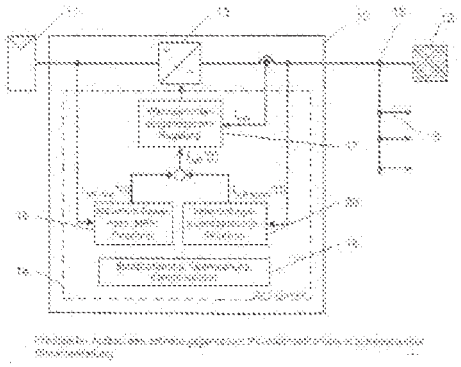
Publication number: DE19961705 (A1)
Publication date: 2001-07-05
Inventor(s): CRAMER GUENTHER [DE]; KLEINKAUF WERNER [DE]; MEINHARDT MIKE [DE]; ZACHARIAS PETER [DE] +
Applicant(s): SMA REGELSYSTEME GMBH [DE] +
Classification:
- international: ***H02J3/38; H02M1/12; H02M7/48;*** **H02J3/38; H02M1/12; H02M7/48;** (IPC1-7): G05F1/10; G05F1/67; H02J3/01; H02J3/38; H02M1/12; H02M7/48
- European: H02J3/38; H02M1/12; H02M7/48
Application number: DE19991061705 19991221
Priority number(s): DE19991061705 19991221

Also published as:
DE19961705 (B4)

Cited documents:
DE19819869 (A1)
DE19756777 (A1)

Abstract of **DE 19961705 (A1)**

The arrangement regulates the voltage at a combination point for controlled electrical supply quality improvement. The arrangement for supplying power and the voltage regulator are in one unit. The regulator has arrangements for specifying a desired voltage spectrum at the combination point, diagnosing the state of the supply network and determining demand values of harmonics and/or a fundamental frequency reactive power to be compensated. The arrangement performs voltage regulation at a combination point for controlled improvement of the quality of the electrical supply. The arrangement for supplying power and the voltage regulator are contained in one unit.; The regulator (17,20) has arrangements for specifying a desired voltage spectrum at the combination point, for diagnosing the state of the supply network and for determining demand values of harmonics to be compensated and/or a fundamental frequency reactive power to be compensated. Independent claims are also included for the following: a current converter.



Data supplied from the ***espacenet*** database — Worldwide

(19) Bundesrepublik Deutschland
Deutsches Patent- und Markenamt

(10) **DE 199 61 705 B4** 2005.12.01

(12) # Patentschrift

(21) Aktenzeichen: **199 61 705.8**
(22) Anmeldetag: **21.12.1999**
(43) Offenlegungstag: **05.07.2001**
(45) Veröffentlichungstag
der Patenterteilung: **01.12.2005**

(51) Int Cl.[7]: **H02J 3/38**
H02J 3/01, H02M 7/48, H02M 1/12, G05F 1/10, G05F 1/67

Innerhalb von drei Monaten nach Veröffentlichung der Patenterteilung kann nach § 59 Patentgesetz gegen das Patent Einspruch erhoben werden. Der Einspruch ist schriftlich zu erklären und zu begründen. Innerhalb der Einspruchsfrist ist eine Einspruchsgebühr in Höhe von 200 Euro zu entrichten(§ 6 Patentkostengesetz in Verbindung mit der Anlage zu § 2 Abs. 2 Patentkostengesetz).

(73) Patentinhaber:
SMA Technologie AG, 34266 Niestetal, DE

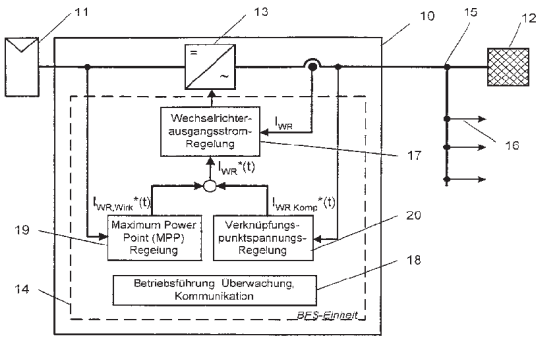
(74) Vertreter:
Walther, Walther & Hinz GbR, 34130 Kassel

(72) Erfinder:
Cramer, Günther, 34128 Kassel, DE; Kleinkauf, Werner, Prof. Dr.-Ing., 34125 Kassel, DE; Meinhardt, Mike, Dr.-Ing., 34266 Niestetal, DE; Zacharias, Peter, Dr.-Ing., 34414 Warburg, DE

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 198 19 869 A1
DE 197 56 777 A1
EN 6100;

(54) Bezeichnung: **Vorrichtung zur dezentralen Einspeisung regenerativer Energie**

(57) Hauptanspruch: Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes (12) mit insbesondere regenerativer Energie, aufweisend Mittel (13) zur Einspeisung von elektrischer Energie in das Energienetz (12) mit einer an einem Verknüpfungspunkt mit dem Energienetz (12) angeordneten Spannungsregelung (17, 20), dadurch gekennzeichnet, dass die am Verknüpfungspunkt angeordnete Spannungsregelung (17, 20) Mittel (20) zur Erfassung einer am Verknüpfungspunkt anliegenden Energienetzspannung, Mittel (33) zur Vorgabe eines am Verknüpfungspunkt gewünschten Spannungsspektrums, Mittel (31) zur Diagnose der erfassten Energienetzspannung in Bezug auf das gewünschte Spannungsspektrum, Mittel (32) zur Bestimmung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der am Verknüpfungspunkt anliegenden Spannung mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung aufweist.



Beschreibung

[0001] Die Erfindung betrifft eine Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes gemäß dem Oberbegriff des Anspruchs 1. Ferner bezieht sich die Erfindung auf einen entsprechenden Stromrichter gemäß dem Oberbegriff des Anspruches 12.

Stand der Technik

[0002] Die Merkmale der Oberbegriffe sind aus DE 197 56 777 A1 bekannt.

[0003] In der Druckschrift DE 197 57 777 A1 ist ein Verfahren zur Regelung der Spannung am Verknüpfungspunkt beschrieben. Hierbei wird die effektive Spannung, d. h. der geometrische Mittelwert aller Oberschwingungsspannungsteile, in einem vorgegebenen Zeitbereich erfasst. Sinkt die Spannung, wird entsprechend Wirk- oder Blindleistung in das Netz eingespeist. Insbesondere werden dort ausschließlich die netzfrequenten Anteile auf einen Sollwert geregelt, und zwar die jeweilige Amplitude eines von mehreren Frequenzanteilen.

[0004] Auf dem Gebiet der Photovoltaik (PV) sind PV-Wechselrichter bekannt, die Stromrichter darstellen, deren Aufgabe die Umwandlung von Gleichspannungsleistung in Wechselspannungsleistung darstellt, mit dem Ziel, photovoltaisch erzeugte Leistung in ein elektrisches Inselnetz oder in ein großräumiges elektrisches Energieversorgungsnetz einzuspeisen. Die Qualität der elektrischen Energieversorgung ist neben der Verfügbarkeit des Netzes im wesentlichen bestimmt durch Netzspannungseffektivwert, Netzfrequenz und Kurvenform der Netzspannung. Die Liberalisierung des europäischen Strommarktes birgt die Gefahr einer Verschlechterung der Stromversorgungsqualität. Durch die zunehmende Zahl der Anschlüsse elektronischer Geräte mit nicht-linearer Verbraucherkennlinie wird die Notwendigkeit für aktive Maßnahmen zur Verbesserung der Stromqualität noch weiter erhöht.

[0005] Eine Verbesserung der Stromversorgungsqualität (Spannungsqualität) kann prinzipiell geschehen durch

a) gezieltes Einspeisen bzw. Verbrauchen von Grundschwingungsblindleistung zur Anhebung bzw. Absenkung des Netzspannungseffektivwertes mittels (geschalteter) Kondensatoren oder geeigneter Stromrichter;

b) gezieltes Einspeisen bzw. Herausfiltern von Oberschwingungsströmen zur 'Entzerrung' der Netzspannungskurven (Verringerung des Klirrfaktors) mittels passiver Filter (Bandpässen bzw. Bandsperren) oder geeigneter Stromrichter (aktive Filter).

[0006] Um der Verschlechterung der Netzqualität entgegenzuwirken, werden bei PV-Anlagen sogenannte selbstgeführte Wechselrichter eingesetzt, die meist nur reine Wirkleistung ins Netz einspeisen. Nachts werden diese Wechselrichter in der Regel vom Netz getrennt, da dann kein solares Energieangebot vorliegt und Stand by-Verluste vermieden werden sollen. Abhängig von der Schaltfrequenz der Wechselrichter ist der Oberschwingungsgehalt des Klemmenstroms relativ gering, so dass man häufig auch von "ideal sinusförmiger" Einspeisung redet. Die heutigen PV-Wechselrichter können allerdings nicht zur aktiven Verbesserung der Netzspannungsqualität eingesetzt werden.

[0007] Maßnahmen zur Spannungsqualitätsverbesserung kommen in den meisten Fällen an zentralen Netzpunkten (Sammelschienen oder Unterverteilungen) zum Einsatz. Um eine optimale Wirkung zu erzielen, muss die Kompensation von Oberschwingungsströmen und Blindleistung jedoch dezentral stattfinden, da auch deren Generierung in den Verbrauchern dezentral geschieht. Derzeit hierfür eingesetzte Filter werden allerdings ausschließlich 'gesteuert' betrieben, d.h. die Sollwerte für die zu kompensierende Blindleistung und/oder Oberschwingungsströme werden stationär von außen vorgegeben. Eine 'Regelung' der Spannungsqualität findet nicht statt. Desweiteren erlauben diese aktiven Filter im Allgemeinen nicht die Einspeisung von Wirkleistung in das Netz über einen längeren Zeitraum.

Aufgabenstellung

[0008] Der vorliegeden Erfindung liegt somit die Aufgabe zugrunde, eine Vorrichtung bzw. einen entsprechenden Stromrichter anzugeben, welche die Stromqualität der in ein Netz eingespeisten elektrischen Energie verbessern.

[0009] Diese Aufgabe wird durch die Merkmale der Ansprüche 1 bzw. 12 gelöst. Vorteilhafte Ausgestaltungen sind in den Unteransprüchen angeführt.

[0010] Der Erfindung liegt das Konzept zugrunde, die Kompensation von Oberschwingungsströmen und Blindleistung geregelt und dezentral stattfinden zu lassen. Da auch deren Generierung in den Verbrauchern dezentral geschieht, bietet ein ebenfalls dezentrales Entgegenwirken den höchsten Grad an erzielbarer Wirkung, da es direkt an der Quelle ansetzt. Durch diese dezentrale und geregelte Art der Blindleistungs- und Oberschwingungskompensation werden insbesondere Verluste und Störungen vermieden, die durch eventuelle Über- bzw. Unterkompensation und/oder große räumliche Distanz zwischen störaussendender Quelle und Geräte zur Stromversorgungs-Qualitätsverbesserung in unnötiger Weise entstehen.

Page 105 of 219 SMA Solar Technology America, LLC, Ex. 1006

[0011] Die Besonderheit der Erfindung liegt nun darin, die Einspeisung regenerativer Energie in ein Netz und eine kontrollierte Einflussnahme auf die Netzqualität in einer einzigen Vorrichtung gleichzeitig durchzuführen. Zu diesem Zweck wird eine Betriebsführungseinheit des Stromrichters erfindungsgemäß um einen Funktionsblock "Regelung der Spannung am Verknüpfungspunkt (VP)" erweitert, der den Zustand des angeschlossenen Netzes diagnostiziert und entsprechende Sollwerte für die zu kompensierenden Oberschwingungsströme und Blindleistung ermittelt. Dadurch wird eine geregelte Einflussnahme auf das Spannungsspektrum der Versorgungsspannung (Spannung am Verknüpfungspunkt) ermöglicht. Zudem ermöglicht der vorgeschlagene PV-Wechselrichter eine Regelung der Grundschwingungsamplitude der Verknüpfungspunktspannung an entfernt liegenden Verknüpfungs-Einspeisepunkten durch eine gezielte Einspeisung von Wirkleistung und/oder kapazitiver bzw. induktiver Blindleistung.

[0012] Natürlich kann die Einspeisung von Oberschwingungsströmen und kapazitiver bzw. induktiver Blindleistung auch weiterhin gesteuert erfolgen.

[0013] Der Einsatz eines PV-Wechselrichters mit integrierter, geregelter Filterfunktion ist zudem wirtschaftlich günstiger als der Einsatz von zwei getrennten Einheiten zur Einspeisung von PV-Energie und der Kompensation der Störgrößen, und zwar ein PV-Wechselrichter und daneben ein aktives Filter. Der vorgeschlagene Wechselrichter ist daher billiger und kleiner herstellbar als bekannte Geräte.

[0014] Bei der technischen Realisierung eines erfindungsgemäßen Stromrichters, insbesondere im Zusammenhang mit der erforderlichen Signal- bzw. Datenverarbeitung bei der Erfassung und Auswertung der genannten Netzgrößen, können vorteilhaft kostengünstige Digitale Signalprozessoren (DSP) eingesetzt werden.

Ausführungsbeispiel

[0015] Weitere Eigenschaften, Merkmale und Vorteile der Erfindung ergeben sich aus der nachfolgenden detaillierten Beschreibung eines Ausführungsbeispieles.

[0016] Im Einzelnen zeigen:

[0017] Fig. 1 Prinzipieller Aufbau eines erfindungsgemäßen PV-Wechselrichters in schematischer Blockdarstellung;

[0018] Fig. 2 die Struktur des Wechselrichterausgangsstrom-Regelkreises;

[0019] Fig. 3 die Funktionsgruppen der Verknüpfungspunktspannungs (U_{VP})-Regelung;

[0020] Fig. 4 die Struktur des U_{VP}-Regelkreises;

[0021] Fig. 1 zeigt den Prinzipaufbau eines erfindungsgemäßen Photovoltaik (PV)-Wechselrichters **10**, der am Verknüpfungspunkt (VP) **15** gemeinsam mit anderen Verbrauchern **16** an das Energieversorgungsnetz **12** angeschlossen ist. Der PV-Wechselrichter **10** verbindet einen Solargenerator **11** mit einem elektrischen Energieversorgungsnetz **12**, wobei eine vom Solargenerator **11** gelieferte Gleichspannung über ein Wechselrichterleistungsteil **13** in eine Wechselspannung umgewandelt wird.

[0022] Der PV-Wechselrichter **10** ist erfindungsgemäß als aktives Filter zur Regelung der Spannung bzw. Verbesserung der Spannungsqualität am Verknüpfungspunkt ausgebildet. Der PV-Wechselrichter besteht im Einzelnen aus einem leistungselektronischen Stellglied mit hoher Dynamik **13** und einer Betriebsführungs- und Systemsteuerungseinheit (BFS) **14**. Die BFS umfasst eine Funktionseinheit **18**, die die Überwachung sowie den Schutz des Wechselrichterleistungsteils übernimmt, so dass ein sicherer Betrieb der gesamten Anlage **10**–**12** gewährleistet ist. Desweiteren übernimmt diese Funktionseinheit die Kommunikation mit dem Benutzer.

[0023] Es existieren mehrere, kaskadierte Regelkreise, die ebenso Teil der BFS-Einheit sind. Der innerste Regelkreis ist die Wechselrichterausgangsstrom (I_{Wr})-Regelung. Die überlagerten Regelkreise sind die Maximum Power Point (MPP)-Regelung **19** und die Verknüpfungspunktspannungs (U_{VP})-Regelung **20**. Dabei ist $I_{WR,Wirk}^{*}$ die Stellgröße des MPP-Reglers und $I_{WR,Komp}^{*}$ die Stellgröße des U_{VP}-Reglers.

[0024] Wie in Fig. 1 zu erkennen ist, setzt sich der Sollwert des I_{WR}-Regelkreises aus der Summe des Wirkstromsollwertes $I_{WR,Wirk}^{*}$, der vom MPP-Regler vorgegeben wird, und dem Kompensationsstromsollwert $I_{WR,Komp}^{*}$ vorgegeben vom U_{VP}-Regler, zusammen.

[0025] Die Struktur der I_{WR}-Regelung ist in Fig. 2 dargestellt. Als Überlastungsschutz (z.B. Schutz der Leistungshalbleiter des PV-Wechselrichters vor zu hohen Strömen) enthält der I_{WR}-Regelkreis eine Sollwertbegrenzung. Bei Überschreiten des maximal zulässigen Wertes wird eine Rückmeldung an den U_{VP}- und/oder MPP-Regler gegeben, damit die Sollwerte ($I_{WR,Wirk}^{*}$ bzw. $I_{WR,Komp}^{*}$) entsprechend verzerrungsfrei reduziert werden können.

[0026] Der PV-Wechselrichter dient als leistungselektronisches Stellglied. Die Verknüpfungspunktspannung U_{VP} kann als Störgröße für den I_{WR}-Regelkreis aufgefasst werden.

[0027] Die Anforderungen an die I_{WR}-Regelung sind

hohe Dynamik sowohl im Führungsverhalten als auch im Störverhalten. Die Grenzfrequenz der Regelung muss in jedem Fall größer sein als die höchste Frequenz des zu kompensierenden Oberschwingungsspektrums.

[0028] Die Implementierung dieser Regelung kann sowohl digital in einem Mikrorechner als auch analog geschehen.

[0029] Der 'Maximum Power Point Regler' sorgt durch die Vorgabe eines geeigneten Wirkanteils des Wechselrichterausgangsstrom-Sollwertes ($I_{WR,Wirk}^*$) für eine optimale Ausnutzung der vom Solargenerator **11** gelieferten Leistung.

[0030] Die vorliegende Erfindung benötigt keine besondere MPP-Regelstrategie. Es kann ein beliebiges aus der Vielzahl der in der Literatur beschriebenen Verfahren gewählt werden. Normalerweise wird die MPP-Regelung in einem Mikrorechner implementiert.

[0031] Wie in Fig. 3 zu sehen, umfasst die U_{VP} Regelung **20** folgende Funktionsblöcke: "Diagnose des Netzzustandes" **31**, "Sollwertvorgabe eines gewünschten Spektrums der Verknüpfungspunktspannung" **32** und "Bestimmung des Kompensationsstromsollwertes" **33**.

[0032] Alle Blöcke werden zyklisch abgearbeitet; somit erreicht man eine dynamische Anpassung des Kompensationsstromsollwertes an den aktuellen Netzzustand und man vermeidet Über- oder Unterkompensation. Die Realisierung der U_{VP}-Regelung kann beispielsweise in einem Mikrorechner bzw. digitalen Signalprozessor geschehen.

[0033] Der Funktionsblock "Diagnose des Netzzustandes" stellt das Messglied des U_{VP} Regelkreises dar. Dieser Funktionsblock ist notwendig, um ein Bild von den Netzverhältnissen am Verknüpfungspunkt zu bekommen. Mögliche Realisierungen sind Messung und spektrale Analyse der Verknüpfungspunktspannung $\underline{U}_{VP}$ und/oder Netzimpedanz $\underline{Z}_{VP}$(Z_{VP}-Erfassung ist für die Funktionsweise nicht notwendig).

[0034] Für den Fall, dass die Verknüpfungspunktspannungs-Regelung n Frequenzanteile f_1 bis f_n (z.B. n = 3, f_1 = 50 Hz, f_2 = 150 Hz, f_3 = 250 Hz) berücksichtigt, erhält man als Ausgabe der "Diagnose des Netzzustandes" m = 2 n Signale. Dies kann beispielsweise Betrag und Phase oder auch Real- und Imaginärteil des entsprechenden Frequenzanteils der Spannung bzw. Impedanz sein.

[0035] Der Funktionsblock "Sollwertvorgabe....." **33** liefert die gewünschten spektralen Anteile (Frequenzanteil) der Verknüpfungspunktspannung (einschließlich der gewünschten Amplitude der Grundschwingung). Idealerweise wird man ein Spektrum ohne Oberschwingungsgehalt vorgeben. Da es sich beim Sollwert der Verknüpfungspunktspannung wie auch bei deren Istwert um eine komplexe Größe handelt, sind auch hier zwei Signale für jeden Frequenzanteil, also insgesamt m = 2 × n Signale zur Beschreibung des gewünschten Spektrums der Verknüpfungspunktspannung $\underline{U}_{VP}^*$ notwendig. Dies ist jedoch in vielen Fällen unwirtschaftlich, denn es kann zu einem sehr großen Kompensationsstromsollwert führen. Ein weiterer möglicher Betriebsmodus besteht darin, dass Frequenzanteile der Oberschwingungsspannung unkompensiert bleiben. Dies ist denkbar für den Fall, dass die gemessenen Oberschwingungsspannungen innerhalb eines gewissen, vom Anlagenbetreiber vorgebbaren Toleranzbereiches liegen.

[0036] Für den Fall, dass der Wechselrichterausgangsstrom-Regler eine Sollwertbegrenzung anzeigt, muss der Kompensationsstromsollwert verringert werden. Dies kann durch eine Änderung des gewünschten Spektrums der Verknüpfungspunktspannung geschehen.

[0037] Im Funktionsblock "Bestimmung des Kompensationsstromsollwertes" **32** wird der Kompensationsanteil des Wechselrichterausgangsstromsollwertes ($I_{WR,Komp}^*$) basierend auf der Kenntnis des Netzzustandes, so berechnet, dass die vorgegebenen Sollwerte der Oberschwingungsspannungen und der Grundschwingungsspannung eingeregelt werden können. Der Kompensationsstromsollwert wird dann an den unterlagerten Wechselrichterausgangsstrom-Regelkreis übergeben.

[0038] Die Funktionsweise der U_{VP} Regelung wird anhand von Fig. 4 erläutert. Für jeden zu kompensierenden Frequenzanteil f_1 ... f_n ist ein gesonderter Regler vorzusehen. Jede dieser n Reglerbaugruppen **41**–**43** kann, wie beispielsweise bei der feldorientierten Regelung von Drehfeldmaschinen weit verbreitet, in einem mit der entsprechenden Frequenz (f_1 ... f_n) rotierenden Koordinatensystem realisiert werden. Für den Fall, dass die Netzimpedanz am Verknüpfungspunkt zur Diagnose des Netzzustandes gemessen wird, kann ein dem Quotienten aus gemessener Verknüpfungspunktspannung und Impedanz am Verknüpfungspunkt proportionaler Wert (z.B. $\underline{I}_{WR,Komp}^*(f_1)$"= $\underline{U}_{VP,ist}(f_1)\cdot\underline{K}(f_1)/\underline{Z}_{VP}(f_1)$) auf den Reglerausgang (z.B. $\underline{I}_{WR,Komp}^*(f_1)$') in Form einer Vorsteuerung **45** aufgeschaltet werden. Eine eventuelle notwendige Begrenzung der Höhe des Stromsollwertanteils $\underline{I}_{WR,Komp}^*(t)$ kann durch Anpassung des Proportionalitätsfaktors (z.B. $\underline{K}(f_1)$) realisiert werden.

[0039] Zur Rücktransformation der Sollwerte ($\underline{I}_{WR,Komp}^*(f_n)$) in den Zeitbereich ($\underline{I}_{WR,Komp}^*(t)$ kann beispielsweise die Fouriertransformation verwendet werden.

[0040] Das Einsatzspektrum des vorgeschlagenen Stromrichters umfasst allgemein Netzanschlüsse von vorbeschriebenen PV-Anlagen, insbesondere Anschlüsse von PV-Anlagen an Verknüpfungspunkten mit hoher Netzimpedanz, d.h. 'schwachen Netzen'. Es versteht sich, dass der Stromrichter auch – über die beschriebene Anwendung im Bereich der Photovoltaik hinaus – bei Industrieanlagen, in denen sowohl Blind- und/oder Wirkleistungsschwankungen als auch Verzerrungen der Netzspannung in unterschiedlichem Maße auftreten, vorteilhaft eingesetzt werden kann. Letztere Störgrößen können beispielsweise durch einen diskontinuierlichen Produktionsprozess oder stark schwankende Tageslastkurven hervorgerufen sein.

Patentansprüche

1. Vorrichtung zur dezentralen Energieversorgung eines elektrischen Energienetzes (**12**) mit insbesondere regenerativer Energie, aufweisend Mittel (**13**) zur Einspeisung von elektrischer Energie in das Energienetz (**12**) mit einer an einem Verknüpfungspunkt mit dem Energienetz (**12**) angeordneten Spannungsregelung (**17**, **20**), **dadurch gekennzeichnet**, dass die am Verknüpfungspunkt angeordnete Spannungsregelung (**17**, **20**) Mittel (**20**) zur Erfassung einer am Verknüpfungspunkt anliegenden Energienetzspannung, Mittel (**33**) zur Vorgabe eines am Verknüpfungspunkt gewünschten Spannungsspektrums, Mittel (**31**) zur Diagnose der erfassten Energienetzspannung in Bezug auf das gewünschte Spannungsspektrum, Mittel (**32**) zur Bestimmung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der am Verknüpfungspunkt anliegenden Spannung mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung aufweist.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die Mittel (**13**) zur Einspeisung von elektrischer Energie und die Spannungsregelung (**17**, **20**) in einer Baueinheit angeordnet sind.

3. Vorrichtung nach Anspruch 1, gekennzeichnet durch Mittel (**31**) zur Bestimmung eines Netzspannungs-Istwertes sowie Mittel (**32**) zur insbesondere dynamischen Bestimmung eines Kompensationsstrom-Sollwertes aus dem ermittelten Netzspannungs-Istwert.

4. Vorrichtung nach Anspruch 3, gekennzeichnet durch Mittel zur insbesondere dynamischen Bestimmung eines Soll-Ausgangsstromes unter Berücksichtigung des Kompensationsstrom-Sollwertes und eines Wirkstromes.

5. Vorrichtung nach einem oder mehreren der vorangehenden Ansprüche, gekennzeichnet durch ein geregeltes, aktives Leistungsfilter.

6. Vorrichtung nach Anspruch 5, dadurch gekennzeichnet, dass das geregelte Filter Mittel zur Regelung der Blindleistungsaufnahme aus bzw. Blindleistungslieferung an das Energienetz und/oder Mittel zur Regelung des Spektrums der Spannung am Verknüpfungspunkt mit dem Netz aufweist.

7. Vorrichtung nach einem der voranstehenden Ansprüche, dadurch gekennzeichnet, dass bei der Ermittlung von Sollwerten eine Begrenzung der Höhe des Sollwertes stattfindet, um den Wechselrichter vor Überlast zu schützen.

8. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, dass durch das Mittel (**33**) zur Sollwertvorgabe der Verknüpfungsspannung ($\underline{U}_{VP}^{*}$) die Begrenzung der Höhe des Wechselrichterausgangsstrom-Sollwertes ($\underline{I}_{WR}$) auf der Basis des Frequenzbereiches erfolgt.

9. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass für jeden Frequenzanteil (f_i) des Spektrums der Verknüpfungspunktspannung eine Regelbaugruppe (**41**–**43**) vorgesehen ist, wobei durch diesen Regler ein Wechselrichterstrom-Sollwert $\underline{I}_{WR,Komp}^{*}(f_i)$ vorgegeben wird, wobei aus der Gesamtheit der Wechselrichterstrom-Sollwerte $\underline{I}_{WR,Komp}^{*}(f_1)$ ....$\underline{I}_{WR,Komp}^{*}(f_n)$ durch Rücktransformation vom Frequenzbereich zum Zeitbereich der Sollwert des Kompensationsstroms im Zeitbereich $\underline{I}_{WR,Komp}^{*}(t)$ erzeugt wird.

10. Vorrichtung nach Anspruch 1 oder 9, dadurch gekennzeichnet, dass in Abhängigkeit von der Netzimpedanz am Verknüpfungspunkt und/oder Spannung am Verknüpfungspunkt für jeden Frequenzanteil (f_i) ein Stromsollwert $\underline{I}_{WR,Komp}^{*}(f_i)$", berechnet aus Impedanz und einem der Spannung proportionalen Wert, auf den $\underline{I}_{WR,Komp}^{*}(f_i)$' aufgeschaltet wird.

11. Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, dass durch Auswahl des Proportionalitätsfaktors der Spannung die Höhe des Stromsollwertes $\underline{I}_{WR,Komp}^{*}(f_i)$" begrenzt ist

12. Stromrichter, insbesondere Photovoltaik-Wechselrichter, mit einer ersten Funktionseinheit (**14**) zur Einspeisung von insbesondere regenerativer Energie in ein Energienetz (**12**) an einem Verknüpfungspunkt des Stromrichters mit dem Energienetz (**12**), gekennzeichnet durch eine wenigstens zweite Funktionseinheit (**20**) aufweisend Mittel zur Erfassung einer am Verknüpfungspunkt vorliegenden Energienetzspannung, Mittel (**31**) zur Diagnose der erfassten Energienetzspannung in Bezug auf ein gewünschtes Spannungsspektrum, Mittel (**32**) zur Er-

mittlung von Sollwerten von zu kompensierenden Oberschwingungen und/oder einer zu kompensierenden Grundschwingungsblindleistung aus dem gewünschten Spannungsspektrum sowie Mittel zur Regelung der Blindleistungsaufnahme aus bzw. der Blindleistungsabgabe an das Energienetz (**12**) mittels der Sollwerte der zu kompensierenden Oberschwingungen und/oder der zu kompensierenden Grundschwingungsblindleistung.

13. Stromrichter nach Anspruch 12, gekennzeichnet durch Mittel (**31**) zur Erfassung eines Netzspannungs-Istwertes sowie Mittel (**32**) zur dynamischen Bestimmung eines Kompensationsstrom-Sollwertes aus dem ermittelten Netzspannungs-Istwert.

14. Stromrichter nach einem oder mehreren der Ansprüche 12 und 13, gekennzeichnet durch einen oder mehrere Mikroprozessoren und/oder digitale Signalprozessoren (DSP) zur Ausführung der Diagnose und/oder Ermittlung der Kompensationsstrom-Sollwerte und/oder Vorgabe einer gewünschten spektralen Zusammensetzung der Spannung am Verknüpfungspunkt und/oder Realisierung der Reglerbaugruppen und/oder Rücktransformation in den Zeitbereich.

15. Stromrichter nach einem der voranstehenden Ansprüche 12 bis 14, dadurch gekennzeichnet, dass bei der Ermittlung von Sollwerten eine Begrenzung der Höhe des Sollwertes stattfindet, um den Wechselrichter vor Überlast zu schützen.

16. Stromrichter nach Anspruch 15, dadurch gekennzeichnet, dass durch das Mittel (**33**) zur Sollwertvorgabe der Verknüpfungsspannung ($\underline{U}_{VP}^{*}$) die Begrenzung der Höhe des Wechselrichterausgangsstrom-Sollwertes ($\underline{I}_{WR}$) auf der Basis des Frequenzbereiches erfolgt.

17. Stromrichter nach Anspruch 12, dadurch gekennzeichnet, dass für jeden Frequenzanteil (f_i) des Spektrums der Verknüpfungspunktspannung eine Regelbaugruppe (**41**–**43**) vorgesehen ist, wobei durch diesen Regler ein Wechselrichterstrom-Sollwert $\underline{I}_{WR,Komp}^{*}(f_i)$ vorgegeben wird, wobei aus der Gesamtheit der Wechselrichterstrom-Sollwerte $\underline{I}_{WR,Komp}^{*}(f_1)''$ $\underline{I}_{WR,Komp}^{*}(f_n)$ durch Rücktransformation vom Frequenzbereich zum Zeitbereich der Sollwert des Kompensationsstroms im Zeitbereich $\underline{I}_{WR,Komp}^{*}(t)$ erzeugt wird.

18. Stromrichter nach einem der Ansprüche 12 bis 17, dadurch gekennzeichnet, dass in Abhängigkeit von der Netzimpedanz am Verknüpfungspunkt und/oder Spannung am Verknüpfungspunkt für jeden Frequenzanteil (f_i) ein Stromsollwert $\underline{I}_{WR,Komp}^{*}(f_i)''$, berechnet aus Impedanz und einem der Spannung proportionalen Wert, auf den $\underline{I}_{WR,Komp}^{*}(f_i)'$ aufgeschaltet wird.

19. Stromrichter nach Anspruch 18, dadurch gekennzeichnet, dass durch Auswahl des Proportionalitätsfaktors der Spannung die Höhe des Stromsollwertes $\underline{I}_{WR,Komp}^{*}(f_i)''$ begrenzbar ist.

Es folgen 4 Blatt Zeichnungen

Page 109 of 219 SMA Solar Technology America, LLC, Ex. 1006

Anhängende Zeichnungen

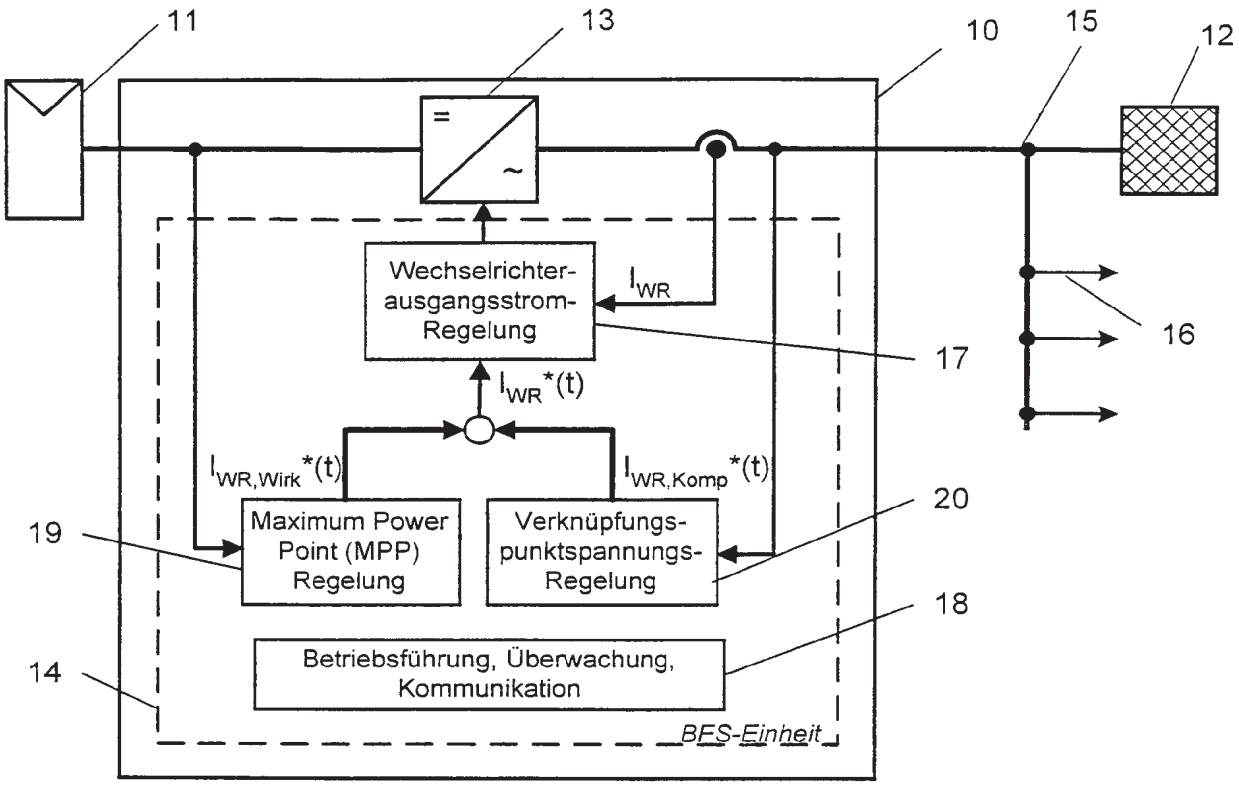


Fig. 1: Prinzipieller Aufbau des erfindungsgemäßen PV-Wechselrichters in schematischer Blockdarstellung

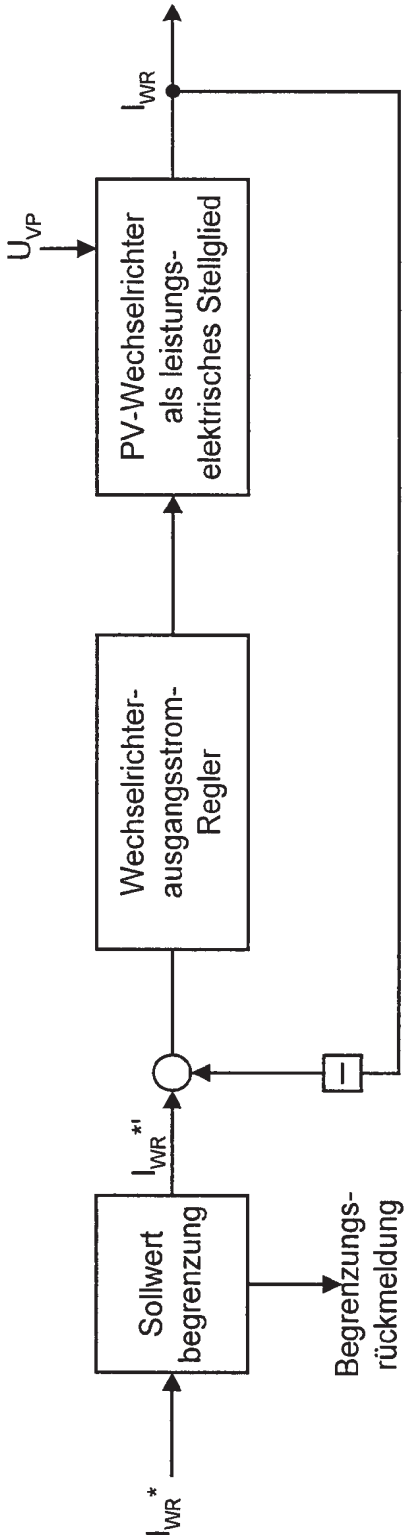


Fig. 2: Struktur des Wechselrichterausgangsstrom-Regelkreises

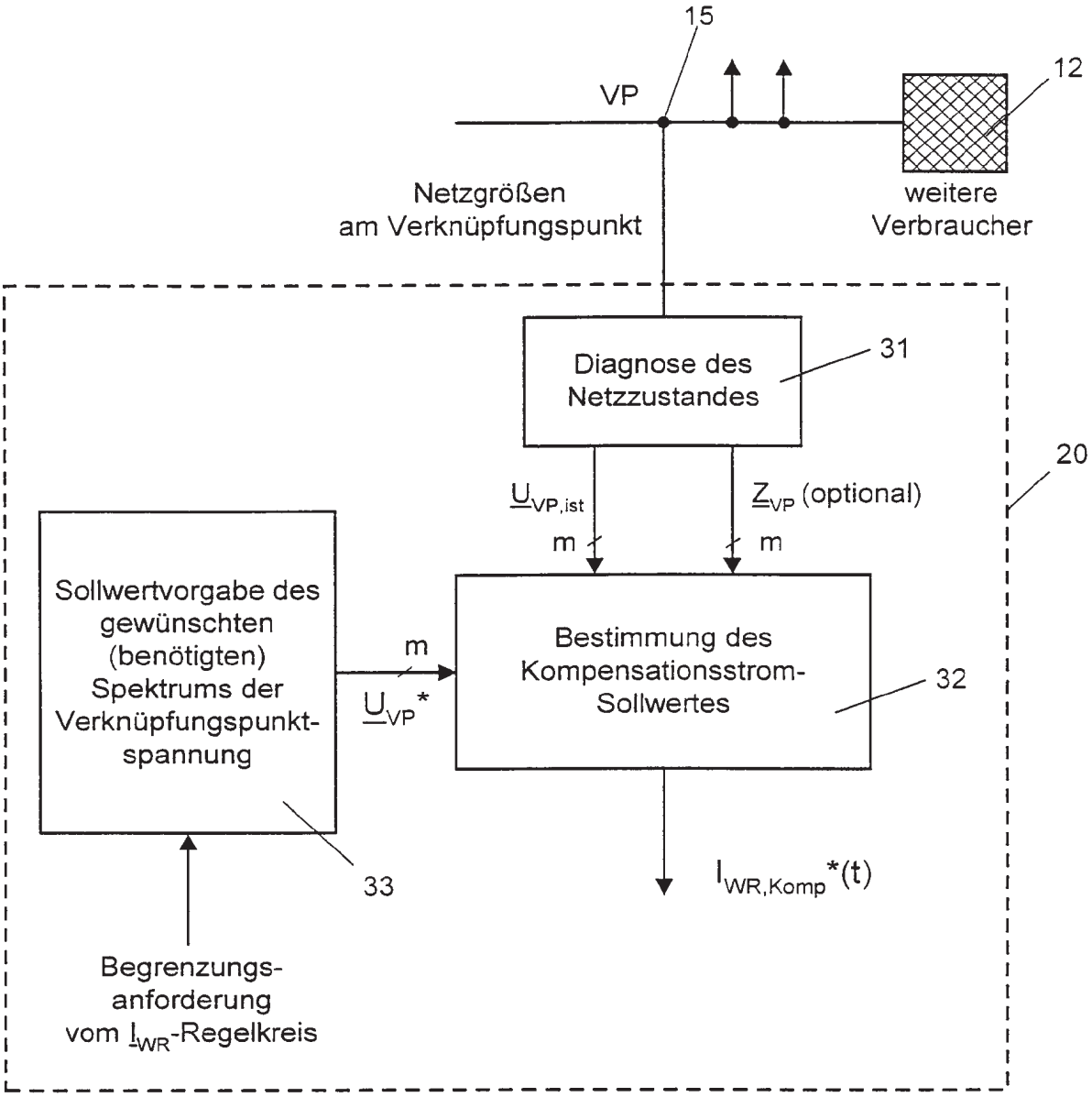


Fig. 3: Funktionsgruppen der Verknüpfungspunktspannungs-Regelung

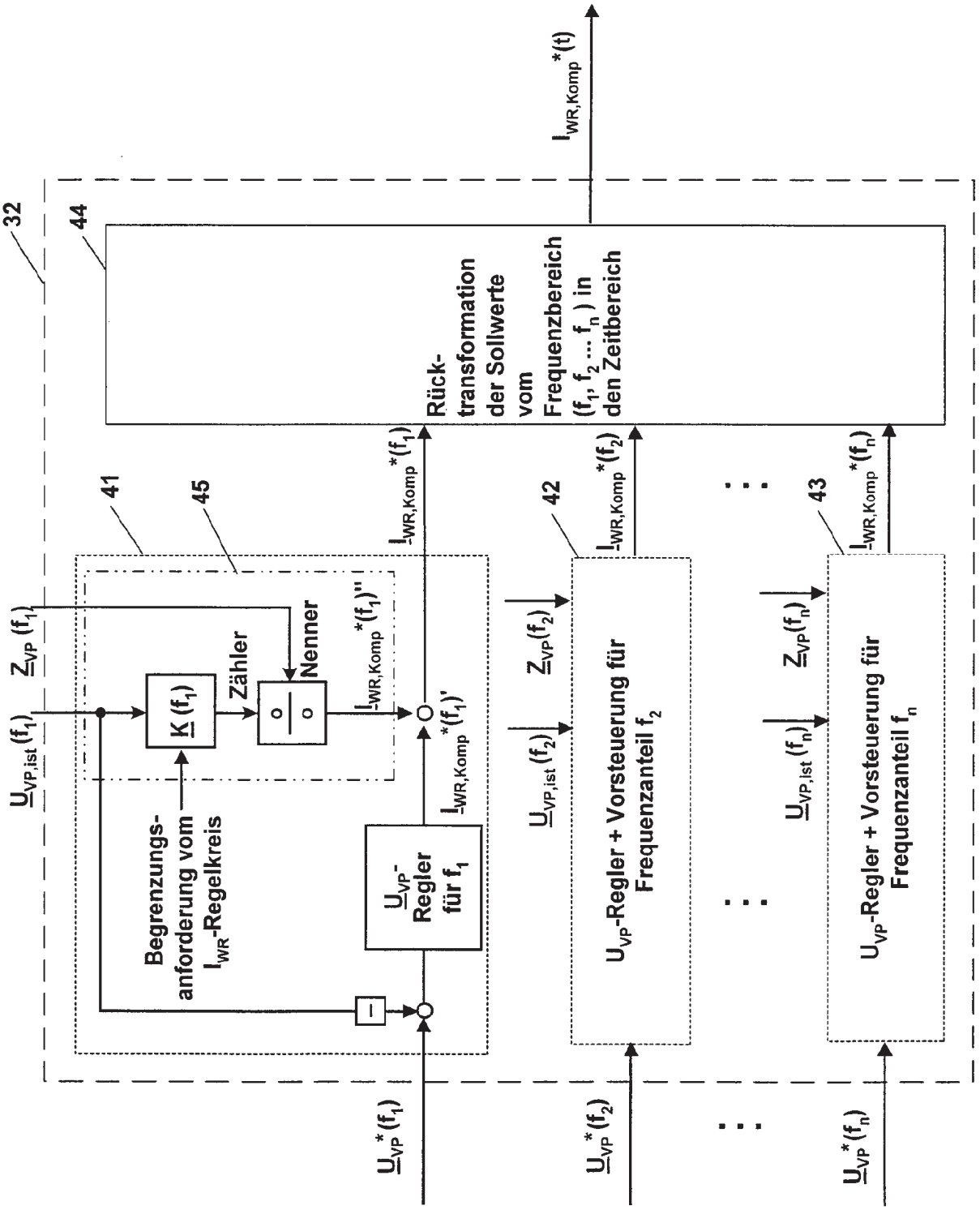


Fig 4 : Struktur des Verknüpfungspunktspannung-Regelkreises

SMA Solar Technology America, LLC, Ex. 1006

Source conditioning circuit at a maximum power point

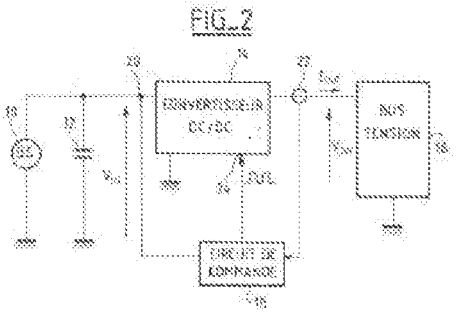
Publication number: EP1388774 (A1)
Publication date: 2004-02-11
Inventor(s): DELEPAUT CHRISTOPHE [BE] +
Applicant(s): CIT ALCATEL [FR] +
Classification:
- international: ***G05F1/67; H01L31/04;*** **G05F1/66; H01L31/04;** (IPC1-7): G05F1/67
- European: G05F1/67
Application number: EP20030291745 20030715
Priority number(s): FR20020010140 20020809

Also published as:
US2004124816 (A1)
US6919714 (B2)
JP2004078950 (A)
FR2843464 (A1)

Cited documents:
FR2819653 (A1)
EP0027405 (A1)
FR2626689 (A1)
US5932994 (A)
US5530335 (A)

Abstract of **EP 1388774 (A1)**

The solar generator (10) is connected to a DC- DC converter (14). A control acts on the DC-DC converter in order to manage the output voltage provided, thus enabling maximum power to be drawn from the solar generator. The power source (10), such as a solar generator, offers a power graph which is a function of the voltage on its terminals, with a maximum value. The source is connected to provide power to a DC- DC converter (14). In order to manage the source, an input power reference is applied to the converter. An increasing input power reference is applied to the converter, such that the derivative of the converter input voltage with respect to time is greater that a first negative threshold value, and a decreasing input power reference is applied such that the derivative of the converter input voltage with respect to time is less than a second positive threshold value. The rate of variation of the average power when the reference in increasing is chosen to be less than the opposite of the rate of variation of the average power when the reference is decreasing.



Data supplied from the ***espacenet*** database — Worldwide

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 388 774 A1

(12) DEMANDE DE BREVET EUROPEEN

(43) Date de publication:
11.02.2004 Bulletin 2004/07

(51) Int Cl.7: **G05F 1/67**

(21) Numéro de dépôt: **03291745.2**

(22) Date de dépôt: **15.07.2003**

(84) Etats contractants désignés:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Etats d'extension désignés:
AL LT LV MK

(30) Priorité: **09.08.2002 FR 0210140**

(71) Demandeur: **ALCATEL**
75008 Paris (FR)

(72) Inventeur: **Delepaut, Christophe**
1700 Dilbeek (BE)

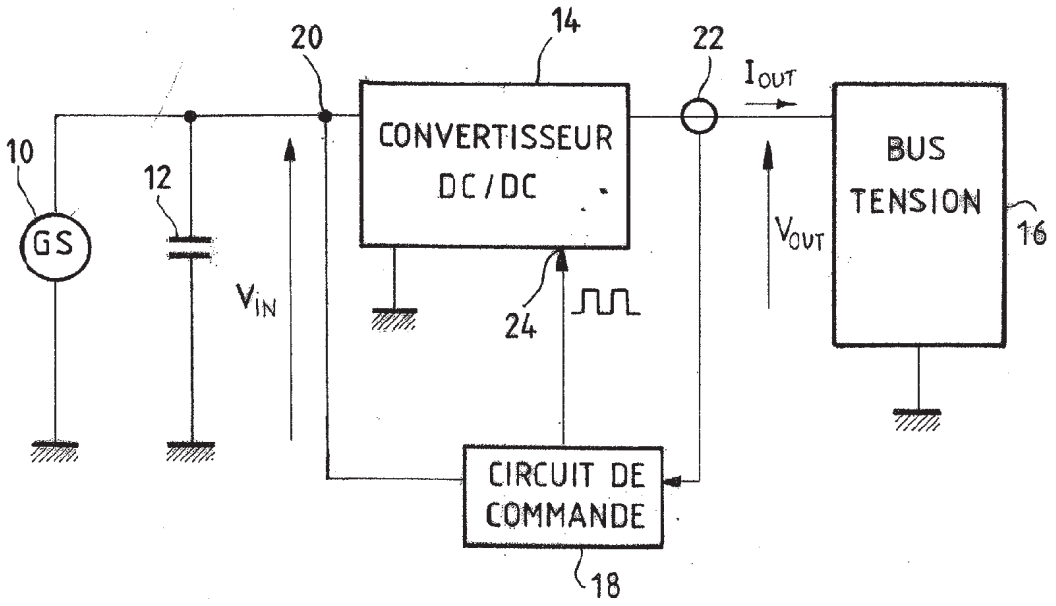
(74) Mandataire: **Sciaux, Edmond et al**
Compagnie Financière Alcatel
Département de Propriété Industrielle,
5, rue Noel Pons
92734 Nanterre Cedex (FR)

(54) Circuit de conditionnement d'une source au point de puissance maximum

(57) Une source de puissance (10), comme un générateur solaire, présente un graphe de la puissance fournie en fonction de la tension à ses bornes avec un maximum. La source alimente un convertisseur continu / continu. Pour conditionner la source, on applique au convertisseur une consigne de puissance d'entrée croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive. Le taux de variation de la puissance moyen lorsque la consigne est croissante est choisi inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

Ce conditionnement permet de faire débiter la source au point de puissance maximum et peut être implémenté simplement.

FIG_2



EP 1 388 774 A1

Printed by Jouve, 75001 PARIS (FR)

SMA Solar Technology America, LLC, Ex. 1006

Description

[0001] La présente invention concerne les sources de puissance et plus précisément l'exploitation de sources de puissance pour lesquelles la courbe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum.

[0002] Pour une telle source, la puissance fournie est maximale lorsque la tension présente une valeur donnée. Il est intéressant pour exploiter au mieux la source de puissance - en tirer une puissance maximale - que la tension aux bornes de la source soit autant que possible égale à cette valeur donnée.

[0003] Les générateurs solaires utilisés pour les satellites constituent un exemple d'une telle source de puissance. La figure 1 montre un graphe du courant et de la puissance en fonction de la tension aux bornes du générateur, dans l'exemple d'un générateur formé d'un montage série de 102 cellules Si BSR (Back Surface Reflector) ; de telles cellules sont disponibles dans l'industrie spatiale. On a porté le long de l'axe des ordonnées le courant fourni par le générateur solaire, en ampères, ainsi que la puissance délivrée par le générateur, en watts; on a porté le long de l'axe des abscisses la tension aux bornes du générateur, en volts. Les courbes 1 et 2 sur la figure 1 correspondent à un fonctionnement à une température de + 100°C; les courbes 3 et 4 correspondent à un fonctionnement à une température de -100°C. La courbe 2 sur la figure 1 est un graphe du courant en fonction de la tension; elle montre que le courant fourni par les cellules diminue lorsque la tension dépasse une valeur de l'ordre de 35 V, ce qui s'explique par un phénomène de saturation des cellules; la courbe 4 est similaire, à ceci près que la tension de saturation est de l'ordre de 75 V. La courbe 1 sur la figure 1 est un graphe de la puissance fournie par le générateur solaire; elle montre que la puissance fournie présente un maximum, qui dans l'exemple présente une valeur de l'ordre de 100 W et est atteint pour une valeur V0 de la tension qui est de l'ordre de 38 V. La courbe 3 est similaire à la courbe 2, avec des valeurs de puissance maximale et de tension V0 respectivement de l'ordre de 200 W et 70V. Ces courbes ne constituent qu'un exemple particulier de générateur dans lequel le graphe de la puissance fournie en fonction de la tension de sortie présente un maximum.

[0004] Pour exploiter un tel générateur solaire ou plus généralement une telle source de puissance, il est intéressant que la tension aux bornes de la source soit aussi proche que possible de la valeur V0 de la tension pour laquelle la source délivre une puissance maximale. Ce problème se pose avec une acuité particulière dans le cas des générateurs solaires utilisés dans les satellites. En effet, pour ces générateurs solaires, la tension V0 pour laquelle la puissance fournie par le générateur est maximale varie en fonction de la température à laquelle le générateur est soumis, comme représenté à la figure 1; cette tension V0 varie aussi en fonction

- de l'intensité du rayonnement solaire auquel le générateur est exposé;
- du vieillissement du générateur.

[0005] Pour un satellite, la température peut typiquement varier dans une plage de - 100°C à +100°C, dans l'exemple d'une orbite terrestre basse. Pour une orbite Mercure, la variation de température serait encore plus important et la température pourrait varier dans une plage de - 150 °C à + 250 °C. L'intensité du rayonnement solaire peut varier en fonction de l'éloignement du soleil; pour une mission depuis la Terre vers Mars, l'intensité du rayonnement solaire peut varier dans un rapport de 3 à 1. Le vieillissement du générateur provoque la mise en court-circuit de certaines cellules. Dans l'ensemble, la tension V0 peut typiquement varier dans un rapport de 1 à 2, et pourrait par exemple varier de 40 à 80 V.

[0006] Il a donc été proposé d'exploiter les générateurs solaires, pour en extraire une puissance maximale, en recherchant que la tension aux bornes du générateur soit proche de la tension V0. Ces techniques sont connues sous le nom de "Maximum Power Point Tracking" (suivi du point de puissance maximal en langue française).

[0007] W. Denzinger, *Electrical Power Subsystem of Globalstar*, Proceedings of the European Space Power Conference, Poitiers, France, 4-8 Septembre 1995, décrit le sous-système de puissance des satellites Globalstar. La recherche du point de puissance maximale s'effectue en considérant que le point de puissance maximale est atteint lorsque l'impédance dynamique du générateur est égale à l'impédance statique, autrement dit lorsque

$$V/I = dV/dI$$

c'est-à-dire lorsque

$$dI/I = dV/V$$

En toute rigueur, VI=max implique VdI+IdV=0 et donc V/I=-dV/dI. Denzinger oublie le signe -.

Ce document décrit un circuit utilisant un capteur de courant, un capteur de tension, deux circuits échantillonneurs, deux comparateurs, une bascule et un intégrateur.

[0008] Kevin Kyeong-Il Choi et Alphonse Barnaba, *Application of the maximum power point tracking (MPPT) to the on-board adaptative power supply subsystem,* Note technique du CNES n°138, juillet 1998, décrit un sous-système d'alimentation électrique pour les satellites de faible puissance. Pour le suivi du point de puissance maximum, ce sous-système utilise un microcontrôleur associant une multiplication numérique du courant par l'intensité et un algorithme de poursuite de la puissance à partir des valeurs calculées.

Page 116 of 219 SMA Solar Technology America, LLC, Ex. 1006

[0009] Ces solutions sont complexes à mettre en oeuvre. Ceci conduit à centraliser le contrôle de suivi du point de puissance maximum des différents générateurs solaires ; cette centralisation affecte la fiabilité du sous-système d'alimentation électrique et est incompatible de points de puissance maximum différents en tension d'une section de générateur solaire à l'autre. En outre, ces solutions exploitent les composantes directes de courants et/ou tensions, lesquelles quantités n'étant pas caractéristiques du suivi de point de puissance maximum.

[0010] Ce problème expliqué en référence aux générateurs solaires dans les conditions des satellites se pose plus généralement pour toute source de puissance pour le graphe de la puissance fournie en fonction de la tension présente un maximum.

[0011] Il existe donc un besoin d'une solution permettant l'exploitation d'une source de puissance pour laquelle la courbe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum. Une telle solution devrait, avec des moyens aussi simples et robustes que possible, assurer que la tension aux bornes de la source de puissance est dans la mesure du possible aussi proche que possible de la tension pour laquelle la puissance débitée est maximale.

[0012] Dans un mode de réalisation, l'invention propose en conséquence un circuit de conditionnement d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, le circuit comprenant :

- un convertisseur continu / continu avec une entrée pour l'alimentation par la source de puissance et une sortie pour alimenter une charge;
- un circuit de commande du convertisseur par une consigne de puissance appliqué au convertisseur

- croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
- décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

[0013] Avantageusement, la première et/ou la deuxième valeur seuil sont / est constante. On peut alors prévoir que les première et deuxième valeur seuil sont opposées.

[0014] Dans un mode de réalisation, la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

[0015] Dans encore un mode de réalisation, la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

[0016] On peut aussi prévoir que la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

[0017] L'invention propose aussi un générateur conditionné, comprenant un tel circuit et une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum; la puissance fournie par la source est appliquée en entrée du convertisseur continu / continu.

[0018] Dans un mode de réalisation, le générateur comprend une capacité en parallèle à la source de puissance. La source peut aussi présenter une capacité intrinsèque. De préférence, la source de puissance est un générateur solaire.

[0019] L'invention propose enfin un procédé de conditionnement d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source étant appliquée à un convertisseur continu /continu; le procédé comprend l'application au convertisseur d'une consigne de puissance d'entrée

- croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
- décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

[0020] On peut prévoir que la première valeur seuil est constante, et / ou encore que la deuxième valeur seuil est constante. Il est alors possible que les première et deuxième valeur seuil soient opposées.

[0021] Avantageusement, la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps. Il est aussi possible que la consigne de puissance décroissante appliquée au convertisseur soit une consigne de dérivée constante et négative de la puissance par rapport au temps. Si tel est le cas, la dérivée constante et positive peut être inférieure à l'opposé de la dérivée constante et négative.

[0022] D'autres caractéristiques et avantages de l'invention apparaîtront à la lecture de la description qui suit de modes de réalisation, donnés à titre d'exemple et en référence aux dessins, qui montrent :

- figure 1, un graphe du courant et de la puissance en fonction de la tension aux bornes d'une source

de puissance à laquelle l'invention s'applique;
- figure 2, une représentation schématique d'un générateur conditionné selon un mode de réalisation de l'invention;
- figure 3, un graphe de la puissance délivrée par la source de puissance en fonction de la tension à ses bornes, dans le générateur conditionné de la figure 2;
- figure 4, une vue plus détaillée du circuit de commande du générateur conditionné de la figure 2.

[0023] On donne dans la suite de la description un exemple d'application de l'invention au suivi du point de puissance maximum dans un générateur solaire. Comme expliqué ci-dessus, un tel générateur n'est qu'un exemple d'une source de puissance pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum.

[0024] La figure 2 est une représentation schématique d'un générateur conditionné selon un mode de réalisation de l'invention, dans une application d'alimentation en tension d'un bus de satellite. Le générateur conditionné présente d'une part un générateur solaire 10, et d'autre part un circuit de conditionnement. Ce circuit de conditionnement permet au générateur conditionné de délivrer une puissance sous une tension fixe, autrement dit de se comporter comme une source de tension, tant que la puissance délivrée est inférieure à la puissance maximale que peut fournir le générateur solaire, alors que le générateur solaire n'est capable de fournir une puissance variable, à concurrence du maximum de puissance disponible, qu'à des tensions variables.

[0025] La figure montre le générateur solaire 10 - la source de puissance - qui est monté en parallèle à une capacité 12. La tension Vin aux bornes du générateur solaire et de la capacité est appliquée en entrée d'un convertisseur continu / continu (ou convertisseur DC/DC) 14. Cette représentation de la source, de la capacité et du convertisseur est schématique; de fait, un générateur solaire présente intrinsèquement une capacité; le convertisseur peut aussi en entrée présenter une capacité. La capacité 12 n'est pas nécessairement un composant distinct du générateur et du convertisseur, mais peut être constituée par la capacité du générateur et/ou du convertisseur. La capacité 12 peut aussi correspondre à la combinaison de la capacité intrinsèque du générateur solaire, d'une capacité additionnelle et d'une capacité prévue dans le convertisseur.

[0026] La tension Vout en sortie du convertisseur 14 correspond au bus de tension du satellite 16; celui-ci comprend habituellement une batterie alimentant les charges, mais ceci est sans incidence sur le fonctionnement du circuit.

[0027] Le convertisseur 14 est commandé par un circuit de commande 18. Ce circuit de commande 18 reçoit en entrée la tension d'entrée Vin appliquée au convertisseur ainsi que le courant Iout en sortie du convertisseur; la figure montre schématiquement le capteur de tension 20 et le capteur de courant 22. Le circuit de commande fournit un signal de commande appliqué à l'entrée de commande du convertisseur 14, comme représenté en 24 sur la figure.

[0028] Comme expliqué plus haut, la puissance fournie par le générateur solaire 10 est fonction de la tension Vin aux bornes du générateur; la tension pour laquelle la puissance fournie est maximale peut varier dans une plage [V0min, V0max], dans l'exemple une plage de 40 à 80 V. Une solution courante est que le bus de tension du satellite fonctionne à une tension nominale de 28 V, qui varie entre 23 et 37 V en fonction de la charge et de l'alimentation du bus de tension. En pratique, la tension nominale du bus est inférieure la borne inférieure V0min de la plage dans laquelle varie la tension pour laquelle la puissance fournie est maximale. Dans une telle configuration, le convertisseur 14 peut être un convertisseur PWM (à modulation de la largeur d'impulsion) du type Buck. Ce convertisseur est particulièrement adapté à fonctionner avec une tension de sortie inférieure à la tension d'entrée. Le signal d'entrée est dans un tel cas un signal représentatif du rapport cyclique de modulation de la largeur d'impulsion.

[0029] Le circuit de commande 18 contrôle le convertisseur 14, à partir des mesures de tension d'entrée Vin et de courant de sortie Iout du convertisseur, par application de consigne de courant de sortie croissante ou décroissante. Ces consignes de courant sont assimilables à des consignes de puissance au facteur de proportionnalité près que constitue la valeur en tension du bus. Plus spécifiquement, le circuit de commande applique au convertisseur une consigne de puissance croissante tant que la dérivée par rapport au temps de la tension extraite du générateur solaire 10 et de la capacité 12 en entrée du convertisseur est supérieure à une première valeur seuil négative. Le circuit de commande applique au convertisseur une consigne de puissance décroissante tant que la dérivée par rapport au temps de la tension extraite du générateur solaire 10 et de la capacité 12 en entrée du convertisseur est inférieure à une deuxième valeur seuil positive. Ainsi, le convertisseur est piloté de sorte à assurer que

$$\frac{dP_{IN}}{dt} > 0$$

tant que

$$\frac{dV_{IN}}{dt} > V'_r$$

V'_r constituant la première valeur seuil négative. P_{in} est la puissance extraite de la source et de la capacité, autrement dit la puissance appliquée en entrée du convertisseur. Le convertisseur est piloté de sorte à assurer

Page 118 of 219 SMA Solar Technology America, LLC, Ex. 1006

que

$$\frac{dP_{IN}}{dt} < 0$$

tant que

$$\frac{dV_{IN}}{dt} < V'_f$$

V'_f constituant la deuxième valeur seuil positive.

[0030] Dans les solutions de W. Denzinger et Kevin Kyeong-Il Choi mentionnées ci-dessus, il est proposé d'exploiter les composantes directes de courants et/ou tensions. Or ces quantités ne sont pas caractéristiques du suivi de point de puissance maximum. A l'inverse, la solution proposée par l'invention n'exploite par contre que les dérivées temporelles de ces quantités; ces dérivées sont bien caractéristiques du suivi du point de puissance maximum, quelles que soient les valeurs des composantes directes.

[0031] La figure 3 montre un graphe de la puissance délivrée par le générateur solaire en fonction de la tension aux bornes de ce générateur. On a porté en ordonnée la puissance fournie par le générateur solaire 10, et en abscisse la tension aux bornes de ce générateur. La figure montre en traits fins la courbe de la puissance délivrée par le générateur solaire 10 en fonction de la tension à ses bornes; cette courbe présente un maximum noté MPP sur la figure; en ce point, pour une tension V_{MPP}, le générateur solaire délivre une puissance P_{MPP} maximum. Cette courbe en traits fins pourrait être qualifiée de courbe de puissance statique - dans la mesure où elle est représentative d'une caractéristique puissance /tension du générateur solaire isolé. La figure 3 montre en traits gras le cycle de puissance suivi lorsqu'est appliquée au convertisseur la commande définie plus haut. La courbe en traits gras montre la puissance extraite de l'ensemble générateur solaire 10 et capacité 12.

[0032] Dans l'exemple considéré, on a

- une consigne de puissance croissante ayant une dérivée k_r constante,
- une consigne de puissance décroissante ayant une dérivée k_f constante,
- des valeurs de seuil V'_r et V'_f opposées.

[0033] Les deux premières conditions sont choisies pour la simplicité de l'explication; la troisième condition assure un fonctionnement autour du point de puissance maximum statique, comme expliqué plus bas. On a noté R et F sur la figure les points du cycle correspondant aux puissances dynamiques maximale et minimale.

[0034] On suppose au départ que le générateur solaire fonctionne avec une puissance légèrement inférieure à la puissance maximale P_{MPP} et que la tension est supérieure à la tension V_{MPP}. On suppose aussi que la consigne appliquée au convertisseur est une consigne de puissance croissante. Le convertisseur continu / continu assure donc que la puissance totale, extraite du générateur solaire 10 et du condensateur 12, croît. Le point de fonctionnement du générateur solaire 10 se déplace sur la courbe en traits fins, vers le maximum MPP ; la capacité 12 est déchargée pour compléter la puissance fournie par le générateur solaire 10. La tension décroît lentement.

[0035] Lorsque la puissance maximum du générateur solaire 10 est atteinte, le générateur solaire ne 10 peut pas fournir de puissance supplémentaire : la capacité 12 est alors déchargée plus rapidement pour fournir la puissance requise par le convertisseur, sous la consigne de puissance croissante. Ceci accroît la vitesse de chute de la tension V_{IN}; du fait de la chute de tension, la puissance fournie par le générateur solaire 10 chute aussi, ce qui accentue encore la décharge de la capacité 12. La dérivée de la tension V_{IN} par rapport au temps chute de plus en plus vite.

[0036] Lorsque cette dérivée de la tension V_{IN} atteint la valeur seuil négative V'_f, le circuit 18 applique au convertisseur 14 une consigne de puissance décroissante. Le basculement correspond au point R de la courbe en traits gras.

[0037] Le convertisseur reçoit alors une consigne de puissance d'entrée décroissante. Dans un premier temps, la tension décroît, avec une variation plus lente, la capacité 12 continuant à se décharger. Lorsque la puissance extraite de la source et de la capacité continue à diminuer, il arrive un moment où la capacité cesse de se décharger, ce qui correspond sur la courbe en traits gras à l'intersection de la partie gauche de la courbe avec la courbe en traits fins et au minimum de la tension. La puissance extraite du générateur solaire 10 est alors suffisante pour fournir la puissance requise par le convertisseur 14. Comme la consigne appliquée au convertisseur est encore une consigne de puissance décroissante, la capacité se recharge; la tension remonte; compte tenu de la consigne de puissance décroissante appliquée au convertisseur, la puissance extraite par le convertisseur continue de décroître. Comme la tension remonte, la puissance fournie par le générateur solaire tend à croître, ce qui augmente encore la dérivée de la tension par rapport au temps.

[0038] Lorsque la dérivée de la tension par rapport au temps dépasse la deuxième valeur seuil positive, le circuit de commande applique au convertisseur une consigne de puissance croissante. On revient à l'état initial considéré plus haut.

[0039] La stabilité de la commande est assurée, dans le cas où l'on applique une consigne de dérivée de puissance constante, par la condition

$$k_r < -k_f$$

Page 119 of 219 SMA Solar Technology America, LLC, Ex. 1006

Intuitivement, ceci revient à dire que le passage sur la courbe en gras de la figure 3 du point R au point F est plus "rapide" que le passage du point F au point R. Autrement dit, il est expliqué plus haut que le seuil de dV/dt négatif est atteint avec une chute de plus en plus rapide de la tension; la condition $k_r < - k_f$ signifie que l'on applique une consigne de puissance "assez" croissante pour rapidement revenir vers une situation stable. Un rapport de 1 entre les valeurs absolues correspond à la limite de stabilité. Le choix d'une valeur dépend essentiellement du convertisseur : rapprocher la valeur du rapport de 1 impose de disposer d'un convertisseur de performances plus précises, et augmente le coût. Dans les applications à des satellites, les variations de la courbe de puissance en fonction de la tension pour le générateur solaire (le passage des courbes 1 et 2 aux courbes 3 et 4) sur la figure 1, comme les vitesses de variations des caractéristiques de la batterie appliquée comme charge du circuit conditionné sont lentes et ne sont donc pas généralement dimensionnantes. On peut typiquement sélectionner un rapport $- k_f/k_r$ voisin de 2, avec par exemple

$k_r = 50$ W/ms et
$k_f = -100$ W/ms.

[0040] On notera que le fonctionnement décrit ci-dessus est indépendant que la valeur de la consigne de puissance croissante ou décroissante appliquée au convertisseur. Il est plus simple, comme le montre la figure 4, d'utiliser des valeurs de consigne de puissance constantes, mais ceci n'a pas d'incidence sur le principe de pilotage du convertisseur. Si les consignes de puissance proposées ne sont pas constantes - autrement dit si les valeurs de dP_{IN}/dt appliquées au convertisseur ne sont pas constant, la condition de stabilité peut alors s'exprimer en indiquant que le taux de variation de la puissance moyen lorsque la consigne est croissante est inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est croissante. Ceci revient à généraliser sur les intervalles temporels de consigne de puissance croissante et décroissante la condition instantanée $k_r < - k_f$.

[0041] L'application des consignes proposées au convertisseur continu /continu permet ainsi de faire varier la tension autour de la valeur de tension pour laquelle la puissance extraite du générateur solaire 10 est maximum. Le choix des valeurs de consigne appliquées au convertisseur, comme des valeurs seuils, permet d'adapter le fonctionnement du circuit de conditionnement.

[0042] Plus spécifiquement, il est plus simple, du point de vue de l'implémentation du circuit de commande d'avoir des valeurs de seuil V'_r et V'_f constantes. Ceci ne fait que faciliter la conception du circuit de commande. On pourrait toutefois faire varier ces valeurs seuil en fonction du temps - par exemple pour tenir compte des variations du point MPP.

[0043] Le rapport des valeurs absolues des valeurs de seuil V'_r et V'_f permet de déterminer le point du graphe de la puissance en fonction de la tension autour duquel on se déplace. Dans l'exemple considéré plus haut, des valeurs de seuil constantes et opposées V'_r et V'_f correspondent à un déplacement autour du point MPP de puissance maximum. Un rapport de valeurs absolues égal à 1 est donc avantageux. Toutefois, on peut aussi choisir d'autres valeurs, ce qui conduit simplement à écarter le point de fonctionnement du point de puissance maximum. Ceci peut être avantageux en fonction de contraintes autres sur le circuit de conditionnement ou sur le générateur.

[0044] La figure 4 montre un exemple du principe de réalisation du circuit de commande, dans le cas d'un convertisseur Buck. Le circuit 18 présente un dériveur 26 qui reçoit la tension d'entrée du convertisseur et en fournit la dérivée. La dérivée de la tension est appliquée à un comparateur 28. La sortie du comparateur fournit un signal logique dont l'état dépend de la comparaison entre la valeur de la dérivée de la tension et les valeurs seuils V'r et V'f du comparateur. Le circuit présente un autre dériveur 30 qui reçoit le signal de courant de sortie du convertisseur et en fournit la dérivée. Un additionneur 32 fournit un signal représentatif de la différence entre le signal du comparateur 28 et le signal de dérivée fourni par le deuxième dériveur 30. Le signal fourni par l'additionneur est appliqué à un contrôleur 34 dont le rôle est d'annuler la consigne. Le signal de sortie du contrôleur forme le signal de sortie du circuit de commande 18.

[0045] Le fonctionnement du circuit de la figure 4 est le suivant. Le comparateur fournit en sortie un signal fonction de la position de la dérivée de la tension d'entrée du convertisseur par rapport aux valeurs seuil V'_r et V'_f. Ce signal est comparé à la dérivée du courant de sortie du convertisseur, après une mise à l'échelle non-représentée sur la figure. Cette dérivée du courant de sortie constitue une bonne approximation de la dérivée de la puissance appliquée en entrée du convertisseur, du fait que :

- la puissance consommée par le convertisseur continu / continu est faible;
- la tension de sortie du convertisseur est sensiblement constante, dans la mesure où le convertisseur est utilisé comme source de tension.

Le contrôleur assure donc que

$dI_{out}/dt < 0$ ou > 0 (dans un rapport $< - 1$)

en fonction du résultat de la comparaison de dV_{IN}/dt avec les valeurs seuils. Avec V_{OUT} sensiblement constante, on a bien la consigne requise.

[0046] Le montage de la figure 4 n'est qu'un exemple d'un circuit de commande utilisable pour le convertisseur continu /continu. On peut aussi utiliser d'autres types de circuits de commande pour comparer les dérivées des tensions et appliquer les consignes requises.

Page 120 of 219 SMA Solar Technology America, LLC, Ex. 1006

On peut aussi prévoir d'autres capteurs que les capteurs 20, 22 de la figure 2. Le montage des figures 2 et 4 présente néanmoins l'avantage de la simplicité; ainsi, il n'est pas nécessaire de disposer d'un microcontrôleur; le nombre de composants est aussi plus restreint que dans la solution proposée dans l'article de W. Denzinger plus haut.

[0047] Bien entendu, l'invention n'est pas limitée aux exemples décrits plus haut. Ainsi, on a mentionné un convertisseur Buck, adapté au cas d'une tension de sortie inférieure à la tension d'entrée. On pourrait aussi utiliser d'autres types de convertisseurs; par exemple, si la tension d'entrée est inférieure à la tension de sortie, on pourrait utiliser un convertisseur PWM du type Boost. D'autres topologies de convertisseurs permettent aussi un fonctionnement lorsque le rapport entre la tension d'entrée et la tension de sortie varie autour de 1. Le type de convertisseur utilisé ne change pas le principe de la commande décrit en référence à la figure 3.

Revendications

1. Un circuit de conditionnement d'une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, le circuit comprenant :

   - un convertisseur continu / continu (14) avec une entrée pour l'alimentation par la source de puissance et une sortie pour alimenter une charge;
   - un circuit de commande du convertisseur par une consigne de puissance appliqué au convertisseur

     croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et

     décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

     le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance moyen lorsque la consigne est décroissante.

2. Le circuit de la revendication 1, **caractérisé en ce que** la première valeur seuil est constante.

3. Le circuit de la revendication 1 ou 2, **caractérisé en ce que** la deuxième valeur seuil est constante.

4. Le circuit des revendications 3 et 4, **caractérisé en ce que** les première et deuxième valeur seuil sont opposées.

5. Le circuit de l'une des revendications 1 à 4, **caractérisé en ce que** la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

6. Le circuit de l'une des revendications 1 à 5, **caractérisé en ce que** la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

7. Le circuit des revendications 5 et 6, **caractérisé en ce que** la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

8. Un générateur conditionné, comprenant :

   - un circuit selon l'une des revendications 1 à 7;
   - une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source étant appliquée en entrée du convertisseur continu / continu (14).

9. Le générateur de la revendication 8, **caractérisé par** une capacité (12) en parallèle à la source de puissance.

10. Le générateur de la revendication 8, **caractérisé en ce que** la source présente une capacité intrinsèque.

11. Le générateur de la revendication 8, 9 ou 10, **caractérisé en ce que** la source de puissance est un générateur solaire.

12. Un procédé de conditionnement d'une source de puissance (10) pour laquelle le graphe de la puissance fournie en fonction de la tension aux bornes de la source présente un maximum, la puissance fournie par la source (10) étant appliquée à un convertisseur continu /continu (12), le procédé comprenant l'application au convertisseur d'une consigne de puissance d'entrée

    - croissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est supérieure à une première valeur seuil négative et
    - décroissante tant que la dérivée de la tension d'entrée du convertisseur par rapport au temps est inférieure à une deuxième valeur seuil positive,

      le taux de variation de la puissance moyen lorsque la consigne est croissante étant inférieur à l'opposé du taux de variation de la puissance

Page 121 of 219 SMA Solar Technology America, LLC, Ex. 1006

moyen lorsque la consigne est décroissante.

13. Le procédé de la revendication 12, **caractérisé en ce que** la première valeur seuil est constante.

14. Le procédé de la revendication 12 ou 13, **caractérisé en ce que** la deuxième valeur seuil est constante.

15. Le procédé des revendications 13 et 14, **caractérisé en ce que** les première et deuxième valeur seuil sont opposées.

16. Le procédé de l'une des revendications 12 à 15, **caractérisé en ce que** la consigne de puissance croissante appliquée au convertisseur est une consigne de dérivée constante et positive de la puissance par rapport au temps.

17. Le procédé de l'une des revendications 12 à 16, **caractérisé en ce que** la consigne de puissance décroissante appliquée au convertisseur est une consigne de dérivée constante et négative de la puissance par rapport au temps.

18. Le procédé des revendications 16 et 17, **caractérisé en ce que** la dérivée constante et positive est inférieure à l'opposé de la dérivée constante et négative.

Page 122 of 219 SMA Solar Technology America, LLC, Ex. 1006

FIG_1

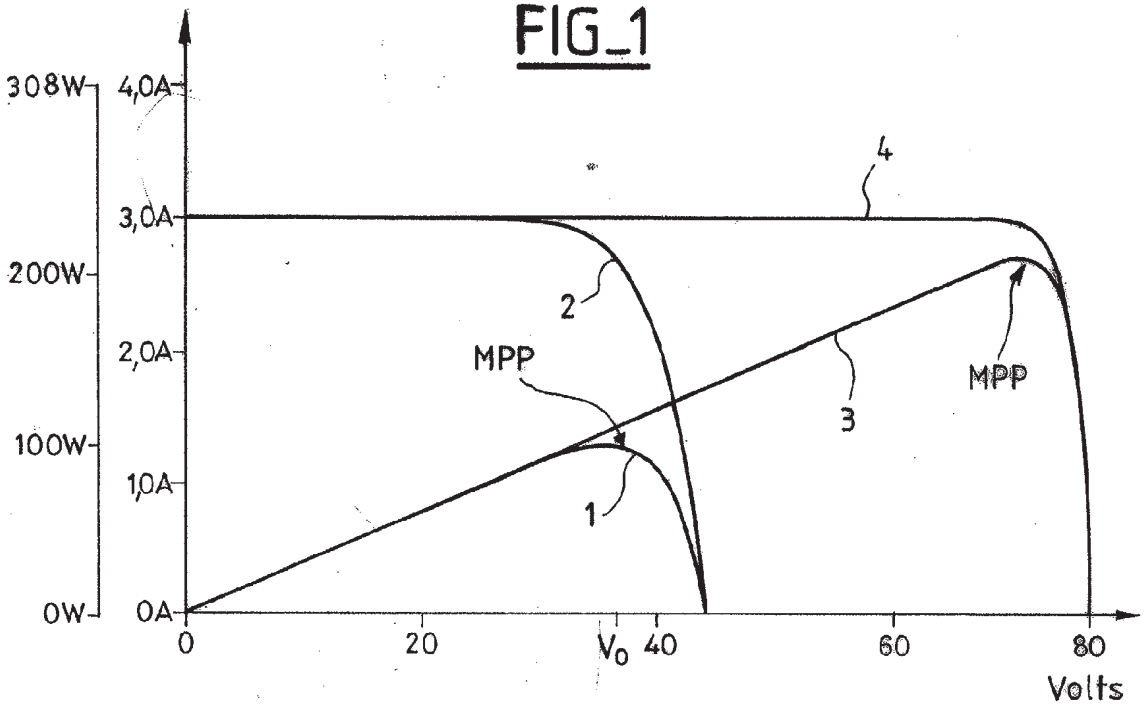

308W
200W
100W
0W
4,0A
3,0A
2,0A
1,0A
0A
0
20
V_o 40
60
80
Volts
MPP
MPP
1
2
3
4

FIG_2

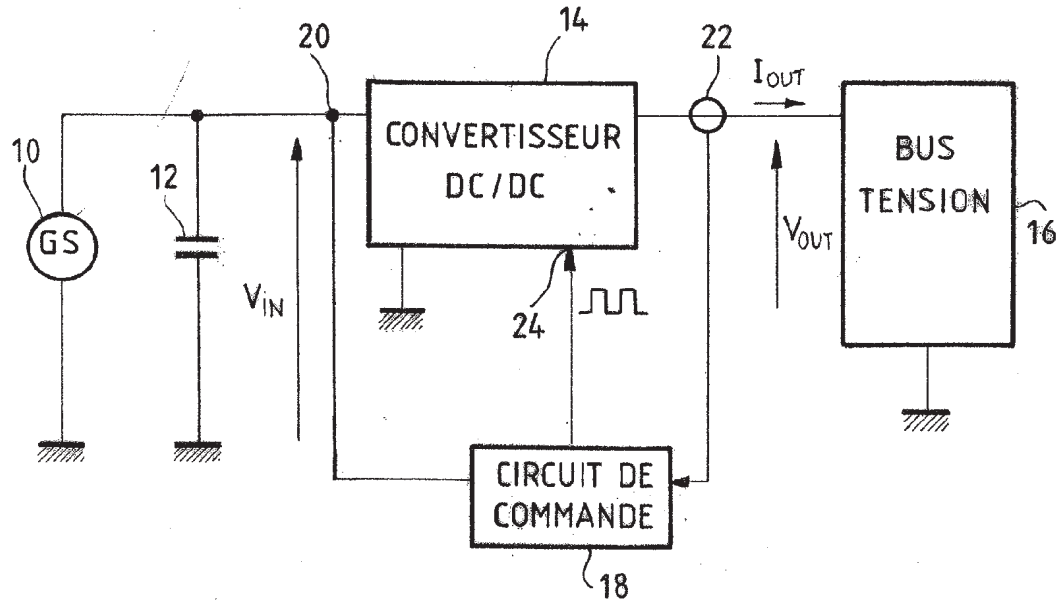

10
GS
12
20
14
22
I_{OUT}
CONVERTISSEUR DC/DC
BUS TENSION
16
V_{OUT}
V_{IN}
24
CIRCUIT DE COMMANDE
18

FIG_3

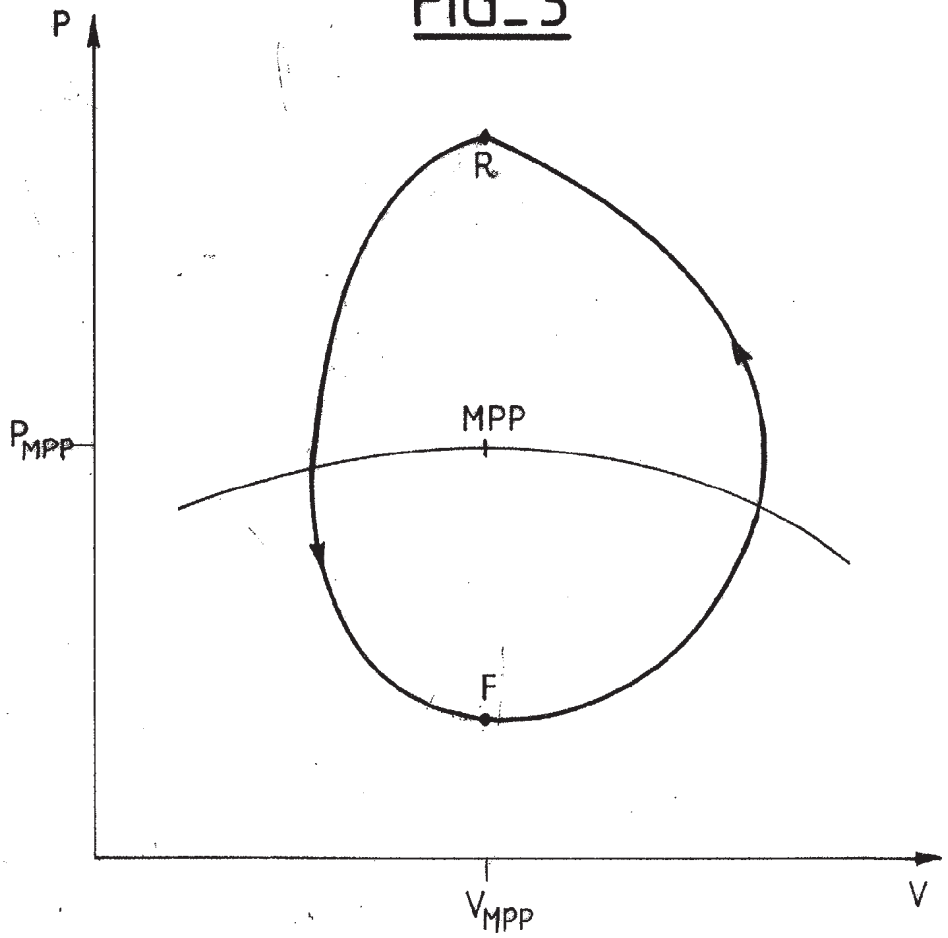
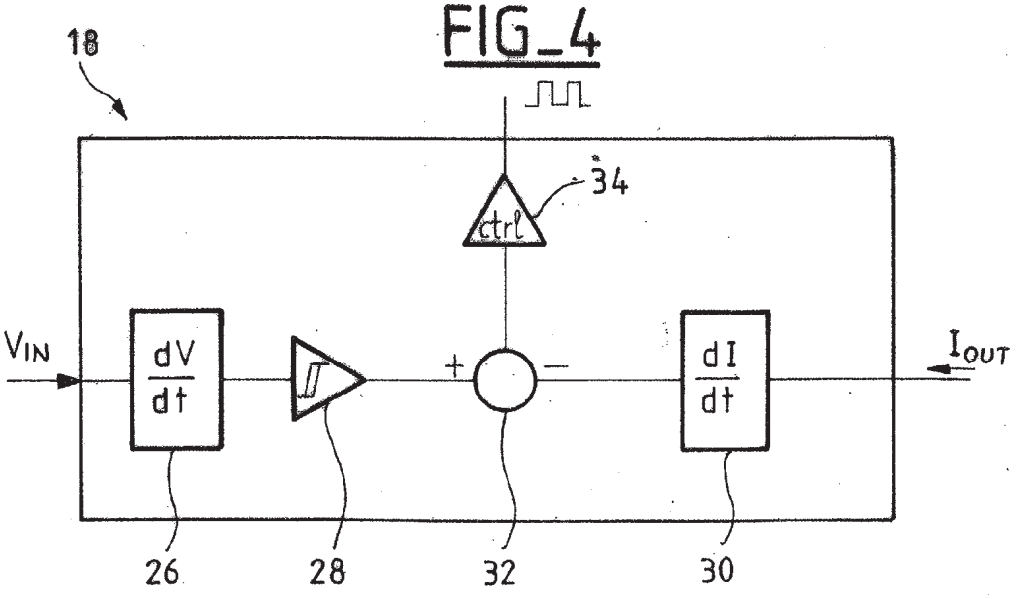


FIG_4



SMA Solar Technology America, LLC, Ex. 1006

Office européen des brevets

RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 03 29 1745

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X	FR 2 819 653 A (CNRS) 19 juillet 2002 (2002-07-19)	1,8,12	G05F1/67
A	* le document en entier *	2-7, 9-11, 13-18	

X	EP 0 027 405 A (COMMISSARIAT ENERGIE ATOMIQUE) 22 avril 1981 (1981-04-22)	1,8,12	
A	* le document en entier *	2-7, 9-11, 13-18	

X	FR 2 626 689 A (CENTRE NAT ETD SPATIALES) 4 août 1989 (1989-08-04)	1,8,12	
A	* le document en entier *	2-7, 9-11, 13-18	

X	US 5 932 994 A (JO HYUN-MIN ET AL) 3 août 1999 (1999-08-03)	1,8,12	
A	* le document en entier *	2-7, 9-11, 13-18	DOMAINES TECHNIQUES RECHERCHES (Int.Cl.7) G05F

	-/--		

Le présent rapport a été établi pour toutes les revendications

Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
A : arrière-plan technologique
O : divulgation non-écrite
P : document intercalaire

T : théorie ou principe à la base de l'invention
E : document de brevet antérieur, mais publié à la date de dépôt ou après cette date
D : cité dans la demande
L : cité pour d'autres raisons

& : membre de la même famille, document correspondant

EPO FORM 1503 03.82 (P04C02)

SMA Solar Technology America, LLC, Ex. 1006

Office européen des brevets

RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 03 29 1745

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X	GOW J A ET AL: "A MODULAR DC-DC CONVERTER AND MAXIMUM POWER TRACKING CONTROLLER FORMEDIUM TO LARGE SCALE PHOTOVOLTAIC GENERATING PLANT" 8TH EUROPEAN CONFERENCE ON POWER ELECTRONICS AND APPLICATIONS. LAUSANNE, CH, SEPT. 7 - 9, 1999, EPE. EUROPEAN CONFERENCE ON POWER ELECTRONICS AND APPLICATIONS, BRUSSLS: EPE ASSOCIATION, BE, vol. CONF. 8, 7 septembre 1999 (1999-09-07), pages 1-8, XP000883026 ISBN: 90-75815-04-2	1,8,12	
A	* page 1 - page 8 *	2-7, 9-11, 13-18	

X	CALDWELL D J ET AL: "ADVANCED SPACE POWER SYSTEM WITH OPTIMIZED PEAK POWER TRACKING" AEROSPACE POWER SYSTEMS, CONVERSION TECHNOLOGIES. BOSTON, AUG. 4 - 9, 1991, PROCEEDINGS OF THE INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, NEW YORK, ANS/IEEE, US, vol. 2 CONF. 26, 4 août 1991 (1991-08-04), pages 145-150, XP000280495 ISBN: 0-89448-163-0	1,8,12	
A	* page 1 - page 6 *	2-7, 9-11, 13-18	

	-/--		

DOMAINES TECHNIQUES RECHERCHES (Int.Cl.7)

Le présent rapport a été établi pour toutes les revendications

Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
A : arrière-plan technologique
O : divulgation non-écrite
P : document intercalaire

T : théorie ou principe à la base de l'invention
E : document de brevet antérieur, mais publié à la date de dépôt ou après cette date
D : cité dans la demande
L : cité pour d'autres raisons

& : membre de la même famille, document correspondant

EPO FORM 1503 03.82 (P04C02)

Office européen des brevets

RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 03 29 1745

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X	HUA C ET AL: "CONTROL OF DC/DC CONVERTERS FOR SOLAR ENERGY SYSTEM WITH MAXIMUM POWER TRACKING" PROCEEDINGS OF THE IECON '97: 23RD. INTERNATIONAL CONFERENCE ON INDUSTRIAL ELECTRONICS, CONTROL, AND INSTRUMENTATION. NEW ORLEANS, NOV. 9 - 14, 1997, PROCEEDINGS OF IEEE IECON: INTERNATIONAL CONFERENCE ON INDUSTRIAL ELECTRONICS, CONTROL, AND INSTRUME, vol. 2, 9 novembre 1997 (1997-11-09), pages 827-832, XP000898581 ISBN: 0-7803-3933-9	1,8,12	
A	* page 1 - page 9 *	2-7, 9-11, 13-18	

A	US 5 530 335 A (DECKER DARWIN K ET AL) 25 juin 1996 (1996-06-25) * abrégé *	1-18	
	-----		DOMAINES TECHNIQUES RECHERCHES (Int.Cl.7)

Le présent rapport a été établi pour toutes les revendications

Lieu de la recherche	Date d'achèvement de la recherche	Examinateur
LA HAYE	15 octobre 2003	Schobert, D

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
A : arrière-plan technologique
O : divulgation non-écrite
P : document intercalaire

T : théorie ou principe à la base de l'invention
E : document de brevet antérieur, mais publié à la date de dépôt ou après cette date
D : cité dans la demande
L : cité pour d'autres raisons

& : membre de la même famille, document correspondant

EPO FORM 1503 03.82 (P04C02)

ANNEXE AU RAPPORT DE RECHERCHE EUROPEENNE RELATIF A LA DEMANDE DE BREVET EUROPEEN NO. EP 03 29 1745

La présente annexe indique les membres de la famille de brevets relatifs aux documents brevets cités dans le rapport de recherche européenne visé ci-dessus.
Lesdits members sont contenus au fichier informatique de l'Office européen des brevets à la date du
Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office européen des brevets.

15-10-2003

Document brevet cité au rapport de recherche		Date de publication		Membre(s) de la famille de brevet(s)	Date de publication
FR 2819653	A	19-07-2002	FR	2819653 A1	19-07-2002
			WO	02056126 A1	18-07-2002
EP 0027405	A	22-04-1981	FR	2467508 A1	17-04-1981
			EP	0027405 A1	22-04-1981
FR 2626689	A	04-08-1989	FR	2626689 A1	04-08-1989
			AT	86399 T	15-03-1993
			DE	68905049 D1	08-04-1993
			DE	68905049 T2	17-06-1993
			EP	0326489 A1	02-08-1989
			ES	2038420 T3	16-07-1993
			FR	2634293 A2	19-01-1990
			JP	1224817 A	07-09-1989
			JP	2765716 B2	18-06-1998
			US	4899269 A	06-02-1990
US 5932994	A	03-08-1999	KR	205229 B1	01-07-1999
			CN	1171650 A ,B	28-01-1998
			DE	19720427 A1	20-11-1997
			JP	10023686 A	23-01-1998
US 5530335	A	25-06-1996	US	5648731 A	15-07-1997

EPO FORM P0460

Pour tout renseignement concernant cette annexe : voir Journal Officiel de l'Office européen des brevets, No.12/82

Page 128 of 219 SMA Solar Technology America, LLC, Ex. 1006

(19) OFICINA ESPAÑOLA DE PATENTES Y MARCAS

ESPAÑA

(11) Número de publicación: **2 249 147**

(21) Número de solicitud: 200401597

(51) Int. Cl.
G05F 1/67 (2006.01)
H01L 31/042 (2006.01)
H02J 3/38 (2006.01)

(12) SOLICITUD DE PATENTE A1

(22) Fecha de presentación: **01.07.2004**

(43) Fecha de publicación de la solicitud: **16.03.2006**

(43) Fecha de publicación del folleto de la solicitud: **16.03.2006**

(71) Solicitante/s: **FUNDACIÓN ROBOTIKER**
Parque Tecnológico, Edificio 202
48170 Zamudio, Vizcaya, ES

(72) Inventor/es: **Román Medina, Eduardo;**
Elordulzapatarletxe Fadrique, Sabino y
Ibáñez Ereño, Pedro

(74) Agente: **Carpintero López, Francisco**

(54) Título: **Módulo fotovoltaico inteligente.**

(57) Resumen:
Módulo fotovoltaico inteligente.
El módulo fotovoltaico está compuesto por un panel fotovoltaico (1) y un circuito electrónico (2), integrado en el propio módulo, que incluye un convertidor DC-DC (3) controlado por un algoritmo de seguimiento del punto de máxima potencia. Este módulo se conecta a otros módulos, a través del convertidor DC-DC (3) y éstos a su vez a un inversor (7) que suministra la corriente alterna a la instalación a alimentar, reduciendo las pérdidas debidas a desadaptaciones entre los distintos módulos de la instalación.

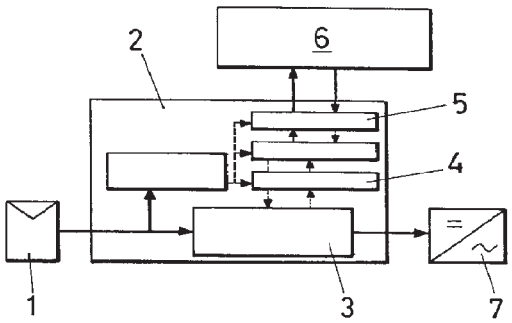


FIG.1

ES 2 249 147 A1

Venta de fascículos: Oficina Española de Patentes y Marcas. C/Panamá, 1 – 28036 Madrid

DESCRIPCIÓN

Módulo fotovoltaico inteligente.

Objeto de la invención

La presente invención se refiere a un módulo fotovoltaico que integra medios electrónicos que permiten realizar el seguimiento del punto de máxima potencia individual de cada panel fotovoltaico y conectarse a otros paneles, según una arquitectura distribuida que permite reducir las pérdidas de potencia de la instalación fotovoltaica.

Antecedentes de la invención

Un sistema fotovoltaico para la transformación de energía solar en energía eléctrica se basa en la utilización de múltiples paneles fotovoltaicos que se conectan eléctricamente entre sí, obteniéndose, en condiciones óptimas, una potencia eléctrica total que correspondería a la suma de las potencias máximas de cada panel.

Tradicionalmente, los paneles fotovoltaicos se disponen según una arquitectura centralizada, conectándose todo el conjunto a un inversor que suministra corriente alterna a la red o instalación que se debe alimentar. El inversor realiza un seguimiento del punto de máxima potencia de todo el conjunto.

No obstante, en cualquier sistema fotovoltaico se producen pérdidas eléctricas, cercanas al 25% de la potencia, que se deben principalmente a las desadaptaciones entre los diferentes paneles fotovoltaicos que constituyen el sistema y que están derivadas de la propia arquitectura del sistema que hacen que cuando uno de los paneles no puede suministrar toda su potencia máxima, el resto de paneles se ven afectados y tampoco pueden dar su potencia máxima.

Estas desadaptaciones se originan bien por sombras parciales, bien por las diferentes orientaciones e inclinaciones de los paneles o bien por diferencias en el proceso de fabricación o por envejecimiento de los mismos.

Una alternativa para tratar de solucionar estos problemas se describe en las Patentes alemanas nºs. 19919766 y 4305326 en las cuales se propone, en lugar de la arquitectura centralizada mencionada anteriormente, una arquitectura parcialmente distribuida en la cual los paneles fotovoltaicos se reparten en grupos que se conectan en serie a respectivos convertidores DC-DC, siendo estos convertidores los que se conectan finalmente al inversor. En este caso, cada uno de los convertidores DC-DC realiza su propio seguimiento del punto de máxima potencia de los paneles de su grupo mejorando en parte la eficiencia del sistema.

En cualquier caso, este sistema no evita que se produzcan importantes pérdidas de potencia que dependen, del número de paneles conectados en cada grupo y del número de grupos establecidos.

Además, estas arquitecturas resultan poco apropiadas para realizar modificaciones o ampliaciones futuras de la instalación.

Descripción de la invención

Es objeto de la invención el módulo fotovoltaico que permite resolver la problemática expuesta anteriormente reduciendo todas las pérdidas debidas a las desadaptaciones existentes entre los distintos paneles fotovoltaicos.

Para ello, se propone un módulo fotovoltaico que esta compuesto por un panel fotovoltaico que integra una serie de equipos electrónicos y, en especial, un convertidor DC-DC con su correspondiente algoritmo de seguimiento del punto de máxima potencia del módulo. El circuito electrónico incorpora también elementos que permiten la monitorización del estado del módulo y su comunicación con un sistema de control remoto.

La incorporación de un convertidor DC-DC en cada módulo fotovoltaico permite eliminar las pérdidas debidas a las desadaptaciones entre los distintos módulos del sistema y extraer la máxima potencia disponible en cada uno de ellos, con independencia de la potencia que estén suministrando el resto de módulos.

Con estos módulos, que podríamos denominar inteligentes, se puede configurar un sistema completamente distribuido, en el cual los módulos fotovoltaicos se conectan al inversor, a través de sus correspondientes convertidores DC-DC, lo que permite reducir todas las pérdidas debidas a las desadaptaciones entre los módulos.

Además, resulta muy sencillo dimensionar la instalación y realizar ampliaciones y modificaciones futuras, simplemente añadiendo o eliminando módulos inteligentes.

Adicionalmente, el circuito electrónico del módulo fotovoltaico integra sensores que permiten conocer el estado del módulo, así como un módulo de comunicaciones que envía estos datos a una unidad de control y supervisión.

Con la información recogida de cada uno de los módulos de la planta o instalación fotovoltaica, se facilitan las tareas de monitorización, mantenimiento y detección de fallos.

Descripción de los dibujos

Para complementar la descripción que se está realizando y con objeto de ayudar a una mejor comprensión de las características de la invención, se acompaña como parte integrante de dicha descripción, un juego de dibujos en donde con carácter ilustrativo y no limitativo, se ha representado lo siguiente:

Figura 1.- Muestra un esquema general del módulo fotovoltaico inteligente objeto de la invención.

Figura 2.- Muestra un esquema de arquitectura de una instalación fotovoltaica constituida a partir de módulos inteligentes según objeto de la invención.

Figura 3.- Muestra un esquema de instalación utilizando paneles fotovoltaicos convencionales.

Figura 4.- Muestra la curva de potencia de salida de paneles soleados y en sombra.

Figura 5.- Muestra la curva de potencia de salida para una instalación con 20 paneles convencionales.

Realización preferente de la invención

El módulo fotovoltaico objeto de la invención está constituido por un panel fotovoltaico (1) que integra un circuito electrónico (2) que comprende, entre otros elementos, un convertidor DC-DC (3).

Con el módulo objeto de la invención, tal y como se observa en la figura 2, se pueden configurar sistemas completamente distribuidos compuestos por paneles fotovoltaicos (1), con sus correspondientes convertidores DC-DC (3), conectándose estos últimos, a un inversor (4) que alimenta la instalación correspondiente.

Los convertidores DC-DC (3) integrados en cada panel (1), incorporan un algoritmo de seguimiento del punto de máxima potencia, lo que permite reducir todas las pérdidas de la instalación debidas a desadaptaciones entre los distintos paneles (1).

El circuito electrónico (2) incorpora también unos

Page 130 of 219 SMA Solar Technology America, LLC, Ex. 1006

sensores (4) capaces de determinar el estado del módulo y transmitir estos datos, a través de un módulo de comunicaciones (5), a una unidad de control y supervisión (6) de la instalación completa.

En la unidad de control y supervisión (6) se realizan tareas de monitorización, mantenimiento y detección de fallos de toda la instalación fotovoltaica. Las comunicaciones entre módulos y la unidad (6) se realizan a través del propio cableado de continuo empleando la modulación FSK, por lo que no se requiere un cableado adicional.

El protocolo de comunicación es MODBUS-RTU, con arquitectura maestro-esclavo, siendo el maestro la unidad de control y supervisión (6) y los esclavos cada uno de los módulos que envían a la unidad (6) los valores de tensión y corriente, tanto a la entrada como a la salida de su convertidor DC-DC, así como la temperatura de funcionamiento del equipo.

A continuación, se va a describir un ejemplo de funcionamiento, comparando la potencia obtenida con un sistema centralizado, con módulos convencionales, frente a un sistema distribuido con módulos inteligentes de acuerdo al objeto de la invención. Las figuras 4 y 5 muestran unas gráficas de potencia de salida incluidas para ilustrar este ejemplo de funcionamiento.

Supongamos una instalación fotovoltaica con 20 módulos situados por ejemplo en la azotea de un edificio. En este tipo de aplicación resulta imposible evitar sombras parciales, como por ejemplo, las generadas por la chimenea del edificio.

Supongamos también que de los 20 módulos de la instalación, 5 se encuentran parcialmente en sombra debido a la proximidad de una chimenea.

En la figura 4, se han representado las curvas de potencia de salida para módulos soleados y módulos en sombra. En concreto, muestra la potencia de salida máxima de un módulo soleado tipo BP580F (900 W/m^2) y de un módulo sombreado (500 W/m^2). Se puede apreciar como, mientras el primero presenta un máximo de potencia de 82 W, el segundo alcanza un máximo de 44 W. Además, se puede observar como las corrientes para las que se obtiene la máxima potencia son diferentes en cada uno de los casos.

En el caso de una instalación compuesta por módulos fotovoltaicos convencionales, conectados en serie a un único convertidor con seguimiento del punto de máxima potencia, al estar conectados en serie todos los módulos, deben conducir la misma corriente, por lo que la potencia de salida del conjunto corresponde a la curva representada en la figura 4.

En esta curva se puede observar cómo esta conexión en serie provoca la aparición de un máximo de potencia relativo y un máximo de potencia absoluto. Por tanto, en el mejor de los casos, se podría alcanzar el máximo de potencia absoluto, que corresponde a una potencia suministrada de 1213 W.

En el caso de una arquitectura compuesta por 20 módulos fotovoltaicos inteligentes, según el objeto de la invención, resulta posible obtener de cada módulo su potencia máxima disponible, es decir, 44 W para los cinco módulos sombreados y 82 W para los quince módulos soleados. De esta forma, la potencia máxima de la instalación sería de 1450 W que representa casi un 20% mas que con la configuración tradicional.

Page 131 of 219 SMA Solar Technology America, LLC, Ex. 1006

REIVINDICACIONES

1. Módulo fotovoltaico, **caracterizado** porque está compuesto por un panel fotovoltaico (1) y un circuito electrónico (2), integrado en el propio panel (1), que incluye un convertidor DC-DC (3) controlado por un algoritmo de seguimiento del punto de máxima potencia.

2. Módulo fotovoltaico según reivindicación 1, **caracterizado** porque el circuito electrónico (2) incorpora sensores (4) que permiten conocer el estado del módulo fotovoltaico y, en concreto, los valores de tensión y corriente, a la entrada y salida del convertidor (3), y la temperatura de funcionamiento del equipo; así como un módulo de comunicaciones (5) que envía los datos recogidos por los sensores (4) a una unidad de control y supervisión (6), para la monitorización, mantenimiento y detección de fallos de la instalación completa.

3. Módulo fotovoltaico según reivindicación 1, **caracterizado** porque se conecta a otros módulos, a través del convertidor DC-DC (3) y éstos a su vez a un inversor (7) que suministra la corriente alterna a la instalación a alimentar, consiguiendo una arquitectura de conexión distribuida entre los distintos módulos.

Page 132 of 219 SMA Solar Technology America, LLC, Ex. 1006

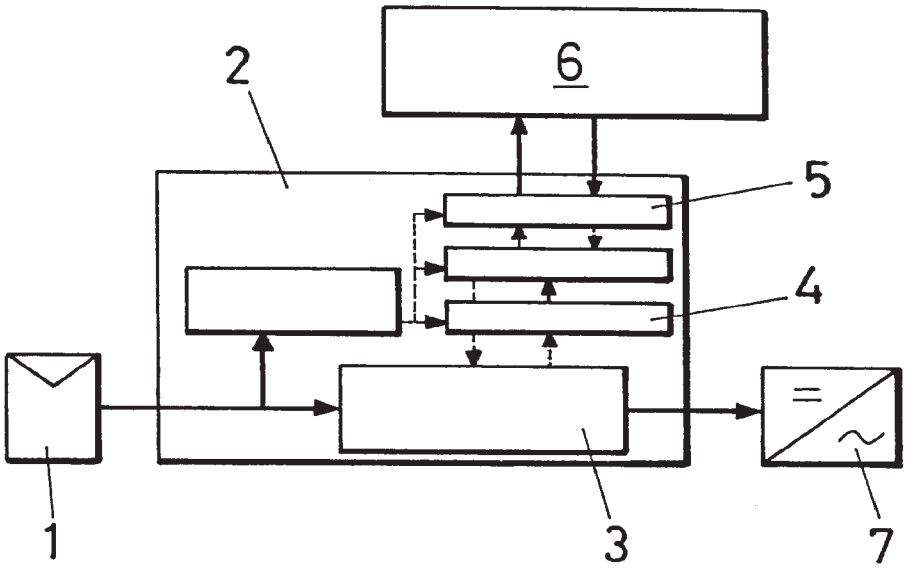


FIG.1

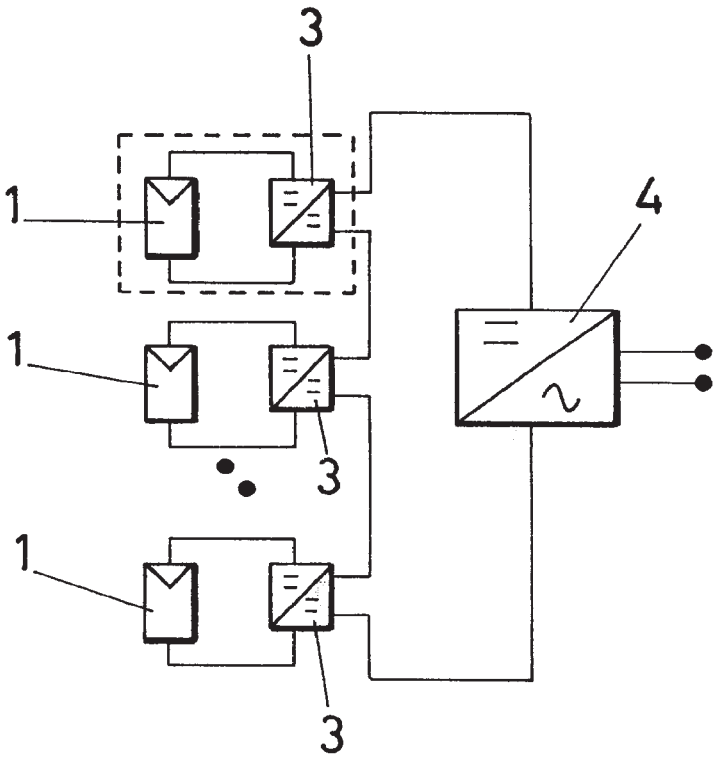


FIG.2

SMA Solar Technology America, LLC, Ex. 1006

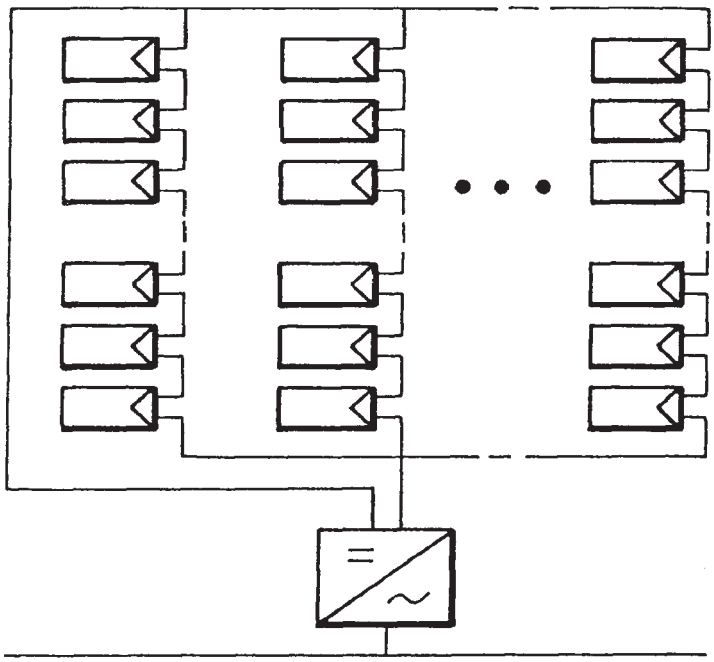


FIG. 3

SMA Solar Technology America, LLC, Ex. 1006

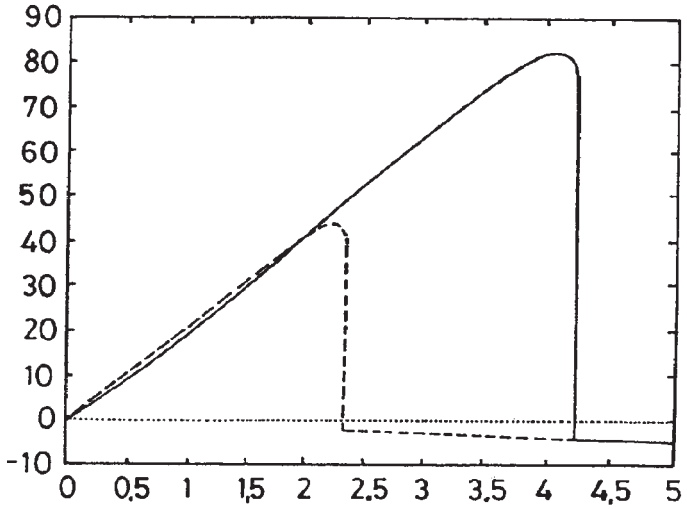

90
80
70
60
50
40
30
20
10
0
-10
0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5

FIG.4

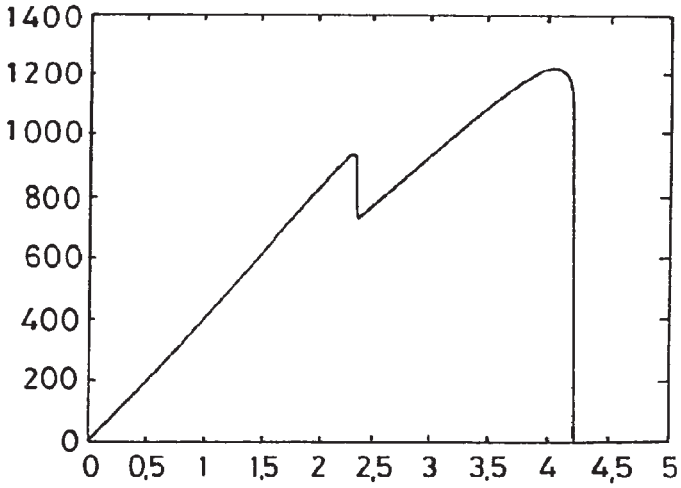

1400
1200
1000
800
600
400
200
0
0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5

FIG.5

OFICINA ESPAÑOLA DE PATENTES Y MARCAS

ESPAÑA

(11) ES 2 249 147

(21) Nº de solicitud: 200401597

(22) Fecha de presentación de la solicitud: **01.07.2004**

(32) Fecha de prioridad:

INFORME SOBRE EL ESTADO DE LA TÉCNICA

(51) **Int. Cl.:** Ver hoja adicional

DOCUMENTOS RELEVANTES

Categoría	Documentos citados	Reivindicaciones afectadas
X	DE 10136147 A1 (KOLM HENDRIK) 20.02.2003, resumen; figura 1.	1-3
X	JP 2000112545 A (DAIHEN CORP) 21.04.2000, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1,3
A		2
X	JP 11318042 A (SHARP KK) 16.11.1999, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1,3
A		2
X	JP 2004055603 A (CANON KK) 19.02.2004, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1
A	JP 2001224142 A (NISSIN ELECTRIC CO LTD) 17.08.2001, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1-3
A	JP 8191573 A (SANYO ELECTRIC CO) 23.07.1996, resumen; figura. Extraída de la Base de Datos PAJ en EPODOC.	1,2

Categoría de los documentos citados

X: de particular relevancia
Y: de particular relevancia combinado con otro/s de la misma categoría
A: refleja el estado de la técnica
O: referido a divulgación no escrita
P: publicado entre la fecha de prioridad y la de presentación de la solicitud
E: documento anterior, pero publicado después de la fecha de presentación de la solicitud

El presente informe ha sido realizado

☒ para todas las reivindicaciones ☐ para las reivindicaciones nº:

Fecha de realización del informe	Examinador	Página
27.02.2006	P. Pérez Fernández	1/2

CLASIFICACIÓN DEL OBJETO DE LA SOLICITUD

G05F 1/67 (2006.01)
H01L 31/042 (2006.01)
H02J 3/38 (2006.01)

ES2249147: Intelligent Photovoltaic Module

ABSTRACT

The photovoltaic module comprises a photovoltaic panel (1) and an electronic circuit (2), integrated the module itself, which includes a converter OC-OC (3) controlled by a tracking algorithm point maximum power. This module is connected to other modules, through the converter OC-OC (3) And these in turn to an inverter (7) which supplies alternating current at the feed installation, reducing losses to maladaptations between modules of the installation.

SPECIFICATION

Object of the invention

The present invention talks about a photovoltaic module that integral electronic means that allow to make the tracking of the point of Maxima individual power of each photovoltaic patch and to connect themselves to other patches, according to a distributed architecture that allows to reduce the power losses of the photovoltaic installation.

Background of the invention

A photovoltaic system for the transformation of solar energy in electrical energy is based on the use of multiple photovoltaic patches that are connected electrically to each other, obtaining itself, in optimum conditions, an electric power total that would correspond to the sum of the maximum powers of each patch.

Traditionally, the photovoltaic patches are arranged according to a centralized architecture, connecting all the assembly to an inverter that provides to alternate stream to the network octyns installation that is due to feed. The inverter makes a tracking of the point of Maxima power of all the assembly.

However, in any photovoltaic system electrical, close losses take place 25% of the power, that must mainly to the mismatches between the different photovoltaic patches that constitute the system and that are derived of the own architecture of the system which they do that when one of the patches cannot provide all its Maxima power, the remainder of patches are affected and either they cannot give its Maxima power.

These mismatches are originated either by partial shadows, or by the different orientations and inclinations of the patches or by differences in the manufacturing process octyns by aging of such.

An alternative to try to solve these problems is described in Apparent German us. 19919766 and 4305326 in which one sets out, instead of the mentioned centralized architecture previously, a partially distributed architecture in which the photovoltaic patches are distributed in groups that are connected in series to respective converters DC-DC, being these converters those that are connected finally to the inverter. In this case, each one of converters DC-DC makes its own tracking of the point of Maxima power of the patches of its group improving partly the efficiency of the system.

In any case, this system does not avoid that important power losses that depend, of the number of connected patches in each group and of the established group number take place.

In addition, these architectures are little appropriate to make modifications octyns future magnifications of the installation.

Description of the invention

The photovoltaic module is object of the invention that allows to solve problematic the exposed one previously reducing all the due losses to the existing mismatches between the other photovoltaic patches.

For it, a photovoltaic module sets out that this compound by integral a photovoltaic patch that series of electronic equipments and, in special, a converter DC-DC with its corresponding algorithm of tracking of the point of Maxima power of the module. The electronic circuit also incorporates elements that allow to the monitoring of the state of the module and its communication with a remote control system.

The incorporation of a converter DC-DC in each photovoltaic module allows to eliminate the due losses the mismatches between the other modules of the system and to extract the Maxima available power in each one of them, independently of the power who are providing the remainder of modules.

With these modules, that we could denominate intelligent, a completely distributed system can be formed, in which the photovoltaic modules are connected to the inverter, through their corresponding converters DC-DC, which allows to reduce all the due losses to the mismatches between the modules.

In addition, it turns out very simple to determine the proportions the installation and to make future magnifications and modifications, simply adding to octyns eliminating intelligent modules.

Additionally, the electronic circuit of the integral photovoltaic module sensors that allow to know the state the module, as well as a module of communications that send these data to a control unit and supervision.

With the collected information of each one of the modules of the plant octyns photovoltaic installation, the tasks of monitoring, maintenance and detection of failures are facilitated.

Description of the drawings

In order to complement the description that is being made and with object to help one better understanding of the features of the invention, it is accompanied like integral part of mentioned description, a game of drawings in where with illustrative and nonlimitative character, the next thing is had shown:

Figure 1. - Sample a block diagram of the intelligent photovoltaic module object of the invention.

Figure 2. - Sample a scheme of architecture of a formed photovoltaic installation from intelligent modules according to object of the invention.

Figure 3. - Sample an installation scheme using conventional photovoltaic patches.

Figure 4. - Sample the curve of output power of sunny patches and in shadow.

Figure 5. - Sample the curve of output power for an installation with 20 conventional patches.

Preferred embodiment of the invention

The photovoltaic module object of the invention is in favor formed of a photovoltaic patch (1) that integral an electronic circuit (2) that includes/understands, among other elements, a converter DC-DC (3).

With the module object of the invention, so and as it is observed in Figure 2, are possible to be formed systems completely distributed compounds by photovoltaic patches (1), with its corresponding converters DC-DC (3), connecting these last ones, to an inverter (4) that feeds the corresponding installation.

Integrated converters DC-DC (3) in each patch (1), incorporate an algorithm of tracking of the point of Maxima power, which allows to reduce all the due losses of the installation to mismatches between the other patches (1).

The electronic circuit (2) also incorporates capable sensors (4) to determine the state of the module and to transmit these data, through a module of communications (5), to a control unit and supervision (6) of the complete installation.

In the control unit and supervision (6) monitoring tasks are made, maintenance and detection of failures of all the photovoltaic installation. The communications between modules and the unit (6) are made through own wiring of continuous using modulation FSK, reason why an additional wiring is not required.

The communication protocol is MODBUS-RTU, with architecture master-slave, being the master the control unit and supervision (6) and the slaves each one of the modules that send to the unit (6) the voltage values and stream, as much to the input as when coming out of their converter DC-DC, as well as the operating temperature of the equipment.

Next, one is going away to describe to an operation example, comparing the obtained power with a centralized system, with conventional modules, vs to a distributed system with intelligent modules according to the object of the invention. Figures 4 and 5 show included graphs of output power to illustrate this example of operation.

Let us suppose a photovoltaic installation with 20 located modules for example in the roof of a building. In this type of application it turns out impossible to avoid partial shadows, like for example, the generated ones by the chimney of the building.

Also let us suppose that of the 20 modules of the installation, 5 are partially in shadow due to the vicinity of a chimney.

In Figure 4, the curves of output power for sunny modules and modules in shadow are had shown. In particular, sample the Maxima output power of a sunny module type BP580F (900 W/m2) and of a shaded module (500 W/m2). It is possible to be appreciated like, while first W presents/displays a maximum of power of 82, the second reaches a maximum of 44 W. In addition, it is possible to be observed like the streams for which one obtains the different Maxima power are in each one of the cases.

In the case of an installation composed by conventional, connected photovoltaic modules in series to a single converter with tracking of the point of Maxima power, when being connected in series all the modules, must lead the same stream, reason why the output power of the assembly corresponds to the shown curve in Figure 4.

In this curve it is possible to be observed how this series connection causes the occurrence of a maximum of relative power and an absolute maximum of power. Therefore, in the best one of the cases, the absolute maximum of power could be reached, that corresponds to a supplied power of 1213 W.

In the case of an architecture composed by 20 intelligent photovoltaic modules, according to the object of the invention, it turns out possible to obtain from each module its available Maxima power, that is to say, 44 W for five shaded modules and 82 W for the fifteen sunny modules. Of this form, the Maxima power of the serious installation of 1450 W that almost represents a 20% but that with the conventional configuration.

CLAIMS

1. A photovoltaic module, comprising a photovoltaic panel (1) and an electronic circuit (2), built into the panel (1), which includes a DC-DC converter (3) controlled by an algorithm point tracking full potential.

2. Photovoltaic module according to claim 1, wherein the electronic circuit (2) includes sensors (4) for the state of photovoltaic modules, in particular, the values of voltage and current, the input and output of the converter (3) and the operating temperature of the equipment, and a communications module (5) that sends the data collected by the sensors (4) to a control and monitoring unit (6), for monitoring, maintenance and fault detection of complete installation.

3. Photovoltaic module according to claim 1, wherein connecting to other modules via the converter DC-DC (3) and these in turn to an inverter (7) which supplies alternating current to feed the plant, getting an architecture distributed connection between modules.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 108144201501	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2010/046272**	International filing date *(day/month/year)* **23 AUGUST 2010 (23.08.2010)**	(Earliest) Priority Date *(day/month/year)* 02 SEPTEMBER 2009 (02.09.2009)

Applicant

TIGO ENERGY, INC. et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 3
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (July 2009)

108144-201501/US

DS-File KR in U.S.

CTLA
DUE DATE: 4-30-2011
DEADLINE:
DOCKETED: 4-8-2011
BY (INITIALS):

SMA Solar Technology America, LLC, Ex. 1006

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/046272

A. CLASSIFICATION OF SUBJECT MATTER

H02J 7/35(2006.01)i, H02M 3/155(2006.01)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)

H02J 7/35; G05F 1/40; G05F 1/5/63

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: two stage, buck converter, switch, feedback

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 7202653 B2 (PAI; CHUNG-LUNG) 10 April 2007 See the abstract; claims 1-5; figures 1-3.	1,8-9,12-19 2-7,11 10,20
Y A	US 2005-0040800 A1 (SEHAT SUTARDJA) 24 February 2005 See the abstract; figure 8.	2-7,11 1,8-10,12-20
A	US 5903138 A (HWANG; JEFFREY H. et al.) 11 May 1999 See the abstract; claim 1; figure 8.	1-20
A	US 2005-0017701 A1 (HSU CHIH-YUAN) 27 January 2005 See the abstract; claims 1-3; figure 6.	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	Date of mailing of the international search report
25 MARCH 2011 (25.03.2011)	**31 MARCH 2011 (31.03.2011)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

WEE Jae Woo

Telephone No. 82-42-481-8540

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2010/046272

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7202653 B2	10.04.2007	TW 234339 A	11.06.2005
		TW 234339 B	11.06.2005
		US 2005-0213354 A1	29.09.2005
US 2005-0040800 A1	24.02.2005	CN 100504708 C	24.06.2009
		CN 100574070 C	23.12.2009
		CN 1591264 A	09.03.2005
		CN 1591264 C0	09.03.2005
		CN 1591265 A	09.03.2005
		CN 1591265 B	22.09.2010
		CN 1591265 C0	09.03.2005
		CN 1612457 A	04.05.2005
		CN 1612457 C0	04.05.2005
		EP 1508956 A2	23.02.2005
		EP 1508956 A3	08.11.2006
		EP 1508958 A2	23.02.2005
		EP 1508958 A3	18.07.2007
		EP 1508958 B1	24.11.2010
		EP 1508959 A2	23.02.2005
		EP 1508959 A3	18.07.2007
		EP 1808952 A2	18.07.2007
		EP 1808952 A3	05.09.2007
		EP 1816734 A2	08.08.2007
		EP 1816734 A3	21.11.2007
		EP 2254226 A1	24.11.2010
		EP 2264879 A1	22.12.2010
		JP 04-435647 B2	08.01.2010
		JP 04-435731 B2	08.01.2010
		JP 04-527470 B2	11.06.2010
		JP 2005-143284 A	02.06.2005
		JP 2005-168277 A	23.06.2005
		JP 2006-101697 A	13.04.2006
		JP 4435647 B2	24.03.2010
		JP 4435731 B2	24.03.2010
		US 2005-0040796 A1	24.02.2005
		US 2005-040796 A1	24.02.2005
		US 2010-277141 A1	04.11.2010
		US 7760525 B2	20.07.2010
		US 7772809 B2	10.08.2010
		US 7872454 B2	18.01.2011
US 5903138 A	11.05.1999	US 05747977 A	05.05.1998
		US 05903138 A	11.05.1999
US 2005-0017701 A1	27.01.2005	TW 240729 Y	11.08.2004
		US 7064533 B2	20.06.2006

Form PCT/ISA/210 (patent family annex) (July 2009)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
WARD JOHN P

GREENBERG TRAURIG, LLP 2450 COLORADO AVENUE SUITE 400 EAST SANTA MONICA CA 90404 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**31 MARCH 2011 (31.03.2011)**
Applicant's or agent's file reference: 108144201501	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2010/046272	**23 AUGUST 2010 (23.08.2010)**	02 SEPTEMBER 2009 (02.09.2009)

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

H02J 7/35(2006.01)i, H02M 3/155(2006.01)i

Applicant

TIGO ENERGY, INC. et al

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	25 MARCH 2011 (25.03.2011)	WEE Jae Woo Telephone No. 82-42-481-8540

Form PCT/ISA/237 (cover sheet) (July 2009)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/046272

Box No. I Basis of this opinion

1 With regard to the **language**, this opinion has been established on the basis of :

☒ the international application in the language in which it was filed

☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

a. a sequence listing filed or furnished

☐ on paper

☐ in electronic form

b. time of filing or furnishing

☐ contained in the international application as filed.

☐ filed together with the international application in electronic form.

☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2010/046272

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	2-7,10-12,14-15,17,20	YES
	Claims	1,8-9,13,16,18-19	NO
Inventive step (IS)	Claims	10,20	YES
	Claims	1-9,11-19	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 7202653 B2 (PAI; CHUNG-LUNG) 10 April 2007
D2: US 2005-0040800 A1 (SEHAT SUTARDJA) 24 February 2005

1. Novelty and Inventive step

1.1. Claims 1-7
D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a high efficiency power converter comprising: a boost converter, a buck converter, a linear regulator, a voltage detector, an error amplifier, a switch, a second switch in claims 1-4. As all of the features of claim 1 are disclosed in D1, claim 1 is anticipated by D1. Therefore, claim 1 lacks novelty under PCT Article 33(2).

Claim 2 differ from D1 in two step-down converters. Therefore, the subject matter of claim 2 is considered to be novel under PCT Article 33(2). However two step-down regulators are described in figure 8 of D2. It would be obvious to a person skilled in the art to apply the two step-down regulators of D2 to the high efficiency power converter of D1 to arrive at the subject matter of claim 2. Thus, the subject matter of claim 2 does not involve an inventive step under PCT Article 33(3).

Claim 3 differ from D1 in a first stage comprising a buck converter. Therefore, the subject matter of claim 3 is considered to be novel under PCT Article 33(2). However two step-down regulators are described in figure 8 of D2. It would be obvious to a person skilled in the art to apply the two step-down regulators of D2 to the high efficiency power converter of D1 to arrive at the subject matter of claim 3. Thus, the subject matter of claim 3 does not involve an inventive step under PCT Article 33(3).

The additional feature of claims 4-5, 7 dependent on claim 3 is considered to be a minor difference over the disclosure of D1-D2, that falls under the general knowledge by a person skilled in the art. Therefore, claims 4-5, 7 lack an inventive step under PCT Article 33(3).

The additional features of claim 6 depending on claim 3 are identical to the feature of two step-down regulators in figure 8 of D2. Therefore, claim 6 lacks an inventive step under PCT Article 33(3).

1.2. Claims 8-17
D1, which is considered to be the closest prior art to the subject matter of claims 8-9, 13, 16 discloses a high efficiency power converter comprising: a boost converter, a buck converter, a linear regulator, a voltage detector, an error amplifier, a switch, a second switch in claims 1-4. As all of the features of claims 8-9, 13, 16 are disclosed in D1, claims 8-9, 13, 16 are anticipated by D1. Therefore, claims 8-9, 13, 16 lack novelty under PCT Article 33(2).

(Continued on the supplemental box.)

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of

Box No. V

The subject matter of claim 10 differs from these prior art document in that claim 10 includes a hysteresis amplifier. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 10 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

Claim 11 differ from D1 in two step-down converters. Therefore, the subject matter of claim 11 is considered to be novel under PCT Article 33(2). However two step-down regulators are described in figure 8 of D2. It would be obvious to a person skilled in the art to apply the two step-down regulators of D2 to the high efficiency power converter of D1 to arrive at the subject matter of claim 11. Thus, the subject matter of claim 11 does not involve an inventive step under PCT Article 33(3).

Claims 12, 15 differ from D1 in the voltage ranges of a first and second and third voltage. Therefore, the subject matter of claims 12, 15 is considered to be novel under PCT Article 33(2). However the additional features of claims 12, 15 dependent on claim 8, 13, respectively, are considered to be a minor difference over the disclosure of D1, which fall under the general knowledge by a person skilled in the art. Therefore, claims 12, 15 lack an inventive step under PCT Article 33(3).

Claim 14 differs from D1 in a switching device selected from FET, MOFET, BJT. Therefore, the subject matter of claim 14 is considered to be novel under PCT Article 33(2). However the additional feature of claim 14 dependent on claim 13 is considered to be a minor difference over the disclosure of D1, which falls under the general knowledge by a person skilled in the art. Therefore, claim 14 lacks an inventive step under PCT Article 33(3).

Claim 17 differs from D1 in a capacitor coupled to the input of the second stage. Therefore, the subject matter of claim 17 is considered to be novel under PCT Article 33(2). However the additional feature of claim 17 dependent on claim 16 is considered to be a minor difference over the disclosure of D1, which falls under the general knowledge by a person skilled in the art. Therefore, claim 17 lacks an inventive step under PCT Article 33(3).

1.3. Claims 18-20
D1, which is considered to be the closest prior art to the subject matter of claims 18-19 discloses a high efficiency power converter comprising: a boost converter, a buck converter, a linear regulator, a voltage detector, an error amplifier, a switch, a second switch in claims 1-4. As all of the features of claims 18-19 are disclosed in D1, claims 18-19 are anticipated by D1. Therefore, claims 18-19 lack novelty under PCT Article 33(2).

The subject matter of claim 20 differs from these prior art document in that claim 20 includes a hysteresis amplifier. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 20 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

2. Industrial Applicability
Claims 1-20 are considered to be industrially applicable under PCT Article 33(4).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 February 2003 (13.02.2003)

PCT

(10) International Publication Number
WO 03/012569 A1

(51) International Patent Classification[7]: G05F 1/67, H02J 7/35

(21) International Application Number: PCT/NL02/00434

(22) International Filing Date: 3 July 2002 (03.07.2002)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1018658 29 July 2001 (29.07.2001) NL
1020893 18 June 2002 (18.06.2002) NL

(71) Applicant *(for all designated States except US)*: **STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND** [NL/NL]; Postbus 1, NL-1755 ZG Petten (NL).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **VELTMAN, Arie, Taeke** [NL/NL]; Drevelstraat 20, NL-1825 KK Alkmaar (NL).

(74) Agent: **DOKTER, Hendrik, Daniël**; Octrooibureau Dokter, P.O. Box 657, NL-7300 AR Apeldoorn (NL).

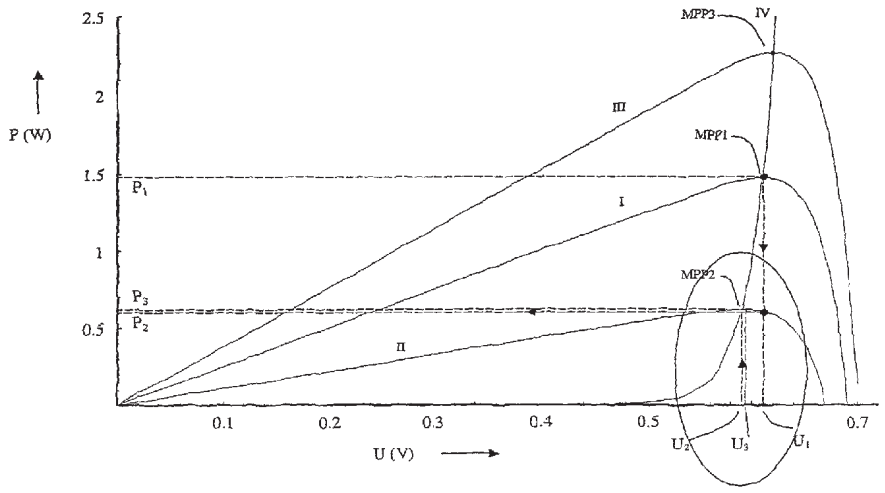
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: MAXIMUM POWERPOINT TRACKER



(57) Abstract: Maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in this energy source depending as desired on the output voltage or the output current of this energy source, and with processor means for determining from this information the maximum power which can be produced by this energy source and the output voltage or output current required for this purpose, wherein the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in this energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source.

WO 03/012569 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SMA Solar Technology America, LLC, Ex. 1006

MAXIMUM POWERPOINT TRACKER

The invention relates to a maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in this energy source depending as desired on the output voltage or the output current of this energy source, and with processor means for determining from this information the maximum power which can be produced by this energy source and the output voltage or output current required for this purpose.

Such a maximum powerpoint tracker, generally designated with the abbreviation MPP-tracker, is a per se known circuit which is applied to maximize the power produced by an energy source with varying power. Examples of such an energy source are photovoltaic systems and wind turbines.

The known MPP-tracker "searches" for the maximum power in the power curve of an energy source, and sends this information to a control circuit which applies a voltage over the output of the energy source (or draws off a current from the energy source) such that it produces a greater output current (or has a higher output voltage) as the power increases, and produces a smaller output current (or has a lower output voltage) as the power decreases. The power curve is defined in the foregoing as the progression of the power produced by the energy source as a function of the output voltage or the output current of this energy source.

In the known MPP-tracker a search algorithm for a so-called extreme value adjustment is applied in order to determine the maximum power which can be drawn off at a given incoming power in the source, for instance incident sunlight or intercepted wind energy. In an extreme value adjustment the output voltage or the

output current of the energy source is changed in stepwise manner (increased or decreased), and the power produced is compared to power produced before the change. If the last-measured power is greater than the previously measured power, the output voltage or the output current is changed in stepwise manner in the same direction (i.e. increased or decreased). If the last-measured power is smaller than the previously measured power, the output voltage or the output current is changed in stepwise manner in opposing direction (i.e. decreased or increased).

It is a drawback of the known MPP-tracker that when the above described search algorithm is applied it responds relatively slowly to acute changes in the incoming power in the energy source. Such acute changes occur for instance in a photovoltaic system when cloud suddenly develops or clears away, and can occur in wind turbines in the case of local variations in wind-force. A slow response of the stepwise search algorithm results in a relatively long period in which the energy source does not produce its optimal power, and therefore in costly energy losses.

It is an object of the invention to provide an MPP-tracker which responds quickly to acute changes in the incoming power in an energy source for which this MPP-tracker is applied.

This objective is realized with a maximum powerpoint tracker of the type specified in the preamble, wherein according to the invention the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in this energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or

output current required for this purpose at at least a second and a third incoming power in this energy source.

In an embodiment of a maximum powerpoint tracker according to the invention, the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source is given by a coefficient U' of an exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit).

The exponential function $P_{mpp}=U'e^{u_{mpp}}$ is based on an ideal solar cell, i.e. a solar cell which, in a simplified model, is represented by a voltage source with a resistance-free diode connected in parallel. It has been found that an exponential function forms a good approximation of the stated relation.

In a practical advantageous embodiment the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source is given by the coefficients a_i of an n^{th} degree polynomial $P_{mpp}=\Sigma_{j=0}^{j=n}a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit), wherein n is a whole number preferably equal to 2.

In a practical simple embodiment the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source comprises the parameters for describing a linear interdependence of the maximum power which can be produced and the output

voltage or output current required for this purpose at the incoming power.

A maximum powerpoint tracker according to the invention is preferably adapted to perform at predetermined time intervals a determination of the information about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in this energy source and to store this information in the memory means.

In an embodiment of an MPP-tracker according to the invention the algorithm comprises an iteration procedure.

In another embodiment the algorithm is followed after a predetermined instruction by a second algorithm for performing an extreme value adjustment, so that the maximum power which can be produced and the associated output voltage or output current can be determined with great accuracy. In a case where the first algorithm comprises an iteration procedure, the determined instruction comprises for instance of performing a predetermined number of iterations.

The invention will now be elucidated hereinbelow with reference to the drawings.

In the drawings

Fig. 1 is a diagram with three curves I-III which show the power P which can be produced by a solar cell as a function of the output voltage U, with a first curve IV which represents the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced,

Fig. 2 shows a part of fig. 1 in enlarged view,

Fig. 3 shows a second curve IV' representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced, and

Fig. 4 shows a third curve IV" representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced.

Fig. 1 shows a diagram with three curves I-III representing the power P which can be produced by a solar cell as a function of the output voltage U at different incoming amounts of power, for instance as a result of different amounts of incident sunlight with varying cloud cover. The points MPP1, MPP2 and MPP3 in the respective curves I-III represent the maximum amounts of power which can be produced at the respective incoming amounts of power, and are connected by curve IV. The operation of the MPP-tracker according to the invention can be understood as follows. The power of a determined quantity of light incident in a solar cell corresponds for instance to a power which can be produced by this solar cell as according to curve I. The maximum power P1 which can be produced at an output voltage U1 is represented by the point MPP1 on curve I. In the case of a sudden fall in the quantity of incident sunlight, the power which can be produced corresponds to another curve, in the example curve II. At the original output voltage U1 a power P2 would be produced which is lower than the maximum power which can be produced in the conditions. According to the invention the MPP-tracker "searches" on the curve IV for the output voltage U2 corresponding to the power P2, then on curve II for the power P3 corresponding to the output voltage U2, on the curve IV for the output voltage U3 corresponding to the power P3, on curve II for the power P4 (not shown) corresponding to the output voltage U3 etc., until after a sufficient number of iterations there follows a search algorithm for an extreme value adjustment according to the prior art.

In practical situations, where the power curves of solar cells manufactured in accordance with a standard

process are known, the optimal power line IV can be predetermined and can be inputted into the memory of an MPP-tracker intended for that type of solar cells.

Fig. 2 shows an enlarged view of the part of fig. 1 enclosed by an ellipse.

Fig. 3 shows a curve IV' representing the maximum power P_{mpp} which can be produced by an ideal solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced. Curve IV' is calculated from the exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose (expressed in a dimensionless unit) for an ideal solar cell.

Fig. 4 shows a curve IV" representing the maximum power P_{mpp} which can be produced by a solar cell as a function of the output voltage U_{mpp} at that maximum power which can be produced, which curve IV" is calculated from a sixth degree polynomial $P_{mpp}=\Sigma_{j=0}^{j=6}a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} (expressed in a dimensionless unit).

An MPP-tracker according to the invention is particularly suitable for application in photovoltaic systems, in particular solar panels assembled from solar cells connected in series, where the shorter recovery time following a change in radiated power results in an increase in the produced power such that the extra investment cost of an MPP-tracker according to the invention is recouped in a relatively short time. The MPP-tracker according to the invention can however also be applied in other energy-generating systems, for instance wind turbines.

CLAIMS

1. Maximum powerpoint tracker provided with memory means for storing information about the power produced by an energy source at a determined incoming power in said energy source depending as desired on the output voltage or the output current of said energy source, and with processor means for determining from this information the maximum power which can be produced by said energy source and the output voltage or output current required for this purpose, **characterized in that** the processor means are adapted to perform an algorithm according to which the maximum power which can be produced by an energy source and the output voltage or output current required for this purpose at a first incoming power in said energy source is determined from information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source.

2. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source is given by a coefficient U' of an exponential function $P_{mpp}=U'e^{u_{mpp}}$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose.

3. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source is given by the coefficients a_i of an n^{th} degree polynomial

$P_{mpp}=\Sigma_{j=0}^{j=n} a_j u_{mpp}^j$ which describes the relation between the maximum power P_{mpp} which can be produced and the output voltage u_{mpp} required for this purpose, wherein n is a whole number.

4. Maximum powerpoint tracker as claimed in claim 3, **characterized in that** n has the value 2.

5. Maximum powerpoint tracker as claimed in claim 1, **characterized in that** the information stored in the memory means about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source comprises the parameters for describing a linear interdependence of the maximum power which can be produced and the output voltage or output current required for this purpose at the incoming power.

6. Maximum powerpoint tracker as claimed in any of the claims 1-5, **characterized in that** it is adapted to perform at predetermined time intervals a determination of the information about the maximum power which can be produced and the output voltage or output current required for this purpose at at least a second and a third incoming power in said energy source, and to store this information in the memory means.

7. Maximum powerpoint tracker as claimed in any of the claims 1-6, **characterized in that** the algorithm comprises an iteration procedure.

8. Maximum powerpoint tracker as claimed in any of the claims 1-7, **characterized in that** the algorithm is followed after a predetermined number of iterations by a second algorithm for performing an extreme value adjustment.

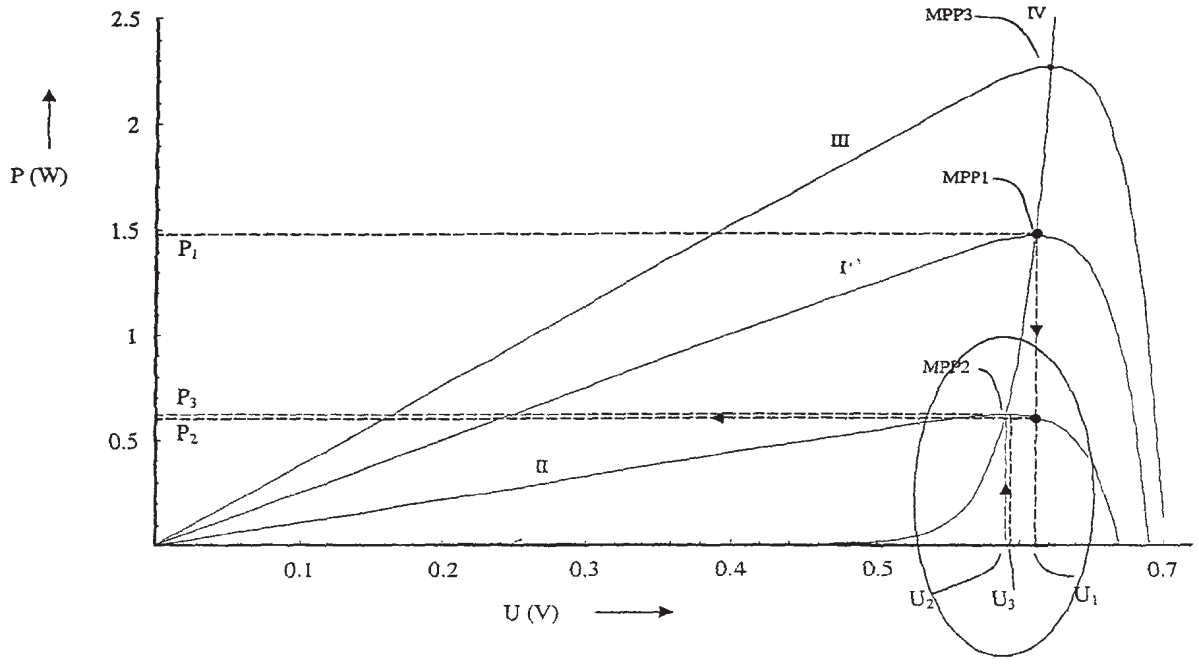

2.5
2
1.5
1
0.5
P (W)
P1
P3
P2
MPP3
IV
III
MPP1
I
MPP2
II
0.1
0.2
0.3
0.4
0.5
0.7
U (V)
U2
U3
U1

Fig. 1

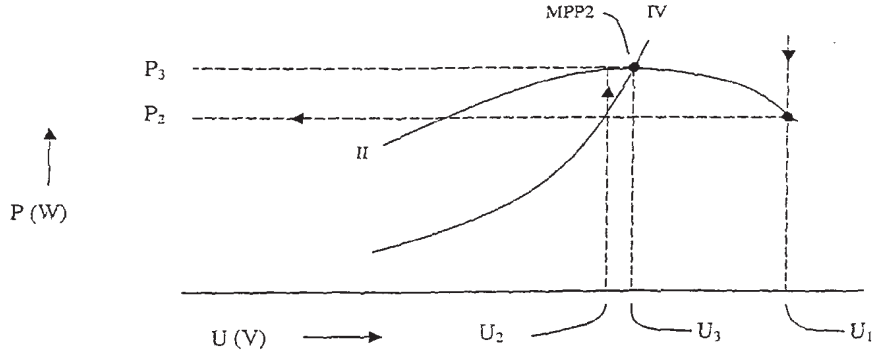

MPP2
IV
P3
P2
II
P (W)
U (V)
U2
U3
U1

Fig. 2

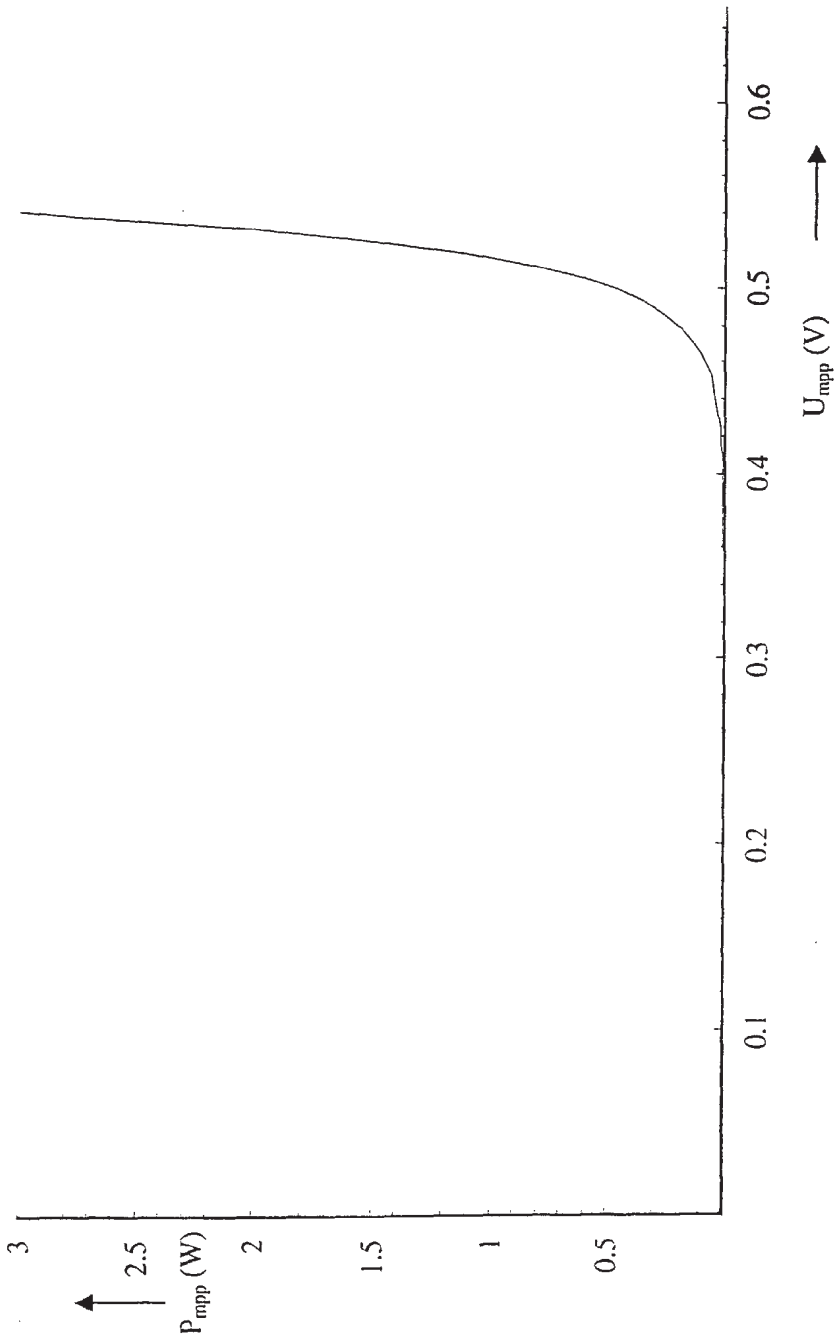


Fig. 3

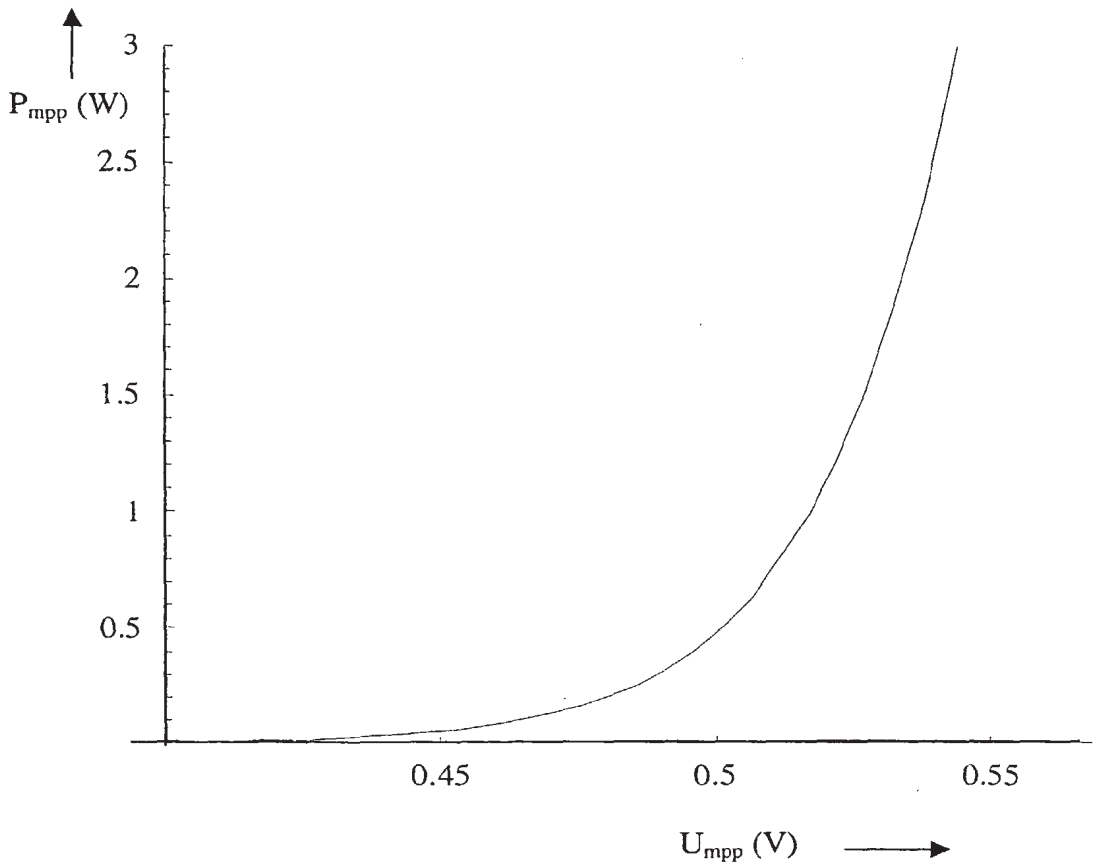


Fig. 4

INTERNATIONAL SEARCH REPORT

ıal Application No
PCT/NL 02/00434

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05F1/67 H02J7/35

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 G05F H02J

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 947 905 A (SANYO ELECTRIC CO) 6 October 1999 (1999-10-06)	1
A	the whole document	2-8

X	CHIHCHIANG HUA ET AL: "Comparative study of peak power tracking techniques for solar storage system" APPLIED POWER ELECTRONICS CONFERENCE AND EXPOSITION, 1998. APEC '98. CONFERENCE PROCEEDINGS 1998., THIRTEENTH ANNUAL ANAHEIM, CA, USA 15-19 FEB. 1998, NEW YORK, NY, USA,IEEE, US, 15 February 1998 (1998-02-15), pages 679-685, XP010263666 ISBN: 0-7803-4340-9	1
A	the whole document	2-8

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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 document 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 another 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	Date of mailing of the international search report
14 October 2002	28/10/2002

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	Schobert, D

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

SMA Solar Technology America, LLC, Ex. 1006

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	CHIHCHIANG HUA ET AL: "DSP-based controller application in battery storage of photovoltaic system" INDUSTRIAL ELECTRONICS, CONTROL, AND INSTRUMENTATION, 1996., PROCEEDINGS OF THE 1996 IEEE IECON 22ND INTERNATIONAL CONFERENCE ON TAIPEI, TAIWAN 5-10 AUG. 1996, NEW YORK, NY, USA,IEEE, US, 5 August 1996 (1996-08-05), pages 1705-1710, XP010203239 ISBN: 0-7803-2775-6	1
A	the whole document	2-8
X	HUA C ET AL: "IMPLEMENTATION OF A DSP-CONTROLLED PHOTOVOLTAIC SYSTEM WITH PEAK POWER TRACKING" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, IEEE INC. NEW YORK, US, vol. 45, no. 1, 1 February 1998 (1998-02-01), pages 99-107, XP000735209 ISSN: 0278-0046	1
A	the whole document	2-8
A	US 5 869 956 A (FUKAE KIMITOSHI ET AL) 9 February 1999 (1999-02-09) abstract	1-8
A	US 5 604 430 A (DECKER DARWIN K ET AL) 18 February 1997 (1997-02-18) abstract	1-8

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

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0947905 A	06-10-1999	JP 11282553 A	15-10-1999
		JP 11282554 A	15-10-1999
		JP 11282555 A	15-10-1999
		CN 1230709 A	06-10-1999
		EP 0947905 A2	06-10-1999
		US 6046919 A	04-04-2000
US 5869956 A	09-02-1999	JP 10083223 A	31-03-1998
US 5604430 A	18-02-1997	NONE	

Electronic Acknowledgement Receipt

EFS ID:	24233205
Application Number:	14822227
International Application Number:	
Confirmation Number:	4926
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	Mordechay AVRUTSKY
Customer Number:	64494
Filer:	John Patrick Ward/Meng Sui
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-201502/US (TGY015)
Receipt Date:	01-DEC-2015
Filing Date:	10-AUG-2015
Time Stamp:	18:36:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	108144-201502_IDS.pdf	614440 d11e2e2ecdddab21f670e668bae43c1e2ee7c35f	no	10

Warnings:

Information:

SMA Solar Technology America, LLC, Ex. 1006

2	Other Reference-Patent/App/Search documents	108144-201502_RelatedApp.pdf	73240 6cf58d78e5e072fc2298c0064fa6a6fb0e1a2f0f	no	2
Warnings:					
Information:					
3	Non Patent Literature	Alonso_Distributed.pdf	316381 bd912fa51bb4928ef3f81333f9c90b06de0bb7c6	no	4
Warnings:					
Information:					
4	Non Patent Literature	Alonso_Experimental.pdf	248866 5f6be18061d8ab4a0030ef3f285ad210e6b4a67f	no	4
Warnings:					
Information:					
5	Foreign Reference	AU_2005262278.pdf	1050806 bda96a04758e1f76854eaf5dc02d37fc4fbd52a0	no	33
Warnings:					
Information:					
6	Non Patent Literature	Basso.pdf	1376968 4f29b54421bf214457ff3985134ccf3beaffb8af	no	56
Warnings:					
Information:					
7	Non Patent Literature	Boostbuck.pdf	68958 a0bdf852811024495d444f923e8f894d034c9398	no	3
Warnings:					
Information:					
8	Foreign Reference	DE_4232356.pdf	419969 baa62003b24ae498de551157556ea08d2e22f652	no	5
Warnings:					
Information:					
9	Foreign Reference	DE_19961705.pdf	675864 d28fed8719d8d91cb96cf7d02fcd3e30bf39e809	no	11
Warnings:					
Information:					
10	Non Patent Literature	Enslin.pdf	450731 d6b6ef36fdc94bd6d4c3ad7f53056299b3bcef80	no	5
Warnings:					
Information:					

SMA Solar Technology America, LLC, Ex. 1006

11	Foreign Reference	EP_1388774A1.pdf	844423 e951ca76db26515029068e73a438c8757d212cfd	no	15
Warnings:					
Information:					
12	Foreign Reference	ES_2249147.pdf	362368 5c0a0e3ad9f5be717ae857a6a8373fe6edc804d5	no	13
Warnings:					
Information:					
13	Non Patent Literature	Gautam.pdf	177477 e0ebf6227917253fb87cfccd0b1747d0bfe1741e	no	15
Warnings:					
Information:					
14	Non Patent Literature	Linares.pdf	1041332 d0053aa44bc0f443d28e3bb9abcd1feed2edf8da	no	7
Warnings:					
Information:					
15	Non Patent Literature	Nordmann.pdf	24716128 d34915b168042169aacaa93ac6e0a94471b8613d	no	20
Warnings:					
Information:					
16	Non Patent Literature	Palma.pdf	300372 d02e2ee50a6851b10f1c5384ae780d9c8f90045a	no	6
Warnings:					
Information:					
17	Non Patent Literature	PCTUS10_046272_ISR_WO.pdf	289618 26e2214e13afbfe88812fc8e52e998093106cc7c	no	7
Warnings:					
Information:					
18	Non Patent Literature	Quaschning.pdf	443496 27d266a23d37c4483a86aa4fde2797688ebe6e90	no	6
Warnings:					
Information:					
19	Non Patent Literature	Roman.pdf	768186 b2a52443fc6f5e6f9f7652e09e1041bbba918bca	no	8
Warnings:					
Information:					

SMA Solar Technology America, LLC, Ex. 1006

20	Non Patent Literature	Uriarte.pdf	342846 82a6719419a9c146cd1266bc86e5d51e970b33f9	no	4
Warnings:					
Information:					
21	Non Patent Literature	Walker_Cascaded_2002.pdf	564877 2441bde60f00ad4a3bcc518a9106fee3f496a0d4	no	6
Warnings:					
Information:					
22	Non Patent Literature	Walker_Cascaded_2004.pdf	823250 2984cf6c5be1dfa83611ebd822e2041f3757a8d8	no	10
Warnings:					
Information:					
23	Foreign Reference	WO_2003012569.pdf	546173 47f2c653a847407e88a712f9d35e413ffc30aa04	no	16
Warnings:					
Information:					
		Total Files Size (in bytes):	36516769		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/01 (08-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ☒ United States application or PCT international application number 14/822,227 filed on August 10, 2015

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

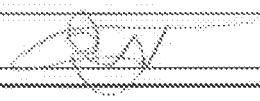
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: MORDECHAY AVRUTSKY Date (Optional) 08/28/2015

Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing this form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	23386813
Application Number:	14822227
International Application Number:	
Confirmation Number:	4926
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	Mordechay AVRUTSKY
Customer Number:	64494
Filer:	John Patrick Ward/Meng Sui
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-201502/US (TGY015)
Receipt Date:	02-SEP-2015
Filing Date:	10-AUG-2015
Time Stamp:	16:52:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	108144-201502_Declaration.pdf	180808 db7be1dc8b4194c099a6594b8ff96851f54b7e9b	no	2

Warnings:

Information:

SMA Solar Technology America, LLC, Ex. 1006

Total Files Size (in bytes):	180808

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/822,227	08/10/2015	Mordechay AVRUTSKY	108144-201502/US (TGY015)

CONFIRMATION NO. 4926

64494
GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

INFORMAL NOTICE

OC000000077047764

Date Mailed: 08/25/2015

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Mordechay AVRUTSKY

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/fhadera/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/822,227

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

SMA Solar Technology America, LLC, Ex. 1006

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/822,227	08/10/2015	2838	800	108144-201502/US (TGY015)	20	3

CONFIRMATION NO. 4926

64494
GREENBERG TRAURIG, LLP (SV)
c/o: Greenberg Traurig LLP - Chicago Office
77 West Wacker Drive, Suite 3100
Intellectual Property Department
Chicago, IL 60601

FILING RECEIPT

OC000000077047763

Date Mailed: 08/25/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Mordechay AVRUTSKY, Alfei Menashe, ISRAEL;

Applicant(s)

Tigo Energy, Inc., Los Gatos, CA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 12/787,205 05/25/2010
which claims benefit of 61/275,734 09/02/2009
and claims benefit of 61/336,743 01/26/2010

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 08/21/2015
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/822,227**
Projected Publication Date: 12/03/2015
Non-Publication Request: No
Early Publication Request: No

** **SMALL ENTITY** **

Title

SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

Preliminary Class

363

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

Attorney Docket No. 108144-201502/US (TGY015)

PATENT APPLICATION

FOR

SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

INVENTOR: MORDECHAY AVRUTSKY
ALFEI MENASHE, IL

PREPARED BY:
GREENBERG TRAURIG
PHONE: (650) 328-8500
FAX: (650) 328-8508

 SMA Solar Technology America, LLC, Ex. 1006

SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE

RELATED APPLICATIONS

[0001] The present application is a continuation application of U.S. Pat. App. Ser. No. 12/787,205, filed May 25, 2010 and entitled "Systems and Methods for Enhanced Efficiency Auxiliary Power Supply Module", which claims the benefit of filing dates of Prov. U.S. App. Ser. No. 61/275,734, filed Sep. 2, 2009 and entitled "System and Method for Enhanced Efficiency Auxiliary Power Supply Module", and Prov. U.S. App. Ser. No. 61/336,743, filed Jan. 26, 2010 and also entitled "System and Method for Enhanced Efficiency Auxiliary Power Supply Module," the entire disclosures of which applications are hereby incorporated herein by reference.

FIELD OF THE TECHNOLOGY

[0002] At least some embodiments of this disclosure relate to photovoltaic systems in general, and more particularly but not limited to, enhancing the efficiency for auxiliary power supply modules used in photovoltaic systems.

BACKGROUND

[0003] Typically, power supplies or power supply modules used for photovoltaic systems may provide, for example, 3.3V to be used as a main supply voltage, in most applications when the photovoltaic system needs to maintain low voltage for energy-saving purposes. However, when the power supplies are driving the metal-oxide-semiconductor field-effect transistors (MOSFET) or similar devices or switches contained within the photovoltaic systems, the power supplies or power supply modules of photovoltaic systems may have to provide higher voltage levels such as, for example, 10V to 12V. Keeping the main supply of the control circuit and the overall power supply module at, for example, 3.3.V may be preferable in order to maintain ideal energy-savings for the operation of photovoltaic systems.

SUMMARY OF THE DESCRIPTION

[0004] Systems and methods in accordance with the present disclosure are described herein. Some embodiments are summarized in this section.

[0005] In one of many embodiments of the disclosure, provided is a power supply for use in a solar electric production system. The power supply includes: a first stage having an input connected to a voltage from a photovoltaic panel and an output providing a first voltage different from the voltage from the photovoltaic panel; and a second stage connected to the output of the first stage, the second stage supplying power at a second voltage to a micro-controller, where the output of the first stage is turned on and stable for a period of time before the second stage is turned on to supply the power at the second voltage to the micro-controller.

[0006] In another embodiment, provided is a power supply for use in a solar electric production system. The power supply includes: a first stage having an input and an output, the input of the first stage to receive power from a photovoltaic panel, the output of the first stage to provide a first voltage different from the voltage received at the input of the first stage; a switchable load; a second stage having an input connected to the output of the first stage, the second stage to supply power at a second voltage to an micro-controller; and a control circuit to provide a signal to the switchable load to switch off the switchable load prior to providing a signal to the second stage to enable output from the second stage to the micro-controller.

[0007] Other embodiments and features of the present disclosure will be apparent from the accompanying drawings and from the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The embodiments are illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

[0009] **Figure 1** shows an example gate charge vs. gate-to-source voltage diagram according to an embodiment of the present disclosure.

[0010] **Figure 2** shows a diagram illustrating R_{DSon} behavior as a function of V_{GS} (voltage between gate and source of a FET) according to an embodiment of the present

disclosure.

[0011] **Figure 3** shows a schematic description of an auxiliary circuit according to an embodiment of the present disclosure.

[0012] **Figure 4** shows a schematic description of a circuit practicing a system and method according to an embodiment of the present disclosure.

[0013] **Figure 5** shows a schematic description of an example startup behavior of wave forms, according to an embodiment of the present disclosure.

[0014] **Figure 6** shows a power supply according to one embodiment.

DETAILED DESCRIPTION

[0015] The following description and drawings are illustrative and are not to be construed as limiting. Numerous specific details are described to provide a thorough understanding. However, in certain instances, well known or conventional details are not described in order to avoid obscuring the description. References to one or an embodiment in the present disclosure are not necessarily references to the same embodiment; and, such references mean at least one.

[0016] Provided is a system and method for an auxiliary power supply module used in a photovoltaic system to increase the efficiency of the photovoltaic system and reduce maintenance responsibilities of the system, or housekeeping requirements, wherein housekeeping roughly means the energy, power or voltage requirements needed to operate controls and switches of a photovoltaic system that converts sunlight into electricity, as well as to manage and control directly associated tasks, including but not limited to communication operations and so on. This increase in efficiency and power savings may be achieved by designing a photovoltaic system where the efficiency curve is as flat as possible. For example, in order to achieve such efficiency objectives, an internal auxiliary power supply having reduced power consumption may be used to drive the MOSFETs of a photovoltaic system at the lower power end of the efficiency curve in order to ultimately obtain the most efficient power savings possible.

[0017] One application of the present disclosure is to power control circuits for a solar panel using the power generated by the solar panel. For example, a power supply module of one embodiment is used to power the link module (200) using the

electricity generated by the photovoltaic panel (101n) described in U.S. Pat. App. Ser. No. 11/875,799, published now as U.S. Pat. App. Pub. No. 2008/0097655. For example, a power supply module of one embodiment is used to power the local management unit (LMU) (101) using the electricity generated by the solar module (102) described in U.S. Pat. App. Ser. No. 12/411,317, now issued as U.S. Pat. No. 7,602,080. In one embodiment, a sun can be shown along with any of the above-referenced **Figures** – illustrate that the sun may be the source of photovoltaic energy absorbed by a solar panel, for instance. The contents of the above discussed patent and publication are incorporated herein by reference.

[0018] **Figure 1** shows an example gate charge vs. gate-to-source voltage diagram according to an embodiment of the present disclosure. Gate charge (Q_G) vs. gate-to-source voltage (V_{GS}) diagram (100) comprises at least one drain-to-source voltage (V_{DS}) curve (102), a gate-to-source voltage (V_{GS}) axis (104), having a unit of measurements of Volts, and a total gate charge (Q_G) axis (106), having a unit of measurement of Coulombs, or capacitive charge, or in the specific case of **Figure 1**, nano-Coulombs (nC).

[0019] **Figure 1** analyzes the gate, drain and source of a typical MOSFET transistor that may be used in a photovoltaic system, for example. According to an embodiment of the present disclosure, driving the gate of the MOSFET relative to the source with a lower voltage value (low V_{GS} values on the gate-to-source voltage axis (104)) may yield energy savings for the associated voltage drive at, for example, saving roughly twice the amount of energy compared to using high-voltage values). Note also that the slope (change in gate-to-source voltage over change in total gate charge) is slightly higher for lower values of VGS as opposed to higher values of V_{GS}, which may mean greater power efficiency overall. Both the lowered voltage of the gate-to-source voltage V_{GS} and the lowered internal gate capacity (which in turn reduces the charge or discharge current across the gate) result in a roughly quadratic savings of power. This power savings allows a photovoltaic system to achieve great reduction in housekeeping energy supply, by using an “adaptive” gate drive that adapts power consumption based on the amount of gate driving voltage provided. Therefore, as can be seen in **Figure 1**, the reduction in gate charge is linear in relation to the gate-to-source voltage V_{GS}.

[0020] MOSFETs have a threshold input voltage, above which the transistor is substantially in full conduction mode or in saturation mode. For safe operation and full conduction, the minimum gate voltage should be at least 1V above the minimum threshold voltage value. Even if full saturation is not achieved, particularly at the low end of the power range, a loss in switching efficiency may be small, whereas at the same low end of the power range, housekeeping energy may suddenly become an issue. Adjusting the gate drive voltage is required to reduce the auxiliary supply current at low load conditions, whereas the effective resistance between the drain and the source of a MOSFET (R_{DS}) has little to no influence on switching efficiency. For a MOSFET above its turn-on threshold voltage, the total gate charge value versus normal gate charge value is a straight line, as is well known in the art, meaning that the behavior per each load current exhibits constant capacitance. Therefore, the gate drive current may behave according to $\frac{1}{2}CV^2f$, where C= the equivalent capacitance, V = the gate voltage, and f= operating frequency. Thus it is clear that reducing the gate voltage from 11V to 7V may reduce the drive current by more than two orders of magnitude. At the same time that the R_{DSon} (the resistance between the drain and the source of a MOSFET switch (or other FET switch) when fully on) is increased by less than 1.5 times its 12V value. At light load conditions (less than 30 percent of a standard-rated load) the change in R_{DSon} does not affect the overall efficiency of the overall MOSFET transistor or of the photovoltaic system.

[0021] **Figure 2** shows a diagram illustrating R_{DSon} behavior as a function of V_{GS} (voltage between gate and source of a FET) according to an embodiment of the present disclosure. Drain-to-source voltage (V_{DS}) to drain-to-source Current (I_D) diagram (200) comprises at least one gate-to-source voltage (V_{GS}) curve 202, a drain-to-source Current (I_D) axis 204, and a drain-to-source voltage (V_{DS}) axis 206. As can be seen from **Figure 2**, a gate-to-source voltage value (V_{GS}) between 15V to 6V does not affect the resistance significantly up to a 1V drop which is the range of R_{DSon} (the resistance between the drain and the source of a MOSFET when fully on) for the switching area. The resistance is not effected significantly up to a 1V drop because the MOSFET is in saturation mode, and because $V_{DS} = I*R_{DSon}$ and R_{DSon} is a function of both V_{GS} and V_{DS}, so when V_{GS} changes, the R_{DSon} value is affected. As also can be observed from

Figure 2, the slope (change in ID over change in VDS) increases for higher values of V_{GS} and begin to decrease and plateau for lower values of V_{GS}. This implies that there is an optimal V_{GS} value to drive the gate voltage at in order to still be efficient and not affect the range of R_{DSon}, which is desired in order to avoid any excessive power consumption from the resistance of R_{DSon}.

[0022] Further details about characteristics of MOSFETs in one embodiment (e.g., used as switches for controlling the output of solar panels) may be provided in IRF8101E/S/SLPbF data sheet from International Rectifier, which is hereby incorporated herein by reference.

[0023] **Figure 3** shows a schematic description of an auxiliary circuit according to an embodiment of the present disclosure. Auxiliary circuit (300) is a circuit designed to control the auxiliary power for a photovoltaic system, for example. In one embodiment, the auxiliary circuit (300) receives in the input terminal (333) electricity from the photovoltaic panel (101n) described in U.S. Pat. App. Ser. No. 11/875,799, or from the solar module (102) described in U.S. Pat. App. Ser. No. 12/411,317. In one embodiment, the auxiliary circuit (300) provides in one output terminal (330) a voltage for control logic, such as the link module (200) described in U.S. Pat. App. Ser. No. 11/875,799 or the controller (109) described in U.S. Pat. App. Ser. No. 12/411,317. In one embodiment, the circuit (300) provides in one output terminal (331) a voltage for driving a switch, such as a switch having characteristics shown in **Figs. 1** and **2**, which can be used as a switch in the link module (200) described in U.S. Pat. App. Ser. No. 11/875,799, or a switch (106) and/or a switch (108) described in U.S. Pat. App. Ser. No. 12/411,317.

[0024] In one embodiment, the auxiliary circuit (300) includes step-down converters, such as a buck converter (301) to drive a first voltage output (331) and a buck converter (311) to drive a second voltage output (330). The auxiliary circuit (300) uses capacitor (326) as a backup power supply in order to keep buck converter (311) running longer than buck converter (301). In other words, capacitor (326) is charged by buck converter (301) and used by buck converter (311) as a power supply such that the output of buck converter (311) lasts longer than the output of buck converter (301). If the output of buck converter (301) is out or unstable for a little while, buck converter

(311) can still keep the auxiliary circuit (300) working properly at 3.3V for this short period of power outage or instability. Thus, the control logic powered by the voltage (330) will have enough power to provide appropriate control signals, until the drive stage powered by the voltage (331) loses the power (e.g., to operate the switch for the solar panel). Utilizing capacitor (326) may be beneficial in situations where the solar panel is temporarily out of power, such as, for example, when the solar panel is covered by a falling leaf or a bird flying by or a brief shadow.

[0025] In one embodiment, auxiliary circuit (300) has input voltage (333), buck converter (301), voltage (332), MOSFET (345), drive voltage (31), resistor (319), resistor (313), capacitor (326), buck converter (311), 3.3.V logic supply output (330), diode (322), resistors (323, 324, 325), transistors (320, 321), control block (315), and resistors (341, 342, 343, 340). The buck converter (301) has: MOSFET (302), diode (305), inductor (306), resistors (308, 309, 310), capacitor (307), MOSFET (303), and control (304). The buck converter (311) has: MOSFET (312), diode (325), inductor (327), capacitor (328) and control (314). Various known converters can be used to replace the voltage conversion portion of the buck converters (301 and 311), such MOSFET (302), diode (305), inductor (306) and capacitor (307) in the buck converter (301), or MOSFET (312), diode (325), inductor (327) and capacitor (328) in the buck converter (311). Therefore, the details shown in buck converter (303) and buck converter (311) are merely illustrative, and other types of buck converters known in the art may be used. In one embodiment, control block 315 has: control circuit (318), and transistors (317, 316). The control circuits 304, 314 and 318 may be interconnected via one or more control signals or connected to one source, such as a micro-controller, although this embodiment is not explicitly shown in **Figure 3**. In one embodiment, the control circuit (318) controls the operations of the control (304) and control (314).

[0026] In auxiliary circuit (300), drive voltage (331) is controlled by a serial MOSFET (345) and resistor (319). Before enabling the serial MOSFET (345), transistor (321) is to be turned on by meeting at least the following two conditions: (i) 3.3V logic supply (330), for example, is on and higher than at least, for example, 2.6V. (ii) At this particular voltage level, the threshold formed by Zener diode (322) and resistors (324) and (325), as well as when the V_{BE} (base-emitter voltage) of transistor (321) (if

transistor (321) comprises a bipolar transistor instead of a MOSFET) activates transistor (321), thus making the control circuit (318) operative and able to control transistor (316) to change from open collector to conductive or on (if transistor (316) is a bipolar transistor, for example). Resistor (323) further enables the 3.3V logic supply (330), for example, to be used in operation with transistor (320) (transistor (320) shown as being a bipolar transistor in **Figure 3**). According to an embodiment of the present disclosure, a MOSFET is used instead of a bipolar transistor for some or all of the bipolar transistors (e.g. (321), (316), (320)) shown in **Figure 3** and throughout the present disclosure. Voltages and/or resistors can be adjusted for the use of MOSFETs, instead of bipolar transistors, to properly accommodate such substitution. In one embodiment, the enable circuit (320, 321, 322, 323, 324, 325, 345, 319) connects the output of buck converter (301) to its load (e.g., MOSFET switches, see description below for **Figure 4**) only when the 3.3V output is stable and above a 2.6V threshold, for example.

[0027] Transistor (316) and control circuit (318) are both internal to control block (315), the control circuit (318) being naturally defined by default in the “open drain” state when turned on. When the above-described two conditions are met, transistor (321) enables MOSFET (345) to turn on the drive voltage to power the V_i for the drive stage output (331). That is, in other words, drive stage output (331) may not actually receive a drive voltage when the control circuit is not operating. The control circuit may disable the drive voltage during other conditions, such as a low output voltage from buck converter (301) sensed by resistors (340) and (341) and connected to control circuit (318). Buck converter (301) may yield a wide range of voltage for the input voltage (333). Buck converter (301) also is controlled by control (304) and feedback from transistor (303). Resistors (342) and (343) connect the input voltage (333) to transistor (302), and the node in between the middle of resistors (342) and (343) may be directly connected to the control circuit (318) of control block (315). Low logic voltage may shut-down the voltage for the drive stage output (331). A wide operation range may be easily achieved by buck converter (301). The buck converter (301) may also be turned on when the input voltage (333) is above 6.5V, for example (at turn on, buck converter (301) is not required to regulate anything, and may just have an output voltage that is

higher than 5V, for example).

[0028] In one embodiment, transistor (316), transistor (320), transistor (321), diode (322), resistor (323), resistor (324), resistor (325), resistor (319) and transistor (345) are configured to ensure that transistor (345) is turned on only when voltage supply (330) is high enough and when control circuit (318) is working properly (e.g., ready and/or sending the proper signals). Transistor (321) will turn on when (I) voltage supply (330) is at an adequate level and (II) when control circuit (318) is working properly (e.g., ready and/or sending proper signals). First, transistor (321) may turn on only when voltage supply (330) is on and higher than, for example, 2.6V. At this voltage level the threshold formed by diode (322) and resistors (324) and (325), as well as the V_{BE} (base-emitter) voltage of transistor (321) activates transistor (321), if transistor (320) is not turned on. Second, if control circuit (318) is operative or working properly, it will provide a high voltage to the base or gate of transistor (316) to turn on transistor (316). Transistor (316) may be the internal part of control circuit (318) with an open collector or open drain. When transistor (316) is on, transistor (320) is off, which prevents transistor (321) from being turned off if the voltage supply (330) is high enough (e.g., above 2.6V). When transistor (316) is turned off because control circuit (318) is not working properly for lack of power or simply not ready, and when logic supply (330) is high enough, resistor (323) is able to turn transistor (320) on. Once transistor (320) is on, the gate or base of transistor (321) is connected to the ground via transistor (320); and thus transistor (321) turns off, which in turn turns off transistor (345).

[0029] When the above described two conditions (I and II) are both met, transistor (321) is turned on to allow transistor (345) to turn on the drive voltage to drive the “Vi to drive stage” output (331). When transistor (321) turns off, the resistor (319) is not sufficient to turn on transistor (345) and thus the “Vi to drive stage” output (331) is disabled by the transistor (345).

[0030] In one embodiment, when (a) voltage supply (330) becomes high enough, at for example above 2.6V and (b) control (318) is not working properly to turn on transistor (316), the voltage level after dropping past resistor (323) is high enough to feed into the base or gate of transistor (320), which then is able to turn transistor (320) on or put it in saturation mode. Transistor (320) may be turned on only if transistor

(316) is off, which indicates that the control circuit (318) is not ready. In such a case where the transistor (320) is turned on in saturation mode, the base or gate of transistor (320) is connected to ground via the transistor (316) in saturation mode. When transistor (320) is on, a voltage near a ground value is sent to the gate or base of transistor (321) via transistor (320), therefore turning transistor (321) and transistor (345) off (since the control circuit (318) is not be ready, as indicated by the state of transistor (316)). In one embodiment, transistor (316) serves as a switch to toggle transistor (320). If transistor (316) is turned off, as discussed above, transistor (320) may be on if the voltage supply (330) is high enough. Likewise, if transistor (316) is turned on, a ground value is fed into the base or gate of transistor (320), therefore turning transistor (320) off. In one embodiment, transistor (316) is controlled by control circuit (318) to indicate the readiness of the control circuit (318). When ready, control circuit (318) provides a high enough voltage to the base or gate of transistor (316) to turn it on.

[0031] When transistor (321) is on, transistor (345) is on if the output (332) from the converter (301) is high enough. Likewise, if transistor (321) is off, transistor (345) is off even if the output (332) is high enough (for the lack of a sufficient voltage drop across bias resistor (319)). In one embodiment, transistor (345) is always off until the voltage drop across resistor (319) increases to turn transistor (345) on (e.g., when output (332) is high enough and transistor (321) is on for a connection to ground). In one embodiment, the transistor (345) is a PMOS transistor or a PNP bipolar junction type of transistor. In one embodiment, a sufficient voltage drop across resistor (319) from logic supply (332) is provided by transistor (321) turning on and therefore connecting the gate of transistor (345) to ground.

[0032] In one embodiment, the input voltage of buck converter (301) is between the input voltage (333) and the ground located at the bottom of the diode (305) and the capacitor (307). The output voltage of buck converter (301) is between the voltage (332) and the same ground located at the bottom of the diode (305) and the capacitor (307). Changing the duty cycle of MOSFET (302) changes the output voltage of buck converter (301). Control circuit (304) of buck converter (301) controls the duty cycle of buck converter (301) by controlling the gate of MOSFET (302). The input voltage of

buck converter (311) is between the voltage on the node just above the capacitor (326) and the ground located at the bottom of the diode (325) and the capacitor (328). The output voltage of buck converter (311) is between the voltage on (330) and the same ground located at the bottom of diode (325) and the capacitor (328). Like buck converter (303), the control circuit (314) of buck converter (311) controls the duty cycle of buck converter (311) by controlling the gate of MOSFET (312).

[0033] The buck converter (311) is operative from 5V to 20V, for example. Thus, if input loss conditions are experienced, buck converter (311) is the last unit to turn off running from bypass capacitor (326) while buck converter (301) cannot regulate the circuit/system or is in off mode. The buck converter (311) also runs off control circuit (314), the control circuit (314) working in tandem with transistor (314) to effectively control buck converter in a feedback mechanism. Furthermore, in one embodiment, the auxiliary circuit (300) is to identify low power conditions and reduce buck converter (301) voltage from 11V to 7V, for example, by transistor (317), which may in turned be controlled by transistor (303), transistor (303) being able to control the buck converter (301) set point or ideal operating point by means of control circuit (304). When the control circuit identifies low power conditions, it may set transistor (317) on, which results in transistor (303) going off and voltage (332) being set to a low operation drive voltage (typically 7V, for example, which is the lowest power consuming mode voltage of the overall control circuit). MOSFET (303) also effectively serves as a switch to selectively lower the voltage output of buck converter (303) from 11V to 7V, for example. For most low voltage MOSFETS, two levels of drive voltage may be enough, but additional levels are possible.

[0034] One of the problematic aspects of operating a controller in a solar power environment is the unreliability of the power source during the early morning hours as well as during late evening hours, when faint blue light allows the panel to generate a high voltage, but presents barely enough current to properly operate. As a result, circuits often create a “false start” in which the voltages appear to be there, but as soon as the controller becomes active there is a drop or brown out or power outage, leading to the undesirable occurrence of unstable or even meta-stable modes, which may occur more frequently for small processors.

[0035] **Figure 4** shows a schematic description of a circuit practicing a system and method according to an embodiment of the present disclosure. Circuit (400) is another circuit that may be used as an auxiliary power supply or power supply module for a photovoltaic system, for example. In one embodiment, circuit (400) uses control logic to ensure that solar power is strong enough to enable output from the buck converter (402). Preload resistor P1 (405) is used to emulate the load of buck converter (402). If the output of buck converter (401) can support the load, the preload resistor P1 (405) is disconnected and the output of the buck converter (402) is connected to its load. Circuit (400) therefore can be used to address the false start problem that occurs when the solar panel is able to provide enough output voltage when it is not connected to the output, but not enough to sustain even a small current provided by the buck converter (402) to its load, such as a control logic, a control circuit, a micro-controller, etc.

[0036] In one embodiment, when the intermediate housekeeping voltage Vbuck1 (i.e., the voltage to operate an auxiliary microcontroller unit or MCU) is turned on by buck converter (401), Vbuck1 is initially used to power a preload resistor P1 (405), by turning on the switch (404), typically a FET or bipolar transistor controlled by one of the outputs of delay circuit (403) (also supplied by Vbuck1 but not shown here for clarity). The other output of delay circuit (403) suppresses at the same time buck converter (402). After the housekeeping voltage Vbuck1 is above a predefined threshold for the full delay period of delay circuit (403), the switch 404, and thus the preload resistor P1, is turned off to provide power for the load of the buck converter (402) and the 3.3V logic is permitted to turn on and output from buck converter (402) in accordance with the enable signal from the delay (403).

[0037] Here, in **Figure 4**, Vbuck1 is shown having an ideal range of 10-11V, for example, but this range has been merely provided for exemplary purposes and should not be taken to limit the disclosure to any particular range. This approach provides a smooth turn-on of the logic voltage. Typically, the load of resistor P1 (405) should exceed the load of buck converter (402) (buck converter's load being the MCU which is not shown), so that activating buck converter (402) does not crash the housekeeping voltage Vbuck1. Otherwise, the system of the circuit (400) might experience turn-on attempts which could not be completed, and as a result, the MCU could get stuck due to

meta-stability effects of the MCU in some cases and some of the time.

[0038] In one embodiment, the loading of this approach is slightly unpredictable; and positive hysteresis is introduced in order to prevent oscillations. For instance, amplifier (406) may be used as a VHV (very high voltage) monitor in order to perform positive hysteresis to ultimately avoid oscillations. The reason this hysteresis modification is used is that at very low light conditions (where the sunlight is very dim for instance), solar panels can provide voltages that are high enough for turning on, but cannot ultimately provide sufficient power for the circuit that is to be powered by the buck converter (402). Therefore, identifying a simple threshold for voltage Vbuck1 does not stop unsuccessful turn-on attempts, if no hysteresis is employed in delay circuit (403) (meaning the delay starts only if Vbuck1 is, for example, at least 1.2 times the minimal input voltage of buck converter (402)). One way to prevent such attempts is to permit the system of circuit (400) to turn on only when it can stay on with the available given power. Power is measured by measuring the voltage on resistor P1 (405) (plus any losses from the switch (404)) as represented by Vbuck1. In one embodiment, the delay circuit (403) can be omitted from the circuit (400), since this approach can also work with zero delay because of positive hysteresis. The above-described approach improves the performance of an electronic device mounted on a panel and a device having a MCU or a device similar to a MCU. The buck converter (401) part should be able to accept any variation in voltage during turn-on because it may not be sensitive.

[0039] In the above **Figures 3 – 4**, the voltage conversion section of the buck converters (e.g. 401, 402, 301, or 311) can be replaced with step-down converters or other converters known in the art.

[0040] In one embodiment, the features illustrated in **Figure 3** can also be used in the circuit in **Figure 4**. For example, the enable circuit (320, 321, 322, 323, 324, 325, 345, and 319) in **Figure 3** can be used in the circuit of **Figure 4** to control the output of the voltage Vbuck1 to a drive stage via MOSFET (345). For example, a capacitor can be connected to the input of the buck converter 402 in **Figure 4**, in a way as the capacitor 326 connected to the input of the buck converter 311 in **Figure 3**. For example, the control block 318 used to control the enable circuit in **Figure 3** can also be used in the circuit of **Figure 4**; and the circuit (317, 303, 308-310) and control block

(304) in **Figure 3**, used to reduce output voltage of the buck converter 301 when the input power from the solar panel is low, can also be used to control the output voltage of the buck converter (401) in **Figure 4**. For examples, the resisters 340-343 connected to input and output of the buck converter 301 in **Figure 3** to detect low power conditions in **Figure 3** can also be used for the buck converter 401 in **Figure 4**.

[0041] One application of the present disclosure is using the high voltages from buck converter (e.g. 301 or 401) (e.g. Vbuck1) to control MOSFET switches used in a solar panel energy system and the low voltage from buck converter (e.g. 311 or 402) can be used to power control circuits for a solar panel using the power generated by the solar panel. Examples of the MOSFET switches can be found in at least U.S. Pat. App. Ser. No. 12/366,597, published as U.S. Pat. App. Pub. No. 2009/0133736, and U.S. Pat. App. Ser. No. 12/411,317, now issued as U.S. Pat. No. 7,602,080, all the contents of which are incorporated herein by reference. Examples of the control circuits can be found in at least U.S. Pat. App. Ser. No. 11/875,799, published now as U.S. Pat. App. Pub. No. 2008/0097655, and U.S. Pat. App. Ser. No. 12/411,317, now issued as U.S. Pat. No. 7,602,080, the contents of which are incorporated herein by reference.

[0042] **Figure 5** shows a schematic description of an example startup behavior of wave forms, according to an embodiment of the present disclosure. Wave forms (500), where the x-axis is time, may be generated from running the circuit (400) shown in **Figure 4**, above, through simulations. Curve (501) may represent the Vin (or input voltage value) from the solar panel into buck converter (401). Curve (502) may represent the output of buck converter (401), which is Vbuck1 as shown in **Figure 4**. Curve (503) may represent the power used from the panel. Note in **Figure 5** the drop of power at dotted line (505) when the photovoltaic system is turned on. At dotted line (505), the second stage is turned on and therefore the system is turned on. Curve (504) may represent the output of delay circuit (403) controlling switch (404) and curve (506) may represent the V_{B2E} value coming out of delay circuit (403) ultimately used to control buck converter (402). Also, Curve (504) may show that the preload resistor P1 (405) may be turned off after Vbuck1 passes a designated threshold level and a delay time has passed.

[0043] It is clear that many modifications and variations of this embodiment may be

made by one skilled in the art without departing from the spirit of the novel art of this disclosure. These modifications and variations do not depart from the broader spirit and scope of the present disclosure, and the examples cited here are to be regarded in an illustrative rather than a restrictive sense.

[0044] The performance of solar modules can vary significantly with temperature. A system capable of measuring temperature can implement methods for controlling the voltage, power output, or the efficiency of one or more strings of solar module controllers using module temperature as a factor. For example, a formula presented by Nalin K. Gautam and N.D. Kaushika in "An efficient algorithm to simulate the electrical performance of solar photovoltaic arrays," Energy, Volume 27, Issue 4, April 2002, pages 347-261, can be used to compute the voltage of a solar module at the maximum power point. Other formulae can also be used.

[0045] Many variations can be applied to the above disclosed systems and methods, without departing from the spirit of the present disclosure. For example, additional components can be added, or components can be replaced. For example, rather than using a capacitor as primary energy storage, an inductor can be used, or a combination of inductor and capacitor. Different types of transistors – such as MOSFET or bipolar transistors – may also be used interchangeably, with appropriate adjustments to voltage and other settings. Also, the balance between hardware and firmware in the micro controllers or processors can be changed, without departing from the spirit of the present disclosure.

[0046] It is clear that many modifications and variations of this embodiment can be made by one skilled in the art without departing from the spirit of the novel art of this disclosure. For example, the systems and method herein disclosed can be applied to energy generating systems besides solar photovoltaics (e.g., windmills, water turbines, hydrogen fuel cells, to name a few). Also, although specific voltage values and thresholds have been mentioned, other reference points for the target voltage can also be used. These modifications and variations do not depart from the broader spirit and scope of the present disclosure, and the examples cited here are to be regarded in an illustrative rather than a restrictive sense.

[0047] In the foregoing specification, the disclosure has been described with

reference to specific exemplary embodiments thereof. It will be evident that various modifications can be made thereto without departing from the broader spirit and scope as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method to supply power, the method comprising:
providing a power supply having a first stage and a second stage, wherein the first stage converts power from a direct current input into a first output, and the second stage powered by the first output has a second output for a micro-controller;
connecting the first output of the first stage to a switchable load to consume at least a portion of the first output while disabling the second stage in supplying the second output to the micro-controller;
determining whether the first output from the first stage powering the switchable load is above a threshold during a time period in which the second output to the micro-controller is disabled; and
in response to a determination that the first output from the first stage powering the switchable load is above the threshold during the time period in which the second output to the micro-controller is disabled,
disconnecting the switchable load from the first output of the first stage; and
instructing the second stage to enable the second output to the micro-controller using power from the first output of the first stage.

2. The method of claim 1, wherein the switchable load comprises:
a resistive device; and
a switching device connected to the resistive device, wherein the switching device is configured to be turned on to be connected to the first output to consume the portion of the first output and turned off to be disconnected from the first stage.

3. The method of claim 2, wherein the disconnecting of the switchable load from the

first output of the first stage comprises sending a first signal to the switching device to turn off the switching device.

4. The method of claim 3, further comprising:
generating the first signal based on the determining of whether the first output from the first stage powering the switchable load is above the threshold; and
delaying the first signal to generate a second signal to the second stage, the second signal enabling the second output to the micro-controller.

5. The method of claim 4, further comprising:
providing a control circuit comprising:
a hysteresis amplifier configured to receive the first output of the first stage and generate the first signal; and
a delay circuit to generate the second signal according to the first signal.

6. The method of claim 3, wherein the switching device includes one of: a field effect transistor (FET), a metal-oxide-semiconductor field-effect-transistor (MOSFET), and a bipolar junction transistor.

7. The method of claim 6, wherein when the switch device is turned on, the switchable load and an input of the second stage are connected in parallel to the first output of the first stage.

8. The method of claim 1, wherein the first stage comprises a first step-down converter; and the second stage comprises a second step-down converter.

9. The method of claim 1, wherein the disconnecting is performed prior to the instructing of the second stage to enable the second output to the micro-controller.

10. A system to supply power, the system comprising:
a power source to provide a direct current input;
a first stage power converter configured to convert the direct current input into a

first output;

a second stage power converter configured to be powered by the first output to generate a second output;

a micro-controller powered by the second output;

a switchable load; and

a control circuit powered by the first output and configured to

connect the first output to the switchable load to consume at least a portion of the first output while disabling the second stage power converter in supplying the second output to the micro-controller;

determine whether a voltage of the first output powering the switchable load is above a threshold during a time period in which the second output to the micro-controller is disabled; and

in response to the voltage being above the threshold during the time period in which the second output to the micro-controller is disabled, disconnect the switchable load from the first output of the first stage power converter and signal the second stage power converter to enable the second output to the micro-controller using power from the first output of the first stage power converter.

11. The system of claim 10, wherein the control circuit comprising:

a hysteresis amplifier configured to receive the first output and generate a first control signal for the switchable load; and

a delay circuit to generate a second control signal for the second stage power converter by delaying the first signal.

12. The system of claim 11, wherein in response to the voltage going above the threshold:

the first control signal causes the switchable load to be disconnected from the first output of the first stage power converter; and

the second control signal causes the second stage power converter to enable the second output to the micro-controller.

13. The system of claim 12, wherein the micro-controller is configured to maximize power generated by the power source.

14. The system of claim 13, wherein the power source comprises a photovoltaic panel; the first stage power converter comprises a first step-down converter; and the second stage power converter comprises a second step-down converter.

15. The system of claim 12, wherein the switchable load comprises:
a resistive device; and
a switching device connected to the resistive device, wherein the switching device is configured to be turned on to be connected to the first output to consume the portion of the first output and turned off to be disconnected from the first stage, and
wherein the first control signal is connected to control the switching device.

16. The system of claim 15, wherein the switching device includes one of: a field effect transistor (FET), a metal-oxide-semiconductor field-effect-transistor (MOSFET), and a bipolar junction transistor.

17. The system of claim 16, wherein when the switch device is turned on, the switchable load and an input of the second stage are connected in parallel to the first output of the first stage.

18. A system to supply power, the system comprising:
a photovoltaic panel to provide a direct current input;
a first stage power converter connected to the photovoltaic panel to generate a first output from the direct current input;
a second stage power converter connected to convert the first output to a second output;
a micro-controller;
a power absorption circuit; and
a control circuit coupled with the first stage power converter and the second stage power converter, the control circuit powered by the first output to

control the second stage power converter, wherein

when the second stage power converter is disabled in providing the second output to the micro-controller, the control circuit monitors a voltage of the first output powering the power absorption circuit and signals the second stage power converter to continue disabling the providing of the second output to the micro-controller during a time period in which the voltage is below a threshold;

when the voltage is above the threshold, the control circuit signals the second stage power converter to enable the providing of the second output to the micro-controller.

19. The system of claim 18, wherein the power absorption circuit includes a capacitor coupled to the first output; and the threshold allows the capacitor to power the second stage to operate the micro-controller for a predetermined period of time even without the output of the first stage.

20. The system claim 18, wherein the power absorption circuit comprises a switchable load; and the control circuit signals the switchable load to be in a first state to consume a portion of the first output when the voltage is below the threshold and to be in a second state not to consume a portion of the first output when the voltage is above the threshold.

ABSTRACT

Provided is a power supply for use in a solar electric production system, including: a first stage having an input connected to a voltage from a photovoltaic panel and an output providing a first voltage different from the voltage from the photovoltaic panel; and a second stage connected to the output of the first stage, the second stage supplying power at a second voltage to a micro-controller, where the output of the first stage is turned on and stable for a period of time before the second stage is turned on to supply the power at the second voltage to the micro-controller.

SMA Solar Technology America, LLC, Ex. 1006

PTO/AIA/14 (07-14)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Mordechay		AVRUTSKY	

Residence Information (Select One) ◯ US Residency ◉ Non US Residency ◯ Active US Military Service

City	Alfei Menashe	Country of Residence i	IL

Mailing Address of Inventor:

Address 1	20 Arbel Street		
Address 2			
City	Alfei Menashe	State/Province	
Postal Code	44851	Country i	IL

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	64494		
Email Address	gtipmail@gtlaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE		
Attorney Docket Number	108144-201502/US (TGY015)	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	Suggested Figure for Publication (if any)	

PTO/AIA/14 (07-14)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	64494		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12787205	2010-05-25
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12787205	Claims benefit of provisional	61275734	2009-09-02

SMA Solar Technology America, LLC, Ex. 1006

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12787205	Claims benefit of provisional	61336743	2010-01-26

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country	Filing Date (YYYY-MM-DD)	Access Code (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

PTO/AIA/14 (07-14)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

(•) Assignee	( ) Legal Representative under 35 U.S.C. 117	( ) Joint Inventor
( ) Person to whom the inventor is obligated to assign.	( ) Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. [X]

Organization Name	Tigo Energy, Inc.

Mailing Address Information For Applicant:

Address 1	420 Blossom Hill Road		
Address 2			
City	Los Gatos	**State/Province**	CA
Country [i]	US	Postal Code	95032
Phone Number		Fax Number	

SMA Solar Technology America, LLC, Ex. 1006

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature	/Meng Sui/			Date (YYYY-MM-DD)	2015-08-10
First Name	Meng	Last Name	Sui	Registration Number	62633

Additional Signature may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	108144-201502/US (TGY015)
	Application Number	
Title of Invention	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent C o o p eration Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

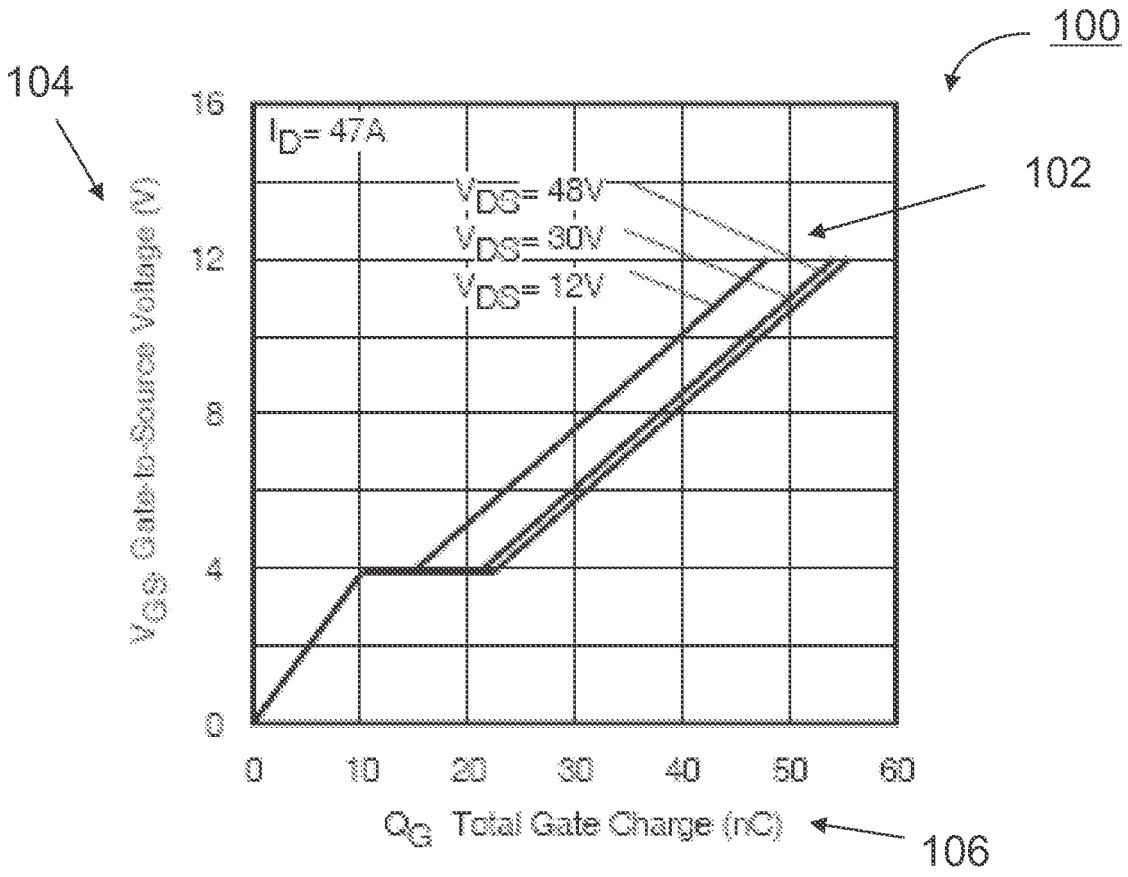

100
104
102
106
16
12
8
4
0
I_D= 47A
V_{DG}= 48V
V_{DS}= 30V
V_{DS}= 12V
V_{GS} Gate-to-Source Voltage (V)
0
10
20
30
40
50
60
Q_G Total Gate Charge (nC)

Figure 1

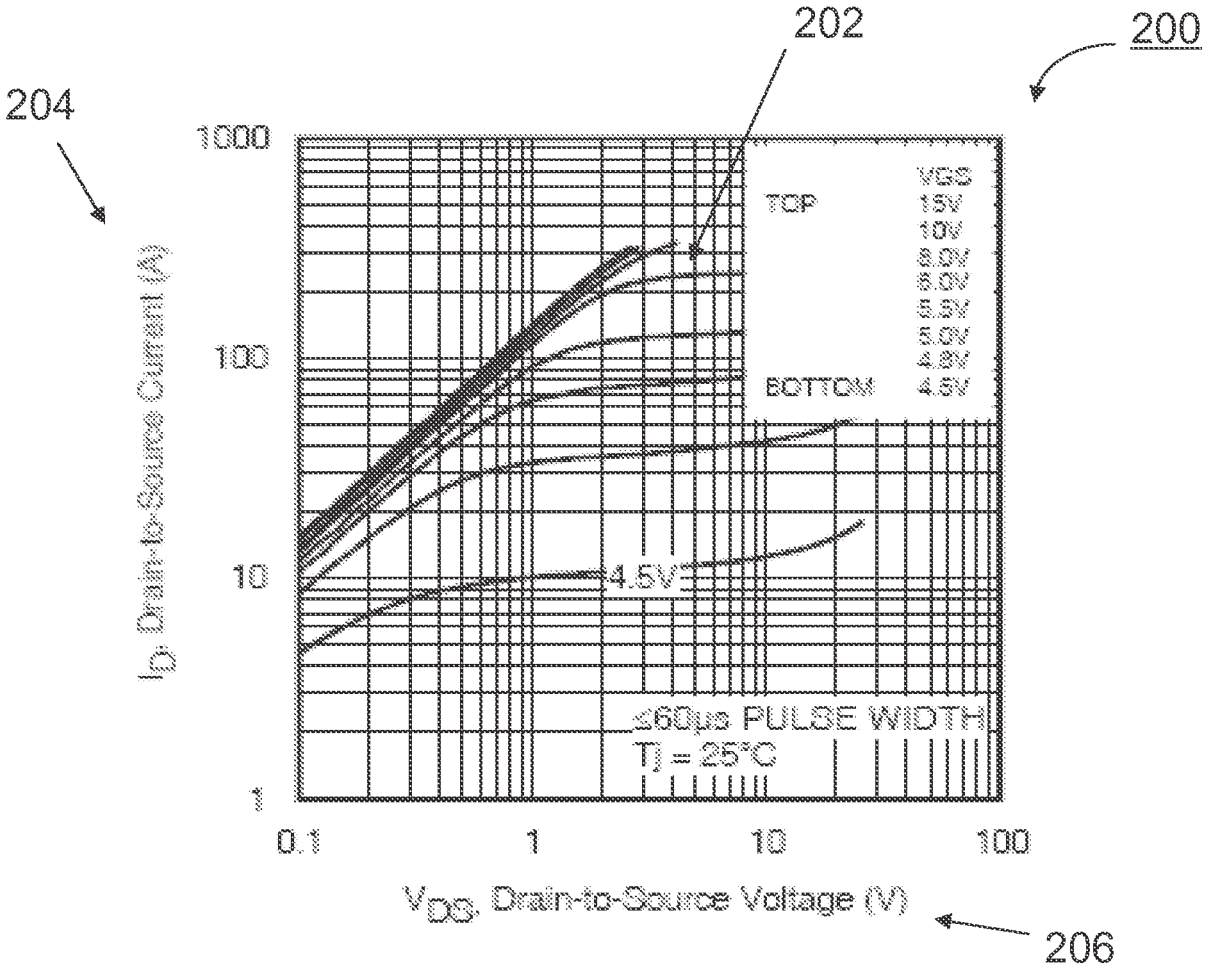

202
200
204
1000
100
10
1
0.1
1
10
100
I_D, Drain-to-Source Current (A)
V_{DS}, Drain-to-Source Voltage (V)
206
VGS
TOP
15V
10V
8.0V
6.0V
5.5V
5.0V
4.8V
BOTTOM
4.5V
4.5V
≤60µs PULSE WIDTH
Tj = 25°C

Figure 2

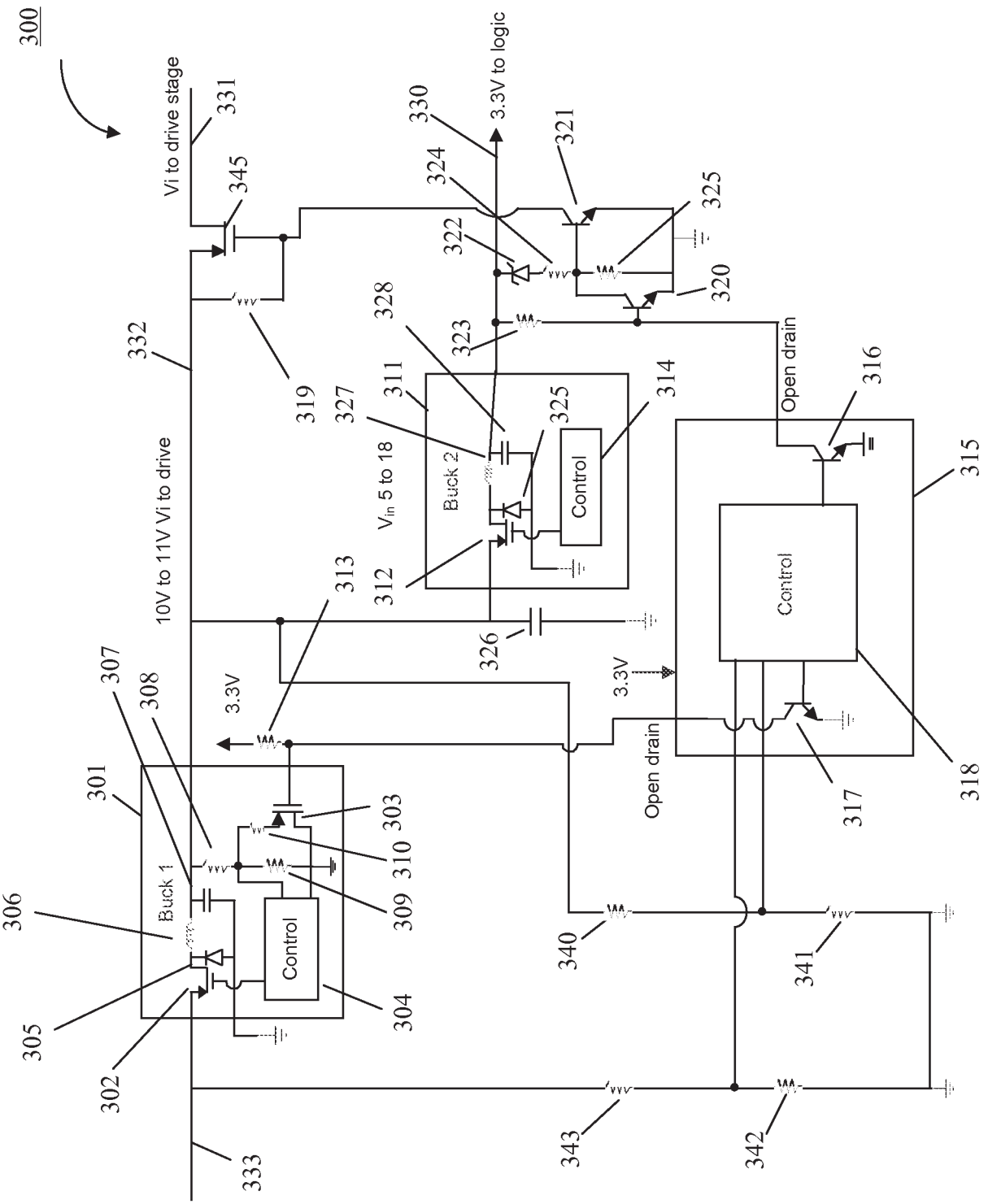


Figure 3

SMA Solar Technology America, LLC, Ex. 1006

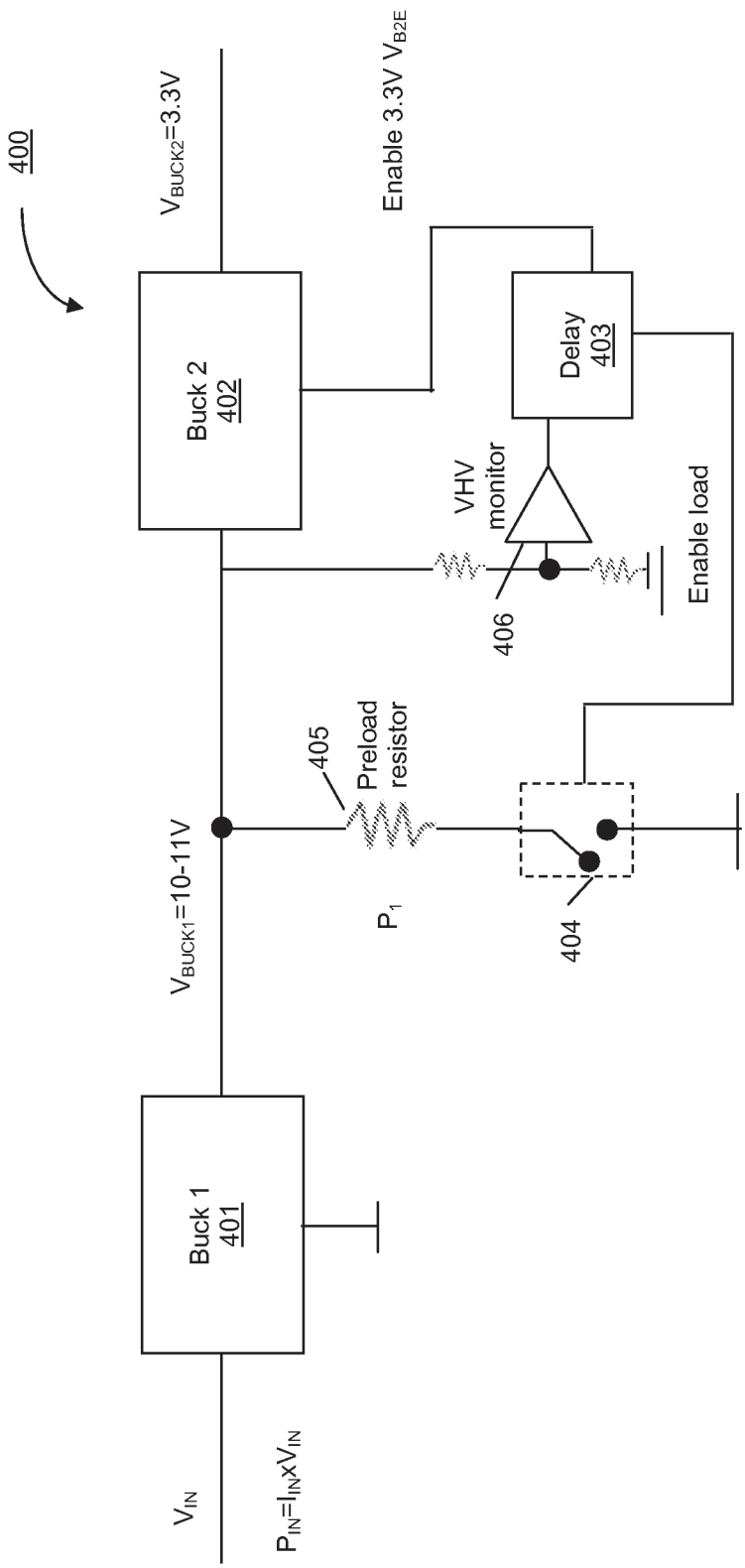


Figure 4

SMA Solar Technology America, LLC, Ex. 1006

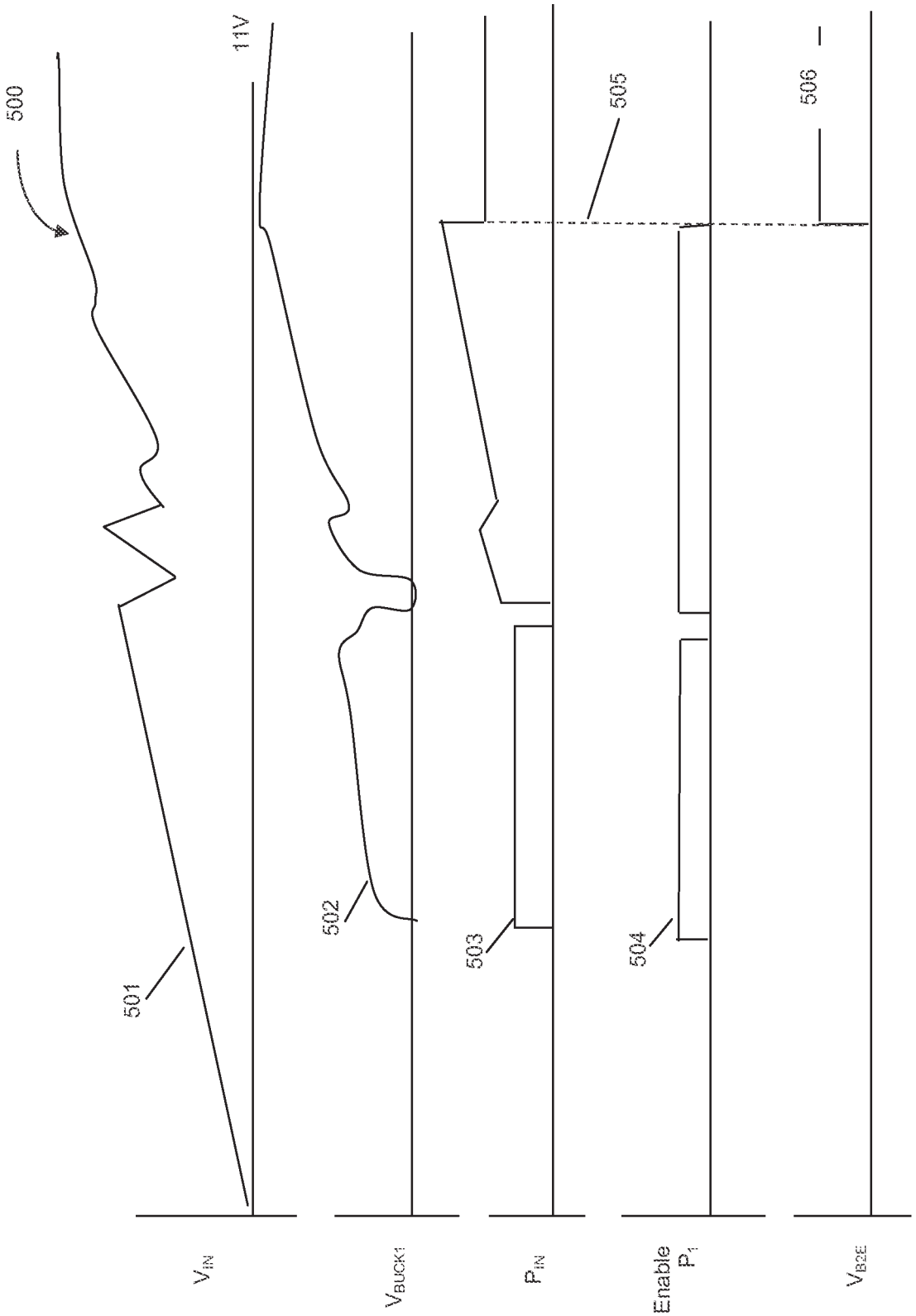


Figure 5

SMA Solar Technology America, LLC, Ex. 1006

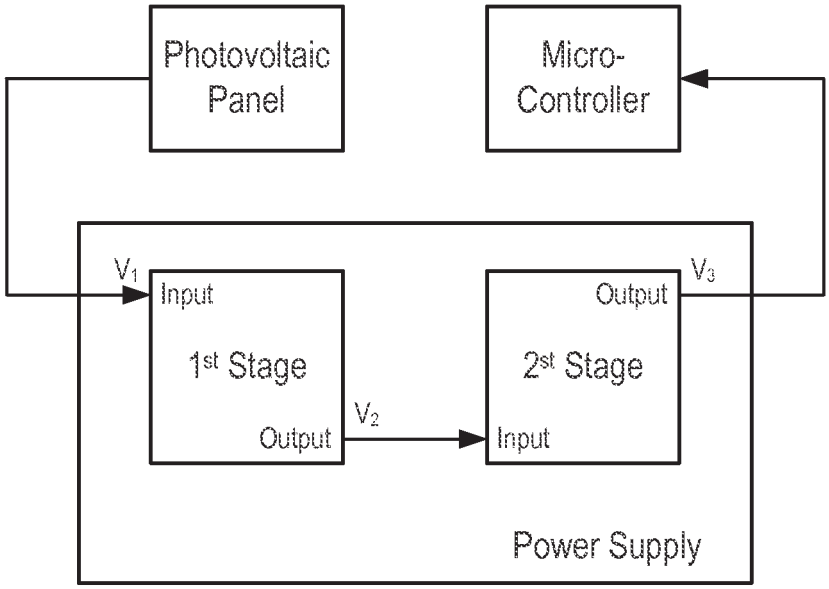

Photovoltaic Panel
Micro-Controller
V1
Input
1st Stage
Output
V2
Input
2st Stage
Output
V3
Power Supply

Figure 6

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	MORDECHAY AVRUTSKY
Filer:	John Patrick Ward/Junchao Zhang
Attorney Docket Number:	108144-201502/US (TGY015)

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	70	70
Utility Search Fee	2111	1	300	300
Utility Examination Fee	2311	1	360	360
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

SMA Solar Technology America, LLC, Ex. 1006

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**730**

Electronic Acknowledgement Receipt

EFS ID:	23161220
Application Number:	14822227
International Application Number:	
Confirmation Number:	4926
Title of Invention:	SYSTEMS AND METHODS FOR ENHANCED EFFICIENCY AUXILIARY POWER SUPPLY MODULE
First Named Inventor/Applicant Name:	MORDECHAY AVRUTSKY
Customer Number:	64494
Filer:	John Patrick Ward/Junchao Zhang
Filer Authorized By:	John Patrick Ward
Attorney Docket Number:	108144-201502/US (TGY015)
Receipt Date:	10-AUG-2015
Filing Date:	
Time Stamp:	15:25:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$730
RAM confirmation Number	1923
Deposit Account	502638
Authorized User	WARD, JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

SMA Solar Technology America, LLC, Ex. 1006

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		108144-201502_Application.pdf	106710 547f873532a044eff05eefac461a06fd3129e8c6	yes	23
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	17	
	Claims		18	22	
	Abstract		23	23	
Warnings:					
Information:					
2	Application Data Sheet	108144-201502_ADS.PDF	1788806 0c90c6347b9684ace8bd3eb3e7193db55e866a03	no	7
Warnings:					
Information:					
3	Drawings-only black and white line drawings	108144-201502_Figures.pdf	222270 9c6821b5a67e505bbdb6f24a0ca5b5bded7ef1c2	no	6
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	35444 e8d743350b39393762d525d2e0307566307bf260	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2153230		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 08/24/2015

MNGUYEN SALE #00000001 Mailroom Dt: 08/10/2015 502638 14822227
01 FC : 2051 70.00 DA