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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	05/05/2020	10640224	00203.3030.00US	6124

136725 7590 04/15/2020

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

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 0 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):

Changxing ZHOU, Shenzhen, CHINA;
SZ DJI TECHNOLOGY CO., LTD., Shenzhen, CHINA;
Qiu LAN, Shenzhen, CHINA;
Jinyun NI, Shenzhen, CHINA;

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

136725 7590 04/06/2020

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

EXAMINER	
RO, BENTSU	

ART UNIT	PAPER NUMBER
2846	

NOTIFICATION DATE	DELIVERY MODE
04/06/2020	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):

uspto.anova@gmail.com
uspto@anovalaw.com

Second Corrected Notice of Allowability	**Application No.** 16/116,279	**Applicant(s)** ZHOU et al.	
	Examiner BENTSU RO	**Art Unit** 2837	**AIA (FITF) Status** Yes

-- 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 applicant's filing of IDS on 02/05/2020.
   ☐ 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 1-17 . 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 02/05/2020.
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 _____.

/BENTSU RO/
Primary Examiner, Art Unit 2837

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. 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	16116279
Filing Date	2018-08-29
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	RO, BENTSU
Attorney Docket Number	00203.3030.00US

U.S.PATENTS

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					

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

U.S.PATENT APPLICATION PUBLICATIONS

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					

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

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	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]
/B.R/	1	0739085	EP	A2	1996-10-23	SWITCHED RELUCTANCE DRIVES LTD		☐
/B.R/	2	1275382	CN	C	2006-09-13	SWITCHED RELUCTANCE DRIVERS LT		☐
/B.R/	3	1412934	CN	A	2003-04-23	YUEJIN ELECT TIANJIN ELECT		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16116279
Filing Date	2018-08-29
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	RO, BENTSU
Attorney Docket Number	00203.3030.00US

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

NON-PATENT LITERATURE DOCUMENTS

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		☐

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

EXAMINER SIGNATURE

Examiner Signature	/BENTSU RO/	Date Considered	03/27/2020

*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.

[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. /B.R/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16116279
Filing Date	2018-08-29
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	RO, BENTSU
Attorney Docket Number	00203.3030.00US

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	/Li Jiang/	Date (YYYY-MM-DD)	2019-10-28
Name/Print	Li Jiang	Registration Number	74191

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

Inventors	: Changxing ZHOU et al.	)	Confirmation No.: 6124
Applicant	: SZ DJI TECHNOLOGY CO., LTD.	)	Examiner: RO, BENTSU
Serial No.	: 16/116,279	)	Art Unit: 2837
Filed	: August 29, 2018	)	
For	: MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	)	

Mail Stop 16 - **Filed via EFS-WEB**
Commissioner for Patents
U.S. Patent and Trademark Office
PO Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

REQUEST TO REPROCESS QPIDS

Applicant filed a QPIDS form, an IDS form with copies of cited foreign references, a conditional RCE, and an e-petition to withdraw from issuance for the above-identified application on October 28, 2019. The e-petition to withdraw from issuance was automatically granted on the same date. Later, Applicant received a Corrected Notice of Allowance on November 18, 2019.

However, on December 10, 2019, Applicant received an Examiner-Initiated Interview Summary indicating that the Corrected Notice of Allowance mailed on November 18, 2019 was in error because the QPIDS was missing the IDS documents. The USPTO PAIR website is also missing the documents filed on October 28, 2019 except for the QPIDS form. Applicant's representative contacted the USPTO multiple times to discuss a resolution to the problem. On February 5, 2020, Applicant's representative spoke with the SPE, Mr. Eduardo Colon, and Mr. Colon suggested that Applicant refile the IDS form with the cited foreign references in order to have the QPIDS and references be reprocessed and considered by the examiner.

Following Mr. Colon's advice, Applicant re-submits herewith the IDS form and

copies of the foreign references that were filed on October 28, 2019, along with the two e-acknowledgement receipts showing granting of the e-petition to withdraw from issuance and the filing of the conditional RCE, QPIDS form, IDS form, and foreign references submitted on October 28, 2019. Therefore, Applicant hereby sincerely requests the QPIDS to be re-entered and considered for a timely allowance of this application.

If any issues may be resolved by telephone with the Applicant's representative, the Examiner is invited to contact the undersigned at the number shown below.

Respectfully submitted,

ANOVA LAW GROUP, PLLC

Dated: February 5, 2020

By: /Li Jiang/
Li Jiang
Reg. No. 74,191
703-430-5759

Textron Specialized Vehicles Inc., Exh. 1003, p. 9

Electronic Acknowledgement Receipt

EFS ID:	38504876
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	05-FEB-2020
Filing Date:	29-AUG-2018
Time Stamp:	17:13:08
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	Transmittal Letter	TransReprocessQPIDS0020330 30.pdf	119453 03dc4c74e523d9a70f75b8cc723d43c71ff2 c1d5	no	2

Warnings:

Textron Specialized Vehicles Inc., Exh. 1003, p. 10

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS002033030p.pdf	1283151 895396e5b14e0e6d356659247535519a2470b30c	no	4
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	EP0739085A2.pdf	673519 d4533de1727dbd82e43c96ae052782384a37dea5	no	13
Warnings:					
Information:					
4	Foreign Reference	CN1275382C.pdf	992888 311229af710ba24acbcb9aabcabcfcdd71815e61	no	17
Warnings:					
Information:					
5	Foreign Reference	CN1412934A.pdf	722121 8bde71aa256761f409c9dd843dab975593773835	no	12
Warnings:					
Information:					
6	Miscellaneous Incoming Letter	efilingAck37582171A.pdf	799251 d084efa7d3dacfcc6b6f5a2166fb3eec310f620d	no	4
Warnings:					
Information:					
7	Miscellaneous Incoming Letter	efilingAck37582338B.pdf	384052 5756ea307c8d224ce7719b3ca99d9bc9b3c483eb	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	4974435	

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.

Electronic Acknowledgement Receipt

EFS ID:	37582338
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	28-OCT-2019
Filing Date:	29-AUG-2018
Time Stamp:	17:12:43
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)	QPIDS002033030.pdf	356138 6a57d2da3b51b89a8ac5e66b6c0820add5c378f74	no	2

Warnings:

Information:	
This is not an USPTO supplied IDS fillable form	
Total Files Size (in bytes):	356138

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New Applications Under 35 U.S.C. 111

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Electronic Acknowledgement Receipt

EFS ID:	37582171
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	28-OCT-2019
Filing Date:	29-AUG-2018
Time Stamp:	17:10:51
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1440
RAM confirmation Number	E20190RH10474963
Deposit Account	
Authorized User	

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

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition automatically granted by EFS	petition-request.pdf	31555	no	2
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	RCE002033030.pdf	1349933	no	3
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	IDS002033030.pdf	1034358	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
4	Foreign Reference	EP0739085A2.pdf	673519	no	13
Warnings:					
Information:					
5	Foreign Reference	CN1275382C.pdf	992888	no	17
Warnings:					
Information:					

6	Foreign Reference	CN1412934A.pdf	722121 [illegible]	no	12
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	31966 [illegible]	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4836340		

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

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New International Application Filed with the USPTO as a Receiving Office

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UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : October 28, 2019

In re Application of :

Changxing ZHOU

DECISION ON PETITION

UNDER CFR 1.313(c)(2)

Application No : 16116279

Filed : 29-Aug-2018

Attorney Docket No : 00203.3030.00US

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed October 28, 2019 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2837 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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(Not for submission under 37 CFR 1.99)

Application Number	16116279
Filing Date	2018-08-29
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	RO, BENTSU
Attorney Docket Number	00203.3030.00US

U.S.PATENTS

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	1	0739085	EP	A2	1996-10-23	SWITCHED RELUCTANCE DRIVES LTD		☐
	2	1275382	CN	C	2006-09-13	SWITCHED RELUCTANCE DRIVERS LT		☐
	3	1412934	CN	A	2003-04-23	YUEJIN ELECT TIANJIN ELECT		☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2837
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[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.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2837
	Examiner Name	RO, BENTSU
	Attorney Docket Number	00203.3030.00US

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).

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☒ 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	/Li Jiang/	Date (YYYY-MM-DD)	2019-10-28
Name/Print	Li Jiang	Registration Number	74191

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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.

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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.

Espacenet

Bibliographic data: CN1412934 (A) — 2003-04-23

Switch reluctance machine control device

Inventor(s): ZHENG RUNCHE [CN] ± (RUNCHE ZHENG)

Applicant(s): YUEJIN ELECT TIANJIN ELECT [CN] ± (YUEJIN ELECTRONIC (TIANJIN) ELECTRIC EQUIPMENT CO. LTD, ; YUEJIN ELECTRONIC (TIANJIN) ELECTRIC EQUIPMENT CO., LTD)

Classification: - **international:** ***H02P6/00; H02P6/08;*** (IPC1-7): H02P6/00; H02P6/08
- **cooperative:**

Application number: CN20011036339 20011010

Priority number(s): CN20011036339 20011010

Also published as: CN1257604 (C)

Abstract of CN1412934 (A)

The switch reluctance machine control device is formed from AC power supply, commutating circuit, inverter consisting of triodes Q1 and Q2 and diodes D/and D2, drive portion of inverter, rotor detection portion, main control portion and voltage detection circuit. It is characterized by that said AC power supply is divided into two output channels, one of them is connected with first commutating circuit and another output is connected with transformer, said transformer is connected with second commutating circuit. The output end of commutating circuit is parallelly-connected with a filter capacitor, and the commutated and filtered output voltage is connected with voltage detection circuit for detecting power voltage change, said voltage detection circuit formed from two series-connected divider resistors and low-pass filter consisting of resistor and capacitor is connected with main control portion.

[19] 中华人民共和国国家知识产权局

[51] Int. Cl[7]
H02P 6/08
H02P 6/00

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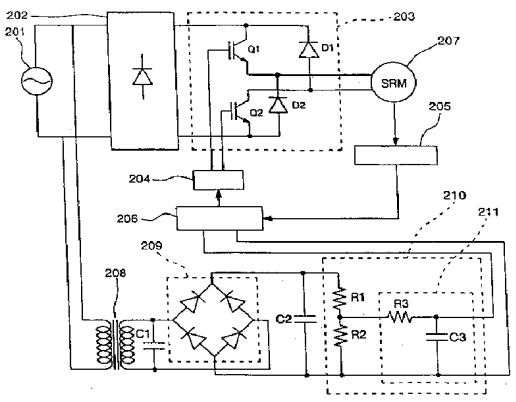
[74] 专利代理机构 天津三元专利事务所
代理人 胡婉明

权利要求书 1 页 说明书 6 页 附图 3 页

[54] 发明名称 开关式磁阻电机控制装置

[57] 摘要

本发明涉及一种当外部电源电压变化时，通过调整加到电机上的电压脉冲的接通时间进行电压补偿，从而使电机转动速度维持不变的开关式磁阻电机控制装置。它由交流电源、整流电路、由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器、逆变器的驱动部分、转子检测部分、主控制部分及电压检测电路组成。其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。电压检测电路是由两个串联的分压电阻 R1、R2 和电阻 R3 与电容 C3 构成的低通滤波器组成。该产品结构简单，成本低，新颖实用。



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Extreme Networks/Avaya Avicles Inc., Exh. 1003, p. 24

1、一种开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。

2、根据权利要求 1 所述的开关式磁阻电机控制装置，其特征在于其中所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。

3、根据权利要求 2 所述的开关式磁阻电机控制装置，其特征在于其中所述的变压器次级两端接有浪涌电容 C1。

4、一种开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于整流电路输出端分成两路，一路接逆变器，另一路接检测电源电压变化的电压检测电路。

5、根据权利要求 4 所述的开关式磁阻电机控制装置，其特征在于其中所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与整流电路的输出端连接，输出端由电容 C2 接主控制部分。

6、根据权利要求 5 所述的开关式磁阻电机控制装置，其特征在于其中所述的分压电阻 R2 两端并联有滤波电容 C1。

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开关式磁阻电机控制装置

技术领域

本发明涉及一种电器领域的电机控制装置，特别是涉及一种当外部供电电源电压变化时，通过调整加到电 机上的电压脉冲的接通时间进行电压补偿,而使电机转动速度维持不变的开关式磁阻电机控制装置。

背景技术

目前， 现有的真空吸尘器等电器所用的电机控制装置，如图 1 所示，它由外部交流电源 101 输入的交流电压变换成直流电压加以输出的整流部分 102；将整流电路 102 输出的直流电压经 2 个晶体三极管 Q1、Q2 和 2 个二极管 D1、D2 构成的逆变器 103 变换成交流电压驱动开关式磁阻电机 107；用以驱动逆变器 103 的驱动部分 104；检测开关式磁阻电机 107 的转子的位置和速度的转子检测部分 105；接收转子检测部分 105 输出信号控制驱动部分 104 的主控制部分 106 构成。

在如此构成的电机控制装置中，交流电源 101 给整流电路 102 输入一交流电压,经整流电路 102 整流变换成直流电压提供给逆变器 103,逆变器 103 将整流电路输入的直流电压变换成适合驱动电机 107 的交流电压。当电机 107 被驱动后，转子检测部 分 105 将检测出 转子的转动速度，并传送到主控制部分 106，主控制部分 106 将转子检测部分 105 输入的检测信号，同设定的基准信号进行比较，把与此 相应的控制命令传送到逆变器驱动部分 104 去，那么逆变器驱动部分 104 将根据控制命令去控制电机 107 上所加的电压，从而控制电机的转动速度。

但是，在如上所述的电机控制装置中，为控制电机 107 的转动速度而加到电机 107 上的电压，通常是用 3 种接通方式去控制。当由外部供给的交流电源 101 的电压变化时，即使是用上述 3 种接通方式中的任意一个相同的运转方式,电机 107 的转动速度还是要变化的。即，当外部交流电源 101 的电压增加时，即使是相同的运转方式，电机的转动速度也要增加，随之逆变器 103 内部的开关元件三极管 Q1、Q2 的耐压极限点也要提高，因而存在有损坏开关元件三 极管 Q1、Q2 的隐患。而且，当外部交流电源 101 的电压下降时,即使是相同的运转方

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式，电机的转动速度也要降低，在这种情况下真空吸尘器的吸入力也要下降，因而得不到满意的吸尘效果。

由此可见，上述现有的电机控制装置存在有诸多的缺陷，而亟待加以改进。

有鉴于上述现有的电机控制装置存在的缺陷，本设计人基于从事此类产品设计制造多年，具有丰富的实务经验及专业知识，积极加以研究创新，以期创设一种新型结构的电机控制装置，能够改进传统现有常规电机控制装置的成型结构，使其更具有竞争性。经过不断的研究、设计，并经反复试作样品及改进后，终于创设出确具实用价值的本发明。

发明内容

本发明所要解决的主要技术问题在于，克服现有的电机控制装置存在的缺陷，而提供一种新型结构的开关式磁阻电机控制装置，使其当外部电源电压变化时，通过调节电机上所加电压脉冲的接通时间进行电压补偿，进而维持电机的转动速度不变。

本发明所要解决的另一技术问题在于，提供一种新型开关式磁阻电机控制装置，使其控制装置具有结构简单，且低成本的优良功效，而更加具有实用性，并能大大提高经济效益，从而在总体上具有增进的功效，且具有产业上的利用价值。

本发明解决其主要技术问题是采用以下技术方案来实现的。依据本发明提出的开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。

前所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。

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前所述的变压器次级两端接有浪涌电容 C1。

本发明解决其技术问题还可以采用以下技术措施来进一步实现。依据本发明提出的开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于整流电路输出端分成两路，一路接逆变器，另一路接检测电源电压变化的电压检测电路。

前所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与整流电路的输出端连接，输出端由电容 C2 接主控制部分。

前所述的分压电阻 R2 两端并联有滤波电容 C1。

本发明与现有技术相比具有明显的优点和有益效果。由以上技术方案可知，本发明在交流电源输出端增加一路整流电路和检测电源电压变化的电压检测电路或在原整流电路输出端加一检测电源电压变化的电压检测电路，检测由外部供给的电源电压的变化，并与此相应地改变电机上供给的电压脉冲的接通时间。因而具有在相同的运转方式上同外部电源的电压变化不相关，可以使电机的转动速度几乎维持不变的优点。该产品结构简单，成本底，可靠实用。

综上所述，本发明开关式磁阻电机控制装置，其在技术发展空间有限的领域中，不论在结构上或功能上皆有较大的改进，且在技术上有较大的进步，并产生了好用及实用的效果，而确实具有增进的功效，从而更加适于实用，诚为一新颖、进步、实用的新设计。

上述说明仅为本发明技术方案特征部份的概述，为使专业技术人员能够更清楚了解本发明的技术手段，并可依照说明书的内容予以实施，以下以本发明的较佳实施例并配合附图详细说明如后。

本发明的具体实施方式由以下实施例及其附图详细给出。

附图说明

图1是现有电机控制装置的电路原理图。

图2是本发明开关式磁阻电机控制装置的第一实施例电路原理图。

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图3是本发明开关式磁阻电机控制装置的第二实施例电路原理图。

具体实施方式

以下结合附图及较佳实施例，对依据本发明提出的其具体实施方式、结构、特征及其功效，详细说明如后。

101. 交流电源 102. 整流电路 103. 逆变器
104. 驱动部分 105. 转子检测部分 106. 主控制部分
107. 开关式磁阻电机
201. 交流电源 202. 第 1 整流电路 203. 逆变器
204. 驱动部分 205. 转子检测部分 206. 主控制部分
208. 变压器 209. 第 2 整流电路 210. 电压检测部分
211. 低通滤波器
301. 交流电源 302. 整流电路 303. 逆变器
304. 驱动部分 305. 转子检测部分 306. 主控制部分
307. 开关式磁阻电机 308. 电压检测部分 309. 低通滤波器

请参阅图 2 所示，本发明开关式磁阻电机控制装置的第 1 实施例具有如下部分：交流电源 201 的交流电压一路送将它变换成直流电压加以输出的第 1 整流电路 202；将由第 1 整流电路 202 来的直流电压变换成交流电压供给开关式磁阻电机用的逆变器 203；用以驱动此逆变器 203 的逆变器驱动部分 204；检测开关式磁阻电机 207 转子的转动速度的转子检测部分 205；接收转子检测部分 205 来的检测信号，再将控制信号送至逆变器驱动部分 204 的主控制部分 206；交流电源 201 的交流电压另一路接变压器 208；变压器 208 次级接第 2 整流电路 209；整流电路 209 接检测电源电压变化的电压检测部分 210。

电压检测部分 210 由两部分构成：一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器 211，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。接在变压器次级上的电容 C1 是用以消除变压器 208 感应电压中混入的浪涌成分。电容 C2 是用以消除第 2 整流电路输出的直流电压中脉冲成分的滤波电容。

第 1 整流电路 202 是将交流电源 201 输入的交流电压变换成直流电压加以输出。逆变器 203 是将第 1 整流电路 202 输出的直流电压变换成适合驱动开关式磁阻电机的交流电压加以输出。随后，若开关式磁

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阻电机被驱动，转子检测部分 205 就检测转子的转动速度，传送到主控制部分 206，主控制部分 206 则接收由转子检测部分 205 来 的检测信号，同设定的基准信号加以比较后，将与此相应的控制命令传送给逆变器驱动部分 204。那么，逆变器驱动部分 204 将按照控制命令控制开关式磁阻电机 207 上所加的电压，其结果就能控制开关式磁阻电机 207 的转动速度。

而且，变压器 208 是将交流电源 201 输入的交流电压按照初、次级的线圈匝数比，变换成所需的交流电压，第 2 整流电路 209 将变压器次级输出的电压变换成直流电压输出给电压检测部分 210，电压检测部分的电阻 R1、R2 按比例加以分压，主控制部分 206 则是输入分压电阻 R2 上的电压，用以检测电压的变化。

在上所述的工作过程中，当交流电源 201 供 给的交流电压变化时，变压器 208 的次级电压及第 2 整流电路 209 的输出电压也将随之变化。其结果，在电压检测部分 210 的电阻 R2 上的电压也将变化，这些变化立即被主控制部分 206 检测到。就是，主控制部分 206 立即就可以知道由外部供给的电压的变化状态。因此，主控制部分 206 将其电压变化量与在相同运转方式上已经设定的电压值加以比较，当外部供给的电压比设定的电压值要高时，就要控制逆变器驱动部分 204，相应地缩短供给开关式磁阻电机 207 的电压脉冲的接通时间，而当外部供给的电压比设定的电压值低时，就要控制逆变器驱动部分 204，相应地延长供给开关式磁阻电机 207 的电压脉冲的接通时间。因此在相同的运转方式上，同外部电源的电源变化不相关联，可以使开关式磁阻电机维持几乎不变转动速度。

请参阅图 3 所示，是本发明开关式磁阻电机控制装置的第 2 实施例具有如下部分：输入由外部交流电源 301 来的交流电压，将它转变成直流电压加以输出的整流电路 302；将整流电路 302 输出的直流电压变换成交流电压供给开关式磁阻电机 307 用的逆变器 303；用以驱动此逆变器的逆变器驱动部分 304；检测开关式磁阻电机 307 转子转动速度的转子检测部分 305；接收转子检测部分 305 的检测信号，再将控制信号送至逆变器驱动部分 304 的主控制部分 206；以及，接整流电路 302 输出端检测电源电压变化的电压检测部分 308。

电压检测部分 308 由两部分构成：一部分是两个串联的分压电阻

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R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器 309，电压检测电路的输入端由电阻 R1、R2 分别与整流电路 302 输出端连接，输出端由电容 C2 接主控制部分。接在分压电阻 R2 上的电容 C1 是用以消除直流电压中混入的脉冲成分的滤波电容。

如上所述第 2 实施例的工作原理和连接关系与第 1 实施例相同。因此，省略第 2 实施例的说明。

第 2 实施例的情况与第 1 实施例的情况，在其基本构成上没有大的差异，只是，在第 1 实施例的情况下，其构成是外部的交流电源 201 的电压变化，要经过另外的变压器 208 和第 2 整流电路 209，在电压检测部分 210 上检测的。而在第 2 实施例的情况下，交流电源 301 的电压是经过整流电路 302 输出的，而在整流电路 302 的输出端上正好设置电压检测部分 308，以此检测外部交流电源 301 的电压变化，这样的构成就是特征上的差异。还有，在第 2 实施例的情况下，外部交流电源 301 的输入电压经过整流电路 302 后的输出电压直接施加到后面，因而它将处理比第 1 实施例更大的电压，同时对相关电路元件的影响也就比第 1 实施例的情况更大，但是整体上的电路构成却要比第 1 实施例简单。

以上所述，仅是本发明的较佳实施例而已，并非对本发明作任何形式上的限制，凡是依据本发明的技术实质对以上实施例所作的任何简单修改、等同变化与修饰，均仍属于本发明技术方案的范围内。

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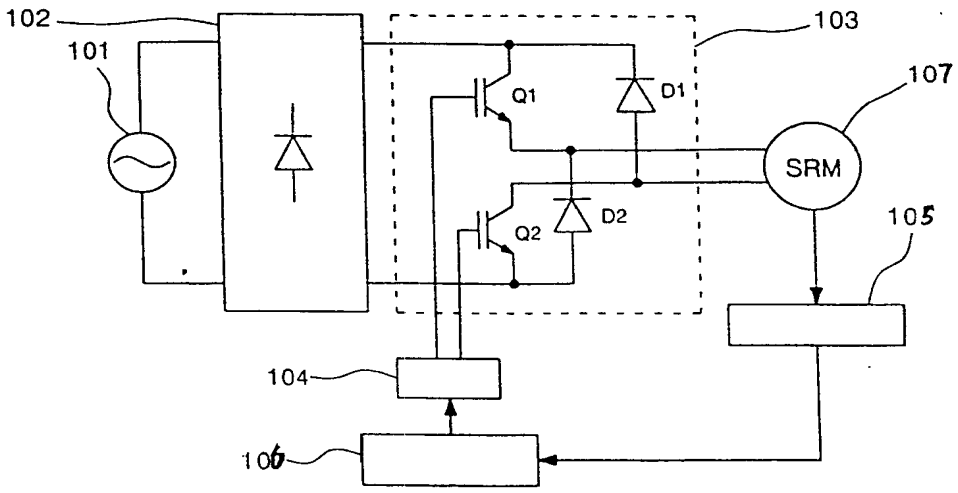


图1

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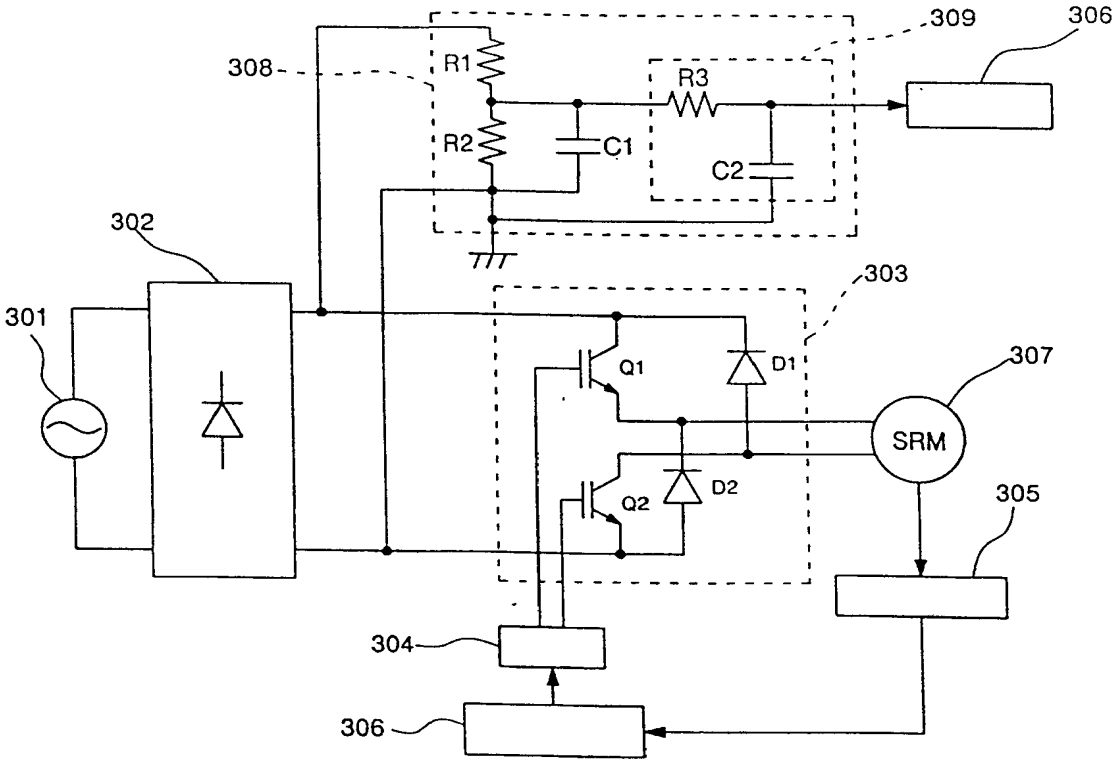


图3

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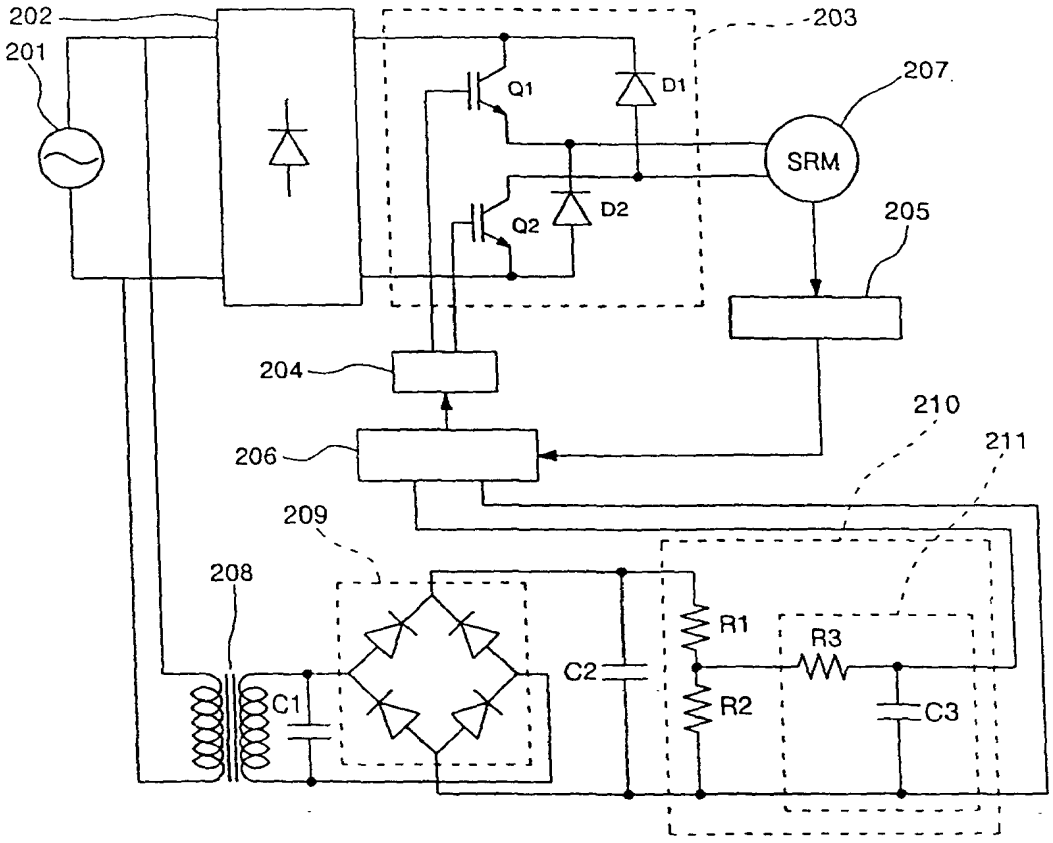


图2

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Variable voltage compensation

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Applicant(s): SWITCHED RELUCTANCE DRIVERS LT [GB] + (SWITCHED RELUCTANCE DRIVERS LTD)

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Abstract not available for CN1275382 (C)
Abstract of corresponding document: EP1239581 (A2)

A switched reluctance drive is supplied from a voltage source which varies from the voltage at which the control laws for the drive were determined. The control system compensates for this by modifying both the speed and torque values used to determine the correct firing angles for the demanded load. The system works over a very wide range of voltage variation and is independent of the shape of the torque / speed curve of the drive.

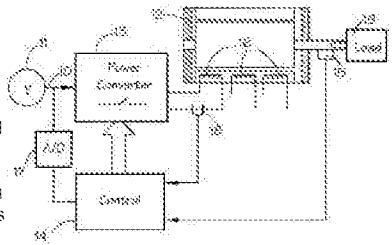


Fig 5

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H02P 6/00 (2006.01)

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[30] 优先权

[32] 2001. 3. 6 [33] GB [31] 0105502.9

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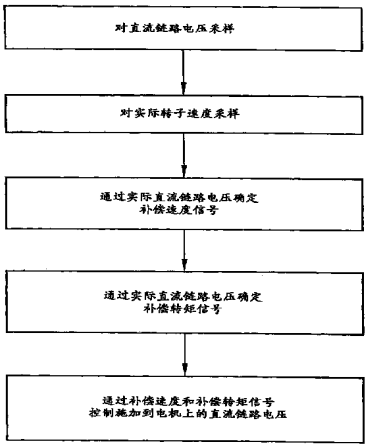
权利要求书 3 页 说明书 8 页 附图 4 页

[54] 发明名称

电力驱动中的可变电压补偿方法和系统

[57] 摘要

本发明涉及可变电压补偿，其中一开关磁阻驱动器由一电压源供电，该电压源与确定的用于驱动器控制规则的电压不同。控制系统通过同时对速度和转矩值进行修正来对上述不同进行补偿，其中速度和转矩值被用来确定驱动所要求的负载的正确触发角。该系统可工作于出现有较宽电压变化范围的环境中并与驱动器的转矩/速度曲线的形状无关。



1.一种在电力驱动系统中对实际直流链路电压与一参考直流链路电压的偏差进行补偿的方法，所述的电力驱动系统包括一电机控制器，其根据转矩需求信号控制电机，所述的电机包括一转子和一带有绕组的定子，在该电机工作的过程中，转子以实际转子速度旋转，其中电机控制器有选择地将实际直流链路电压加到定子绕组中，该方法包括步骤：

对所述的实际直流链路电压进行采样；

对所述的实际转子速度进行采样；

根据实际直流链路电压确定补偿速度信号；

根据实际直流链路电压确定补偿转矩需求信号；以及

根据所得到的补偿速度和补偿转矩需求信号对施加在定子绕组上的实际直流链路电压进行控制。

2.如权利要求 1 所述的方法，其特征在于所述的确定补偿速度信号的步骤包括产生一速度补偿因子和通过该速度补偿因子对实际转子速度进行修正的步骤。

3.如权利要求 2 所述的方法，其特征在于所述的速度补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

4.如前述权利要求中的任一项所述的方法，其特征在于所述的确定补偿转矩需求信号的步骤包括产生一转矩补偿因子和通过该转矩补偿因子对转矩需求信号进行修正的步骤。

5.如权利要求 4 所述的方法，其特征在于所述的转矩补偿因子对应于参考直流链路电压与实际直流链路电压之间的比率。

6.如权利要求 4 所述的方法，其特征在于所述的转矩补偿因子取决于在实际转子速度下所允许的最大转矩需求和在对应于补偿速度信号的速度下所允许的最大转矩需求之间的比率。

7.如权利要求 6 所述的方法，其特征在于作为速度函数的电机的转矩需求值被存储在一控制规则表中，该控制规则表包括多个位置，

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表中的每个位置对应于预先确定的转矩需求值，其中所述的通过转矩补偿因子对转矩需求信号进行修正的步骤被通过转矩补偿因子对转矩需求信号的控制表位置进行修正的步骤所代替，由此确定在对应于补偿速度信号的速度下的补偿转矩需求值的控制表位置。

8.一种在电力驱动系统中对实际直流链路电压与一参考直流链路电压的偏差进行补偿的系统，所述的电力驱动系统包括一电机控制器，其根据转矩需求信号控制电机，所述的电机包括一转子和一带有绕组的定子，在电机的工作过程中，转子以实际转子速度旋转，其中电机控制器有选择地将实际直流链路电压加到定子绕组中，该系统包括：

用于对所述的实际直流链路电压进行采样的装置；

用于对所述的实际转子速度进行采样的装置；

根据所述的实际直流链路电压确定补偿速度信号的装置；

根据所述的实际直流链路电压确定补偿转矩需求信号的装置；

用于将所述的补偿速度信号和所述的补偿转矩需求信号发送到电机控制器的装置；和

使用所述的补偿速度信号和补偿转矩需求信号控制施加于定子绕组上的实际直流链路电压的装置。

9.如权利要求 8 所述的系统，其特征在于所述的确定补偿速度信号的装置包括产生一速度补偿因子的装置和通过所述的速度补偿因子对实际转子速度进行修正的装置。

10.如权利要求 9 所述的系统，其特征在于所述的速度补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

11.如权利要求 8－10 中任一项所述的系统，其特征在于所述的确定补偿转矩需求信号的装置包括产生一转矩补偿因子并通过该转矩补偿因子对转矩需求信号进行修正的装置。

12.如权利要求 11 所述的系统，其特征在于所述的转矩补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

13.如权利要求 11 所述的系统，其特征在于所述的转矩补偿因子

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取决于在实际转子速度下的最大转矩需求和在对应于补偿速度信号的速度下的最大转矩需求之间的比率。

14.如权利要求 13 所述的系统，其特征在于还包括将作为速度的函数的电机的转矩需求值存储在一控制规则表中的装置，该控制规则表包括多个位置，表中的每个位置对应于预先设定的转矩需求值，其中所述的通过转矩补偿因子对转矩需求信号进行修正的装置可由通过转矩补偿因子对转矩需求信号的控制表位置进行修正来代替，由此在对应于补偿速度信号的速度下确定补偿转矩需求值的控制表位置。

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电力驱动中的可变电压补偿方法和系统

技术领域

本发明一般涉及电力驱动系统中的直流链路电压偏差的补偿方法和装置。特别的，本发明涉及开关磁阻驱动器的运行方式，该开关磁阻驱动器能周期地读取与某一直流链路电压相对应的一个值，调节一速度指示信号用于补偿在直流链路中出现的电压变化。补偿速度信号被送至一控制器中，在该控制器中，对开关磁阻驱动器线圈中的能量变化做补偿。

背景技术

有关开关磁阻电机的设计和操作方面的理论已广为人知并多有论述，例如，在文章“开关磁阻电动机和驱动器的特点、设计和应用”，作者是Stephenson和Blake，于1993年6月21－24日，在德国Nuremberg举行的PCIM 93年年会及展览会上进行了公开，在此引述;作为参考。下文对开关磁阻驱动控制器的常用结构和操作的理解和描述仅是出于本发明背景技术需要之目的。

开关磁阻电动机在电动机的活动部分(称转子)一般没有绕组或永磁铁。大多数开关磁阻电动机的静止部分(称定子)包括在定子的磁极上缠绕的线圈，其中通有单向电流。在其中一种类型的开关磁阻电动机中，绕在相对定子磁极上的线圈以串联或并联的方式连接以形成实际上是多相的开关磁阻电动机的单向绕组。按事先确定的，即与转子角位置相同步的顺序，对每项绕组加电压产生运动力矩，这样当定子和转子的磁极相接近时就能产生相互吸引的电磁力。同样的，当定子和转子的磁极分开时的周期的某段时间里设置脉冲电压，也可产生作用力。在典型的操作方式中，每次当开关磁阻电机相绕组被激励时，通过相绕组产生磁通量，从而在转子磁极上产生引力。

图 1 示意性地示出了现有技术中一典型的驱动装置，用于驱动负载

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19。其中包括一直流电源 11，可以是电池或是整流并滤波的交流电源。电源 11 经一直流链路，以线 10 所示，输出直流电压。电源转换器 13 在电子控制单元 14 的控制下在电动机 12 的相绕组 16 之间进行切换。电流传感器 18 用于向控制器提供电流反馈信号。在本申请中，向开关磁阻电机中输出的直流电压(或来自一电池，整流器或其它)被称为“直流链路电压”。

为保证驱动器正常工作，切换应与转子的旋转角准确地保持同步。开关磁阻电机的性能在一定程度上取决于与转子位置相关的相激励的精确定时。对转子位置的检测通常通过传感器 15 获得，如图 1 所示，例如通过安装在电机转子上的旋转齿状盘，与安装在定子上的光学传感器或磁性传感器相配合。产生能指示出转子相对于定子的位置的脉冲序列并将其输出给控制电路 14，用于产生精确的相激励。

为维持开关磁阻电机产生的速度和相关转矩，有必要精确控制电压作用在相绕组上的时刻。然而，在交流电压输出中出现的变化以及在驱动系统工作的电力环境中出现的变化，都会造成直流链路电压随时间的变化而变化。由于电源电压的明显变化，因此以忽略电源电压变化的控制方法可明显减弱用户所要求的对电机的控制能力。这是因为，由相绕组产生的磁通量直接与所施加的电压有关。因此，电源电压中的变化就可导致相绕组产生的磁通量多于或少于所希望得到的磁通量。电动机中，磁通量的这种不希望的变化会导致性能的降低。

在众所周知的开关磁阻驱动器中，电动机的速度，所需的转矩和在对相绕组加电压的时间之间的相互关系可通过一被称为是特性化的处理过程凭经验确定，其中，电动机的操作参数是在很宽的工作条件下确定。之后，这些操作参数被存储在一个被称为控制规则表的模拟或数字电路中。

典型地，数字控制规则表只是某种类型存储器中的一系列存储位置，其中每个存储对应于控制图上的一个点。对于此点，典型系统存储有适用于该工作点的启动角、关闭角和可能的自由旋转角。这些参数可存储在表中的相邻位置上。或者，该表可进一步划分并被认为是由一系列的

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子表组成，每个子表中的值对应于其中一个参数。

控制规则表的一个例子如图 2 所示。在这个例子中，转矩在任意速度上被离散成 128 个值，即，在任一个选定的速度上，该速度的 100%的转矩对应于第 128 个存储位置，50%的转矩对应于第 64 个存储位置，等等。类似的，该速度也被离散，在本例子中，速度被离散为 256 个值。表中的每个位置上存储了用于使电机产生相应速度和转矩的控制的多个参数 A。如上所述，参数 A 中的每个或是一系列控制参数或是单个的控制参数，并且表中的每个位置还包含有一可指向其他表格的指针，用于搜寻其他的参数。也可以使用在现有技术中已知的用于存储数据的其他方法，如 16x16 位置的稀疏矩阵以及一些用于实时确定适当参数值的插值方法。

图 3 和图 4 是对应于控制规则表的控制图的例子。其中，水平轴代表速度值，最大到 256 个单位，该值是驱动器所能达到的最大速度。实线代表在任意速度上可得到的最大转矩值。图上任意一点对应于控制规则表上的一个位置，在该位置中，包含有在该点操作所需的参数。图 3 的例子示出了一个具有相对恒定转矩输出的系统，而图 4 的例子示出了转矩输出随速度明显变化的系统。

在驱动器工作过程中，控制系统向控制规则表输入表征电动机速度的信号和所需要的转矩，以寻找出适合此操作状态的触发角。这些触发角用于对切换进行控制，进而实现对相绕组激励的控制。采用具有控制规则表的电动机控制器已被广泛熟知，在此不再详细描述。

为最小化特性化的处理过程的工作量，通常的做法是在该过程中保持直流链路电压恒定。考虑到当把驱动系统安装于一工作环境中时，直流链路电压的变化较有代表性，因此，特性化常是在假设直流电压处于最低期望值时获得的。换句话说，特性化是在假设直流链路电压工作在最差的情况下获得的。这种类型的特性化在一定程度上是不合乎需要的，因为其是在假定最坏的场合下(而这种假定场合是很少发生的)而不是在所需要的最佳直流链路值的情况下做出的对开关磁阻驱动器的特性化，而驱动效率在所需最佳链路值的情况下将达到最高。此外，工作电压的增

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加会导致所得转矩和电流的增加，从而导致驱动器的零部件过热或失效。对于有些驱动器，可在其处于最佳直流链路电压时进行特性化，但对于此类驱动器，必须在运转过程中对直流链路电压发生的变化给予补偿，否则驱动器性能会减弱，特别是在低电源电压情况下。

一些开关磁阻驱动器使用模拟系统对直流链路电压的变化进行补偿。总的来说，这些系统是通过调节输入到控制规则表中的速度信号来对直流链路电压变化进行补偿的，因此输入到控制器中的速度信号不是电动机的实际速度而是由代表直流链路电压的一个信号对实际速度信号进行修正而得到的一个修正速度信号。有些驱动装置采用一些数字方法对电压变化进行补偿。例如，在美国专利 US 5724477 (Webster 等)中(其已转让给本申请人，在此引述作为参考)，公开了一种直流链路补偿方法，其通过一模数转换器 ADC 对直流链路电压进行数字采样来检测电压的变化。

图 5 是 Webster 提出的开关磁阻驱动器的模型，其中通过 ADC17 对直流链路电压进行采样，采样电压反馈给控制中 14，在控制器 14 中，特性化电压与测量的工作电压之间的比率用于修正实际转子速度以产生一补偿速度参数，用此补偿速度参数对控制规则表进行询问，这意味着与所测得的直流链路电压 10 相反地调节补偿速度信号。举例来说，直流链路电压的增加会得到一较小的估计补偿速度信号，而当直流链路电压降低时则会得到一较大的估计补偿速度信号。补偿速度信号进而被控制器 14 使用，作为控制规则表的索引并用于选择适当的触发角。

作为 Webster 所提方法的一个应用实例，假设特性化的处理过程是在直流链路电压为 560V 时完成的，并且驱动器一直以 227 单位表示的速度工作在 538V 电压上，之后对速度信号进行线形换算，[即(560/538)×227]，获得 236 单位的补偿速度。该补偿速度用于询问控制规则表以获得何种转矩水平是所需的。在这个例子中，电压变化相对较小，(大约是 4%的特性化电压)。如果转矩/速度曲线在工作区内相对平坦，如图 3 所示，综合这些因素可知，实际速度和补偿速度之间的转矩变化也小。举例来说，如果所需转矩为 80%(那么使用存储位置为 80/100×128=102 中的触

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发角)，在该补偿速度上的存储位置 102 中触发角所对应的转矩值将非常接近于 80%，以致于其之间的差距可以忽略不计。相比之下，如果转矩速度曲线的斜率大，如图 4 所示，则在该补偿速度对应于存储位置中的转矩值会极大地区别于未补偿速度时的转矩值。图 4 示出了在电压变化40%时在转矩上出现的误差。这使得现有技术中补偿方法在很多场合下是不适合的。

以上所描述的系统在有限范围的电压变化情况下能正常工作取决于转矩/速度曲线的形状，但当遇到电压的广泛变化时，上述系统不能给出好的性能。此类情形常尤其出现在那些不能与公共设施相连的系统但电压变化又常超过 50%的系统中，如航空，海运或机动环境。尽管，这些变化可以通过对系统在不同电压值时进行特性化处理来局部改善，但这个方法耗时，需要控制系统有相当大的存储空间，使得读取控制规则表更困难，最多只能对特定电压进行精确补偿。

发明内容

对于这些已知补偿系统的缺点，需要设计出一精确，适用于大范围的直流链路电压并且相对经济的直流链路电压补偿系统。

随附的独立权利要求是对本发明的限定。从属权利要求是对本发明的其他一些优选特征的描述。

附图说明

以下结合附图对本发明具体实施例中出现的各种方法进行描述，其中：

图 1 是已知开关磁阻电机的方框图；

图 2 是一控制规则表的例子；

图 3 是当系统的转矩恒定或接近恒定时的转矩/速度图；

图 4 是当系统的转矩随速度明显变化时的转矩/速度图；

图 5 是带有直流链路电压补偿装置的已知开关磁阻电机的方框图；

图 6 示出了电压补偿过程的步骤。

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具体实施方式

附图 5 的装置用于实现电压补偿的改进方法。示出了一开关磁阻电机 12，用于驱动负载 19。电压源 11 给驱动器供电，其可以是一直流电源，也可以是整流交流电源。直流链路以连线 10 代表，并通过切换装置 13 切换到在开关磁阻电机 12 的相绕组 16，控制器 14 确定转换装置 13 上的触发角。还包括一转子位置传感器 15(RPT)，响应于通过随开关磁阻电机 12 的转子一同旋转的一个元件，用于产生代表转子位置的转子位置传感器输出信号。可知，位置信息可以通过各种方法得到，如采用对电动机的电流、电压和/或电感进行估计该信息的软件算法。相绕组中的电流一传统类型的电流传感器 18 测得，并输出适当的信号给控制系统 14。

与直流链路电压相连的是一模拟数字转换器(ADC)17，其对直流链路电压 10 采样，之后将采信号转化为能代表直流链路电压的电压幅度的数字输出。ADC 将该数据输入到控制系统 14。在一实施例中，ADC 输出包括 8 个数据比特，可代表 256 不同电压值。

通过在给定时间周期内监测转子位置的变化，可以确定电机 12 的速度。控制器 14 接收转子位置传感器输出信号并产生对应于转子实际旋转速度的实际速度信号。这种速度测量块的结构对领域的技术人员是显而易见的，并取决于特定转子位置传感器的选择。电动机控制领域的技术人员知道实际速度信号可以传统方式用于电动机控制的其它方面(在此不做详述)。

在控制器 14 中有一数字微控制器，其可以是一个来自 Motorola 的 MC68HC11 系列的微控制器，用于实现该改进的直流链路电压补偿方法。同样的微控制器可用于实现电动机控制器 14 的其它控制功能。这样做的优点在于对直流链路电压的补偿的同时，无须明显增加实现电动机控制器 14 所需的额外电路。

电动机的控制通过一补偿速度信号和一改进的换算方法来完成，该补偿速度信号用于确定来自一控制规则表的电机操作参数，而该改进的换算方法包括将换算速度以确定补偿速度并在该补偿速度下换算转矩以

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恢复原来所需的转矩。有大量的方法可以用来实现这一目的。所有这些方法中，第一个步骤是使用 ADC17 周期地读取代表直流链路电压的信号和实际转子速度。每个读入值被转换为数字表达形式用于随后的处理过程。在实际工作中，在一预先设定的时间周期内，对直流链路电压和转子速度中的每个进行多次检测然后取其在该时间段中的均值。采取这种方式，系统不会对测量电压或转子速度中出现的较小波动而对于敏感。

在第一个例子中，速度和转矩均可通过下面的比率进行换算:

$$Vc/Va$$

其中 Vc 是特性化电压，Va 是通过 ADC17 采样获得的实际工作电压。

为实现这一方法，微处理器中的软件计算 Vc/Va 的比率，然后将计算结果与实际速度信号和实际转矩需求相乘，获得补偿速度和补偿转矩值。之后，这些补偿值被用来对控制规则表进行询问以确定操作参数。一旦该步骤完成，这些选定的操作参数将有选择地用将直流链路电压加到定子绕组中。该简化的方法在很多场合下都很有效，并特别适合于具有恒定电源特性的驱动器中。

当转矩/速度曲线具有特殊形状时，上述描述的第一方法将不适用。为了在此种情况下获得良好的性能，应对用作索引控制规则表的转矩值进行重新设定以使重新设定的值更接近于没有补偿速度时的实际转矩需求。在实际操作中，这一步骤是通过重新定义控制规则表中转矩值的位来实现的，即，使重新定义的转矩值位置上的转矩值更接近于在未有补偿速度时的转矩需求。这一做法的优点在于，不论驱动器的转矩/速度曲线的形状如何，都能得到正确的补偿。应当注意，补偿速度采取与第一个例子相同的计算方法，即用实际速度乘以 Vc/Va。

然而，该方法需要知道在每个速度时刻上代表 100%转矩需求的转矩绝对值。该信息可以附加线的形式存储在控制规则表中或采用其它适宜存储的方法存储。这允许要选择的补偿速度值处的转矩位置数大致对应于工作在实际速度时的转矩需求的绝对值。在实际工作中，转矩需求值在控制规则表中是线性分布的，因此补偿速度所对应的位置数可通过下式给出:

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Lc=|Lu*TMu/TMc|

其中，Lc是对应于补偿速度上的补偿转矩需求的位置数，

Lu是对应于未补偿速度上的实际转矩需求的位置数，

TMu是在未补偿速度时的最大转矩需求，

TMc是在补偿速度时的最大转矩需求。

补偿速度和转矩需求值进而被用于对控制规则表进行询问，以确定所需的操作参数。一旦获得操作参数，这些操作参数将有选择地用于将直流链路电压加到定子绕组中。

在以上两个例子中，控制器在考虑到所需转矩水平的情况下，采用了一种新的方法来选择用于补偿直流链路电压变化时所需的正确操作参数。该方法通过一补偿转矩值和一补偿速度值来实现以提供对直流链路电压中出现的波动进行补偿的改进方法。这是有利的。

总的来说，系统进行特性化所选的电压可在系统工作范围内任何地点进行选择。但应当知道，当实际工作电压高于特性化电压时，补偿速度总是低于实际速度(参考附图 4)。同样的，如果工作电压低于特性化电压，补偿速度将高于实际速度。在这种情况下，当实际速度接近于最大工作速度时，有可能不会有足够的数据可以利用来得到补偿速度值，这取决于特性化电压和工作电压之差。除非，在实际操作中，有其它额外的数据能被用来获得超过最大速度的补偿速度值，否则最大补偿速度值应限于最大速度。因此，优选地，驱动器应工作在最低工作电压上，这样，补偿速度就不会超过实际速度，从而避免了没有足够特性化数据使用的情形出现。

在不脱离本发明的情况下，有经验的人员应当知道对本发明公开的内容所做的改变有多种方法。因此，通过举例的方法而对本发明几个实施例的描述不以限制本发明为目的。有经验的技术人员在对上述描述的方法不做明显改变的情况下，可以很容易地对本发明步骤做些小的修改。本发明仅以下述权利要求范围为限。

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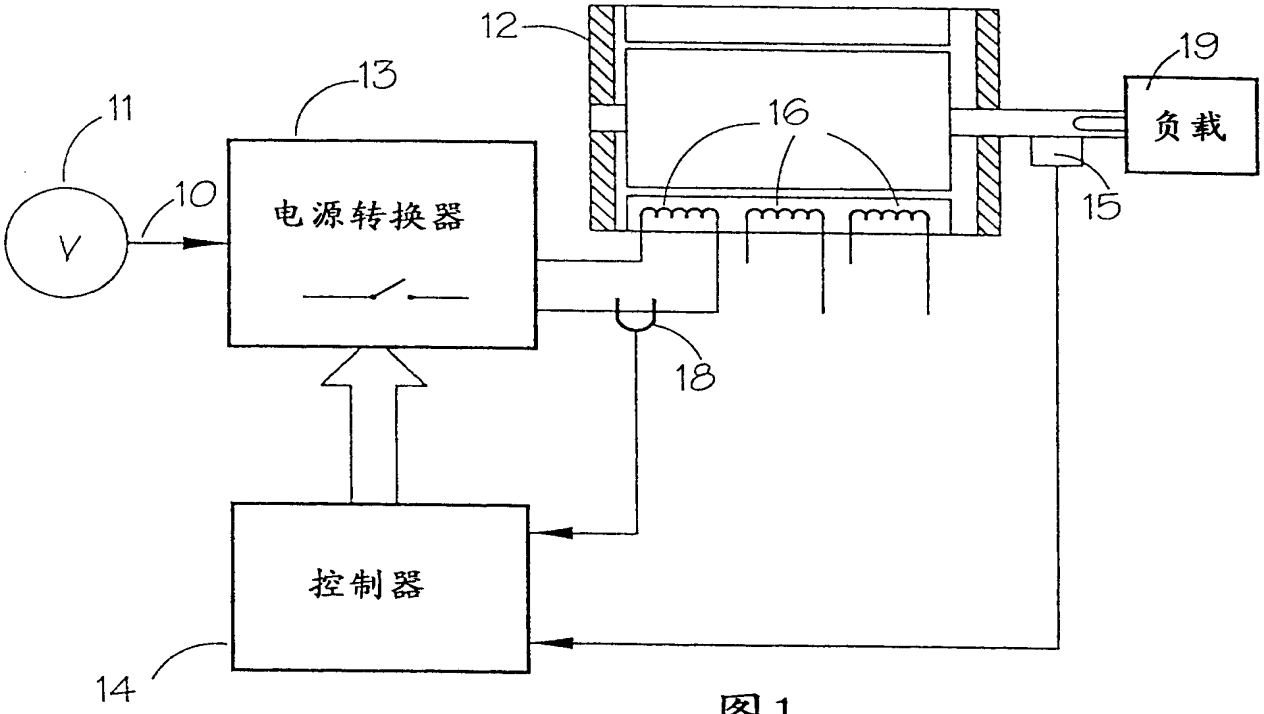


图1

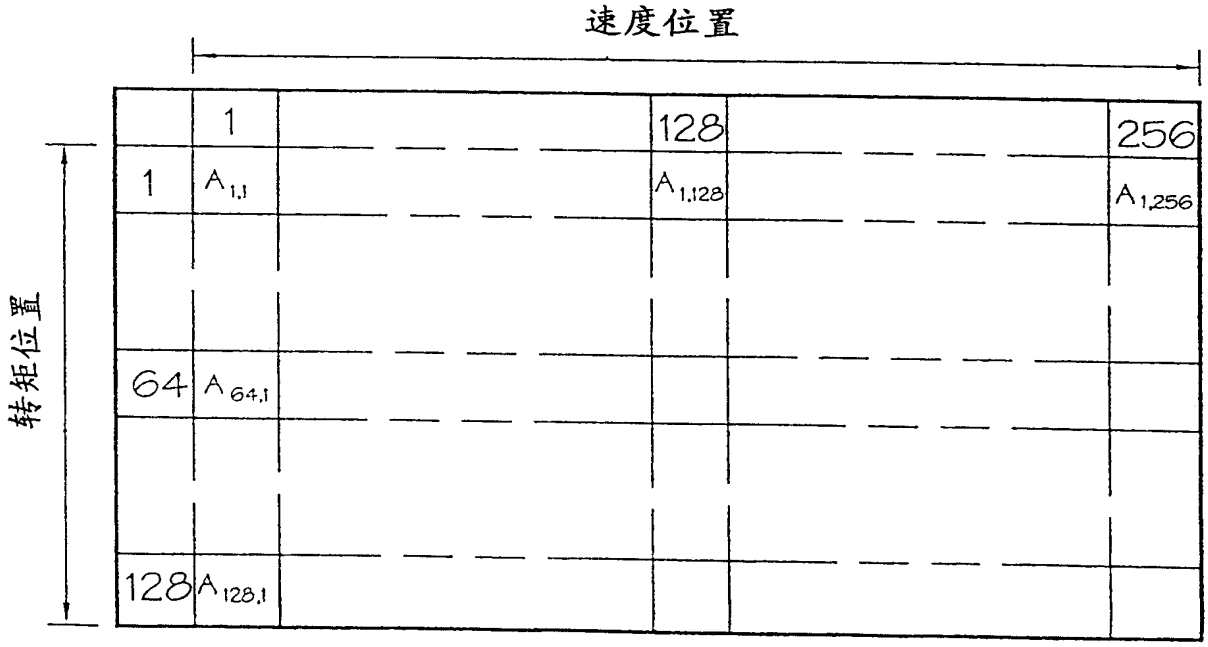


图2

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图 3

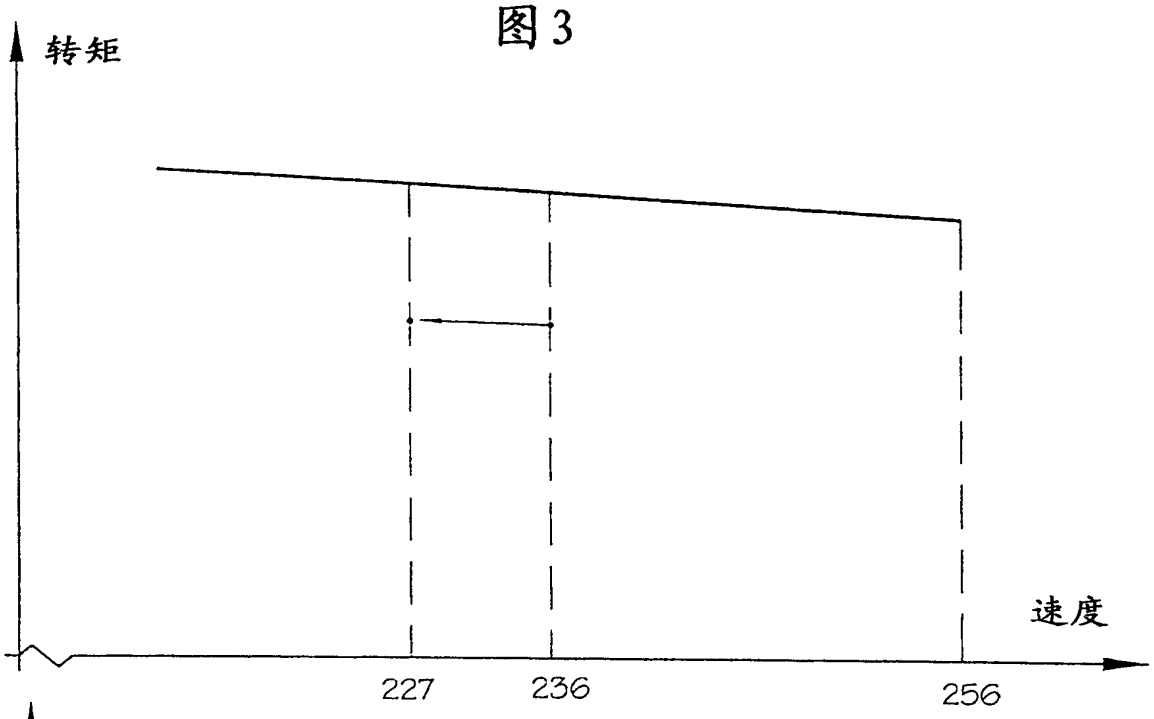
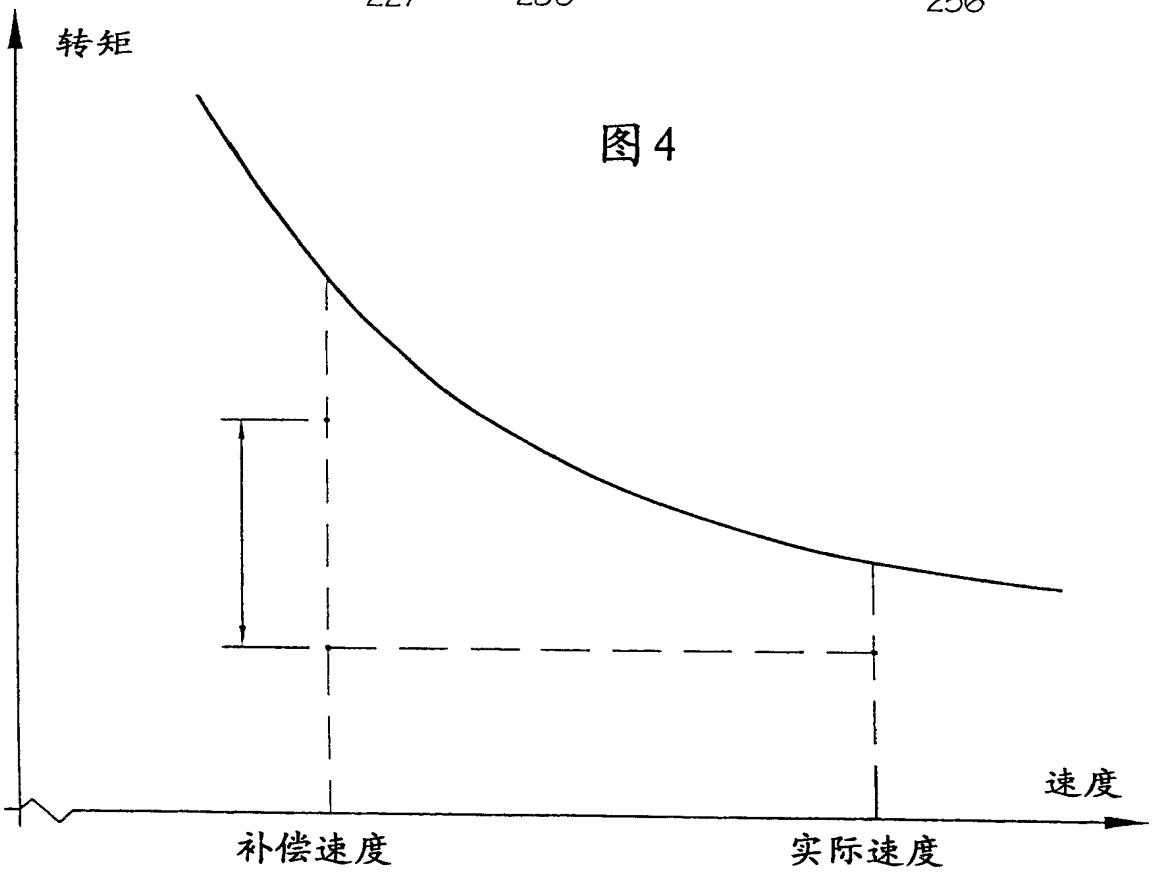


图 4



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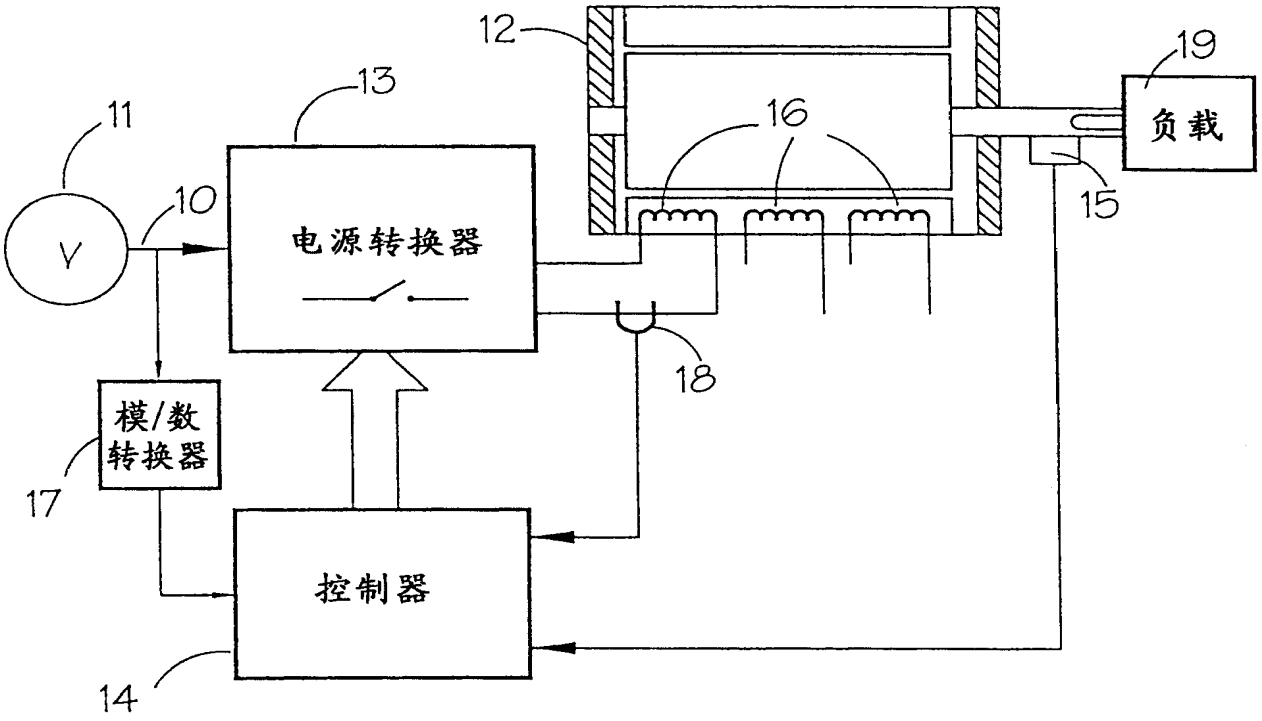


图 5

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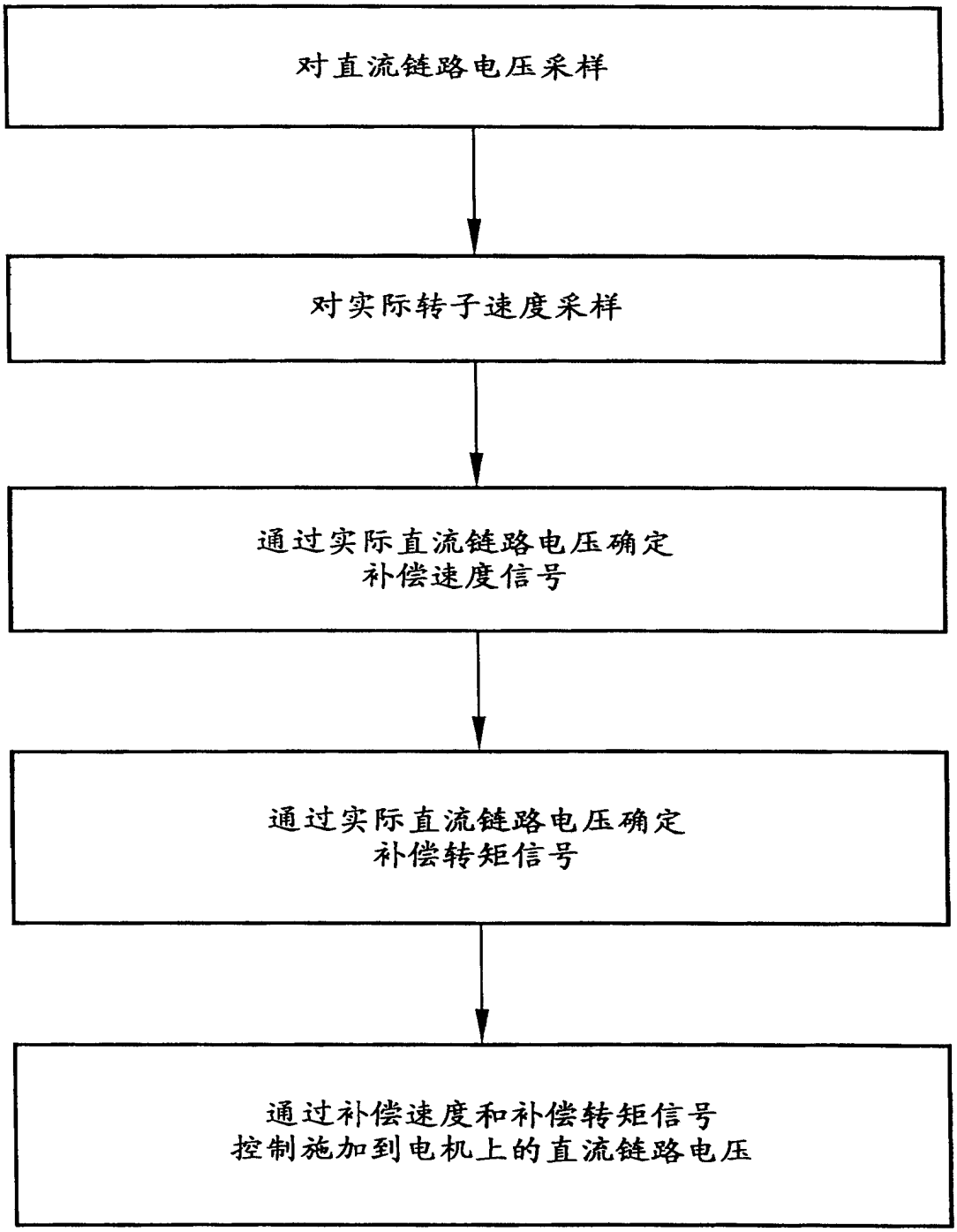


图6

Textron Specialized Vehicles Inc., Exh. 1003, p. 51

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(54) Compensation for input voltage variation in an electric motor drive

(57) The present invention employs digital circuitry to compensate for variations in DC link voltage transmitted to a switched reluctance machine. The digital voltage compensation system of the present invention periodically samples the DC link voltage and actual rotor speed, then supplies the samples in digital form to a microcontroller that derives a compensated speed signal to compensate for changes in DC link voltage.

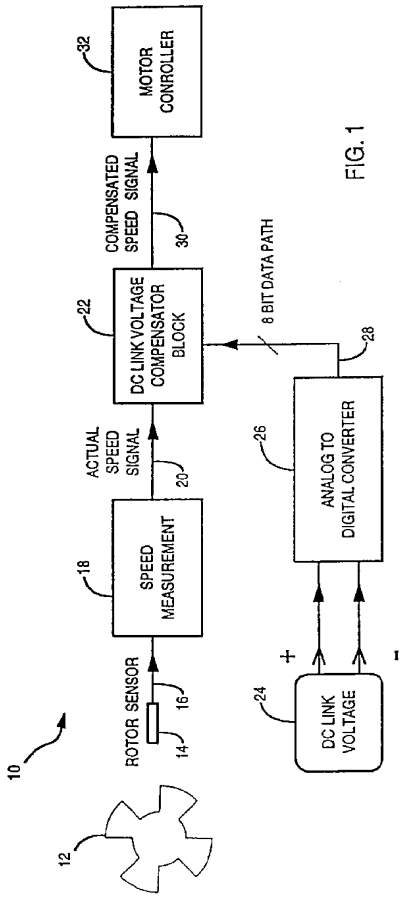


FIG. 1

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Description

The present invention generally relates to an apparatus and method of compensating for DC link voltage variations in an electric motor system. More particularly, the present invention relates to digital circuitry and a method for operating a switched reluctance drive that periodically reads a digital value corresponding to a DC link voltage and adjusts a speed indication signal to compensate for changes in the DC link voltage. The adjusted speed signal is transmitted to a controller where it is used to adjust energisation timing of the switched reluctance drive.

Electric motors turn electrical energy into mechanical energy to produce work. Electric motors work by applying a voltage across one or more windings in the motor thereby energising the windings to produce a resultant magnetic field. Mechanical forces of attraction caused by the magnetic field in turn cause a rotor in the electric motor to move. The efficiency of the electric motor depends in part on the timing and magnitude of each application of voltage to the motor. The magnitude of voltage applied is particularly important in the case of switched reluctance machines.

Historically, the switched reluctance motor was thought to be incapable of competing effectively with other types of motors. Part of the problem was the difficulty in controlling the switched reluctance motor. More recently however, a better understanding of the motor design and application of electronically controlled switching has resulted in robust switched reluctance drives capable of high levels of performance over a wide range of sizes, powers and speeds. Note that the term 'motor' is used here, but it will be appreciated by those skilled in the art that the term covers the same machine in a generating mode unless a particular distinction is made.

The general theory of the design and operation of switched reluctance motors is well known and is discussed, for example, in The Characteristics, Design and Applications of Switched Reluctance Motors and Drives, by Stephenson and Blake and presented at the PCIM '93 Conference and Exhibition at Nüremberg, Germany, June 21-24, 1993.

The switched reluctance motor is generally constructed without windings or permanent magnets on the moving part of the motor (called the rotor). The stationary part of most switched reluctance motors (called the stator) includes coils of wire wound around stator poles that carry unidirectional current. In one type of switched reluctance motor, coils around opposing stator poles are connected in series or parallel to form one phase winding of a potentially multi-phase switched reluctance motor. Motoring torque is produced by applying a voltage across each of the phase windings in a predetermined sequence that is synchronized with the angular position of the rotor so that a magnetic force of attraction results between poles of the rotor and stator as they approach each other. Similarly, generating action is produced by positioning the pulse of voltage in the part of the cycle where the poles are moving away from each other.

In typical operation, each time a phase winding of the switched reluctance motor is switched on (or energised), magnetic flux is produced by the phase winding, thereby turning the two opposing stator poles associated with the phase winding into electro-magnets of opposing polarities. The electro-magnetic field created by the energised phase winding causes a force of attraction on the rotor poles. The general construction and operation of controllers for switched reluctance motors is generally understood and is described herein for background purposes only.

In order to maintain the speed and related torque developed by a switched reluctance motor, it is necessary to carefully control when and how much voltage is applied to the phase windings of the motor. Because the supply voltage can vary significantly, a control scheme that ignores changes in supply voltage may experience a significant reduction in ability to control the machine as demanded by the user. This is because the flux produced by the phase windings is directly related to the amount of voltage applied. Accordingly, a change in the supply voltage may result in more or less flux produced by the phase windings than would otherwise be desired. This undesirable change in the flux in the motor can result in the electro-magnets created by energisation of the phase windings being too strong or too weak resulting in degraded motor performance.

Many switched reluctance motors are run from either battery supplies or, more commonly, from a DC voltage that is derived by rectifying or otherwise converting an AC supply voltage into a DC voltage. In the present application the DC voltage provided to the switched reluctance motor (from a battery, rectifier or otherwise) is referred to as the "DC link voltage". As those skilled in the art will recognize, the DC link voltage available to a switched reluctance motor system is often not constant. Changes in the voltage of the AC supply, changes in the electrical environment in which the motor system operates, and changes in the electrical components used to provide the DC link voltage often result in a DC link voltage that varies over time. These variations in the DC link voltage, if uncompensated, can diminish the performance of a switched reluctance drive.

As discussed above, in switched reluctance drives when and how voltage is applied to the phase windings is very important. In most known switched reluctance drives, the relationship between the speed of the motor, the desired torque, and the time and amount of voltage that is applied to the phase windings is determined empirically through a process referred to as characterisation. In characterisation, the operating parameters of the motor are determined over a wide variety of operating conditions. These operating parameters are then stored in an analogue or digital circuit (called a control law table). During operation of the drive, the control system provides the control law table with signals representing the speed of the motor and the desired torque. Circuitry including the control law table in turn produces signals that control the energisation of the phase windings. The use of motor controllers with control law tables is

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generally understood and is not discussed in detail herein.

For some motors, the characterisation is accomplished in a process that assumes that the DC link voltage available to the motor system is unchanging. Realizing that the DC link voltage will typically vary, characterisation is sometimes done assuming that the DC link voltage is at its lowest expected value. In other words, characterisation is done assuming the "worst case" DC link voltage. This type of characterisation is undesirable to the extent that it characterises the switched reluctance drive to run in a worst-case scenario (which may seldom occur) rather than at the desired optimum DC link value. Other motors are characterised at their optimum DC link voltage. For these motors, there must be some compensation for changes in the DC link value during operation or the drive will suffer diminished performance.

Some known switched reluctance drives do not compensate for changes in DC link voltage. These systems necessarily suffer from the operating problems and loss of efficiency that results from such changes. Other switched reluctance drives use an analogue system to compensate for DC link voltage variations. In general, these systems compensate for the changes in the DC link voltage by adjusting the speed signal provided to the control law table so that the speed signal provided to the controller is not the actual speed of the motor but a modified speed signal that represents the actual speed signal modified by a signal representative of the DC link voltage.

In typical analogue DC link compensation circuits, an analogue feedback signal that corresponds to the rotational speed of the motor is sampled at a fixed frequency using pulses having a duty cycle that corresponds to the DC link voltage. This sampling produces a modified analogue speed signal that is provided to the control circuit, which may include a control law table. For example, if the DC link value is at or near the desired DC link value, the speed feedback signal may be sampled using pulses with a duty cycle of approximately 90%. This will produce a modified speed signal of a first value. If the DC link value drops below the desired DC link voltage, the duty cycle of the sampling pulses may increase up to 100%, which correspondingly increases the modified analogue speed signal provided to the controller. Conversely, if the DC link voltage increases, the duty cycle of the sampling pulses will decrease, reducing the value of the modified analogue speed signal provided to the controller. The controller, which may include a control law table, receives the modified signals and produces the signals that control the energisation of the motor windings in a manner that compensates for the variations in the DC link voltage.

These analogue DC link compensation systems typically suffer from several disadvantages. In particular, these analogue systems suffer from the poor accuracy and performance limitations inherent in all analogue systems. Moreover, these analogue systems require components that are costly and can only operate within a limited operating range. For example, the use of the analogue sampling technique discussed above is limited to the extent that the sampling pulses cannot have a duty cycle of greater than 100%. Still further, as digital controllers are integrated into motor control systems, the requirement of an analogue DC link compensator results in the need for additional, costly circuitry.

Given the disadvantages of the known analogue systems, it is desirable to have a DC link voltage compensation system that is accurate, covers a considerable range of DC link voltages, and is relatively inexpensive.

The present invention is defined in the accompanying independent claims. Preferably features of the invention are recited in the claims respectively dependent thereon.

The present invention generally relates to an apparatus and method of compensating for DC link voltage variations in an electric drive system. More particularly, the present invention relates to a digital system for accurately and efficiently implementing DC link compensation in a manner that overcomes many of the disadvantages associated with known analogue DC link compensation systems. In one embodiment of the present invention, digital circuitry is used to periodically read digital signals representing the DC link voltage and actual rotor speed. The digital circuitry then uses a novel approach to adjust the digital representation of the rotor speed to compensate for changes in the DC link voltage. The compensated speed signal is then transmitted to a controller, which may include a control law table, where it is used to adjust coil energisation timing of the switched reluctance drive.

In accordance with a preferred embodiment of the present invention, the foregoing disadvantages of known switched reluctance drive controllers are overcome by utilizing a microcontroller to digitally process signals representing DC link voltage to achieve compensation for DC link voltage variations.

Other aspects and advantages of the invention will become apparent upon reading the following detailed description of exemplary embodiments of the invention and upon reference to the accompanying drawings, in which:

Figure **1** is a block diagram of a DC link voltage compensation system according to one embodiment of the present invention;

Figure **2** is a flow chart illustrating a method of implementing a DC link voltage compensation system according to one embodiment of the present invention;

Figure **3** is a graph illustrating one possible relationship between the DC link voltage and a compensation factor that may be implemented through the use of the present invention; and

Figure **4** is a table used to determine an acceptable relationship between the digital representation of the average DC link voltage and a compensation factor.

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Figure **1** illustrates a representative block diagram of a digital DC link voltage compensation system **10** for a switched reluctance motor (partially represented by a rotor **12**). The voltage compensation system **10** further includes a rotor position sensor **14** (RPT), which is influenced by a member attached to rotate with the rotor, for creating a rotor position sensor output signal **16** representative of the position of rotor **12**. It will be appreciated by those skilled in the art that rotor position information can be derived by several alternative means, including a rotor position transducer (RPT) or by estimating the information from motor current, voltage and/or inductance. The sensor **14** is shown in block form in Figure **1** for illustrative purposes.

By monitoring the changes in the rotor position over a given time period it is possible to determine the speed of the motor. In Figure **1**, a speed measurement block **18** performs the function of receiving the rotor sensor output signal **16** and providing an actual speed signal **20** that corresponds to the actual rotational speed of the rotor **12**. Construction of the speed measurement block **18** will be straightforward to one skilled in the art and depends on the particular RPT selected. The actual speed signal **20** is provided to a digital DC link voltage compensator block **22**.

In addition to sensing the rotational speed of the rotor, the circuit of the present invention also senses the DC link voltage **24**. In the embodiment of Figure **1**, an analogue to digital converter (ADC) **26** samples the DC link voltage **24** and converts it into a digital output **28** that represents the voltage magnitude of the DC link voltage. The ADC **26** transmits its output **28** to the digital DC link voltage compensator block **22**. In one embodiment the ADC output **28** comprises 8 (eight) data bits, allowing for 2^8 (= 256) different voltage levels to be represented.

The digital DC link voltage compensator block **22** receives the actual speed signal **20** and the ADC voltage output **28** and generates a digital compensated speed signal **30** which is passed to a motor controller **32** associated with the switched reluctance motor. In one embodiment, the digital compensated speed signal **30** is adjusted inversely to changes in DC link voltage **24**. For example, a rise in DC link voltage **24** will produce a smaller valued, compensated speed signal **30**, while a fall in DC link voltage **24** will produce a larger valued, compensated speed signal **30**. The digital compensated speed signal **30** from the digital DC link voltage compensator **22** is then applied to the motor controller **32** that in one embodiment includes a control law table. Control of the motor is accomplished using the compensated speed signal.

It will be appreciated by those skilled in the art of motor control that the actual speed signal will be used for other aspects of control of the motor (not discussed here) in conventional fashion.

The digital DC link voltage compensator **22** may be implemented in a number of different ways. For example, discrete digital components, or an application specific digital integrated circuit may be used to implement the DC link voltage compensator. In one embodiment of the present invention a digital microcontroller, such as a microcontroller from Motorola's MC68HC11 family of microcontrollers, may be used to implement the DC link voltage compensation method of the present invention. In that embodiment the same microcontroller may be used as the motor controller **32**. This embodiment has the advantage of performing DC link voltage compensation without the need for significant additional circuitry over that already required to implement the motor controller **32**.

Turning now to Figure **2**, there is shown a flow chart illustrating a preferred method of implementing the digital DC link voltage compensator **22** within the DC link voltage compensation system **10**. In particular, Figure **2** illustrates a method in accordance with the present invention by which the digital DC link voltage compensator **22** may convert the actual speed signal **20** into the compensated speed signal **30**.

At the beginning of the process, the digital DC link voltage compensator must first determine the actual DC link voltage. This is accomplished by reading the digital value provided by the ADC **26** that corresponds to the actual DC link voltage. To avoid having transient changes in the DC link voltage **24** affect the motor operation, the DC link voltage **24** is averaged over a given period of time. In the embodiment of the present invention illustrated in Figure **2** this reading and averaging is accomplished as follows:

At step **34** the digital DC link voltage compensator **22** reads an eight bit digital output of the ADC **26**. At step **36** the digital value corresponding to the DC link voltage is normalised to values corresponding to decimal values between 123 and 210. The normalisation range corresponds to a range of DC link voltages that the digital DC link voltage compensator **22** can compensate for and still allow the control system of the drive to accurately control speed and torque.

To accomplish the averaging of the DC link voltage over time, the process of reading the digital signal from the ADC **26** is repeated 256 times. The 256 readings are then added together and divided by 256 to get an average DC link voltage. In the present invention this adding and dividing is accomplished through the use of a binary storage register called link_sum. Each normalised DC link voltage reading is added to link_sum, a binary variable representing a running total, in step **38**. In next step **40**, a counter tracks whether 256 readings have been added to link_sum, if not, then the process repeats and another set of DC link voltage readings is taken. However, if exactly 256 readings have been added to link_sum, then 127 is added to link_sum in step **42**. Adding 127 to link_sum effectively allows link_sum to be rounded in step **42**, instead of merely truncating it. The counter is then reset to zero in anticipation of another round of voltage sampling **42**. In step **44** link_sum is shifted to the right 8 (eight) spaces, effectively dividing link_sum by 2^8 (= 256), thereby averaging link_sum to derive an average DC link voltage. The advantage to shifting link_sum

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to the right eight spaces as opposed to dividing by 256 is that the same result is achieved in far less time. Division is much more time consuming that mere shifting of numbers. Saving time is particularly important in real time systems where the present invention finds particular application.

Once the average DC link voltage has been determined, the digital DC link compensator **22** of the present invention then determines the compensation factor to adjust the actual motor speed signal **20** to compensate for any variations in the DC link voltage. Because the present invention uses digital circuitry, the compensation factor may be selected according to any arbitrary relationship between actual DC link voltage and the compensation factor. In one embodiment of the present invention, the relationship between the actual DC link value and the compensation factor is set such that the compensation factor increases with decreasing actual DC link voltage, and decreases with increasing actual DC link voltage.

Line **A** of Figure **3** illustrates one desirable relationship between DC link voltage (represented on the horizontal axis in terms of normalised ADC values) and the compensation factor (represented on the vertical axis). In Figure 3, the relationship between the DC link values and the compensation factor is as follows: the compensation factor is equal to the optimum DC link voltage divided by the actual DC link voltage. For example, in one embodiment of the present invention the optimum DC link voltage may be 1350 V_{DC}, which translates into a normalised ADC value of 172 (based on a 2000 volt scale divided into 256 digital representations). If the actual DC link voltage is 1350 V_{DC} (with an ADC of 172) then the compensation factor should be 1.0 since the actual speed signal does not need to be modified since there is no DC link voltage variation. Using the same example, if the actual DC link voltage is 1550 (with an ADC value of 198) the compensation factor should be (1350/1550) or approximately 0.87. Two examples are illustrated with respect to line **A** of Figure **3**; when the actual DC link voltage is 1056 volts (with an ADC value of 135) the compensation factor should be approximately 1.28. When the actual DC link voltage is 1550 volts (with an ADC value of 198) the compensation factor should be approximately 0.87. It should be noted that the relationship between DC link voltages and the compensation factors represented by line **A** of Figure 3 is but one of many possible relationships that may be used to implement the present invention.

The actual derivation of the compensation factor given the normalised ADC value representing the actual DC link voltage may be accomplished in a variety of ways. For example, a simple look-up table may be used, or the compensation factor may be calculated in some other manner. In the embodiment represented by Figure **2**, the compensation factor is calculated.

Line **A** of Figure **3** represents a constant-slope approximation to a non-linear optimal compensation factor. As those skilled in the art will recognize, it is often difficult to exactly describe complex mathematical relationships, and as such, more simple approximations are often used as good, practical substitutes that may be implemented in digital systems. Accordingly, the embodiment represented by Figure **2** does not implement a precise non-linear optimal relationship between compensation factor and voltage variance, but implements a linear approximation related to the relationship represented by line **A** as described below.

First it was realized that the relationship represented by Line **A** can be expressed as $Y = MX + C$ where Y represents the compensation factor, M represents the slope of line **A**, X represents a digital value corresponding to the actual DC link voltage, and C represents an offset. To determine the characteristics of line **A**, the slope of line **A** was calculated. In the example of Figure 3 this slope M came out to be approximately - 0.00646. Because the fractional number 0.00646 was inconvenient to represent digitally, it was multiplied by a large multiplying factor (in this example 2^{13} or 8192) to produce a whole decimal integer that could be used in a digital system. In this example the initial slope was approximately - 53. Because the right hand side of the equation was multiplied by 2^{13} the left hand side must also be multiplied by the same number so that the calculated compensation factor Y when the actual DC link value equalled the desired DC link value (or when the normalised ADC value was 172) would now be 2^{13} or 8192 rather than 1. Using those numbers the value C was calculated to be -17308.

It was then noted that, while selecting the offset C at -17308 produces the desired compensation factor when the actual DC link voltage is equal to the optimum DC link voltage, it also produced offset errors at DC link voltages that were either greatly above or greatly below the optimum DC link voltage. This would have resulted in the compensation factor being slightly different from the desired compensation factor illustrated by line **A**. Accordingly, it was decided to select other slopes and compare the relative offset errors at the highest and lowest expected DC link values for the different slopes. A tradeoff between percentage error and overcompensation at the high end was then made.

Figure **4** illustrates one example of these calculations for slopes of -53, -54, -55, -56 and -57. The chart in Figure **4** illustrates absolute value of the slope M, the calculated offset C, and absolute value of the percent error from the desired compensation factor represented by line **A** for the highest and lowest expected DC link voltages. The slope of -55 was selected in the present example, because it represents the preferable tradeoff between percentage error and overcompensation at high voltage. The lowest expected DC link voltage was used to determine the slope because it is believed that it is better to have too much DC link compensation at high actual DC link voltages than not enough at low actual DC link voltages. When a slope of -55 is used, the calculated offset factor C comes out to be 17,652.

The selection of the slope -55 was made for the specific example described herein. Depending on the construction

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of the motor, the desired operating points and the goals of the system designer, other suitable slopes can easily be selected.

Referring back to Figure 2, which illustrates an embodiment using a slope of - 55, the average DC link voltage that was derived in step **44** (which corresponds to X in the equation provided above) is multiplied by slope value 55 (fifty-five) in step **46**. The negative nature of the slope is understood and is not used in the example of Figure 2. Multiplying the average link voltage by 55 in step **46** enables determination of a corresponding DC link voltage variation. In order to complete the equation Y = MX + C it is necessary to subtract the value obtained by multiplying the average DC link voltage by 55 from 17,652 in step **48**, to produce Y the compensation factor.

Having calculated the compensation factor, the digital DC link voltage compensator of the present invention then needs to adjust the measured motor speed **20** to reflect the compensation factor. This is accomplished, generally, by multiplying the actual motor speed **20** by the compensation factor to produce a compensated speed signal **30**. That is applied to the controller **32** as discussed above.

In the embodiment of Figure **2** scaling, normalisation and multiplication factors are used to convert the actual speed signal **20** into the compensated speed signal **30**. These scaling factors, normalisation factors, and multipliers are used to optimize the implementation of the present method in a digital system and to compensate for the scaling and offset factors used to calculate the compensation factor from the actual DC link voltage. Those skilled in the art will recognize that these factors and multipliers may be changed and altered without deviating from the present invention.

In the embodiment of Figure **2**, the actual speed signal **20** is received from the speed measurement block **18** and read by the digital DC link voltage compensator block **22** in step **50**. Knowing the actual speed provides a baseline which is altered according to DC link voltage variations. Once the actual speed signal is read in step **50**, it is normalised in step **52**. Here normalisation requires limiting of values greater than 2^{15}-1 = 32767 to be equal to 32,767. This step ensures that the maximum speed signal used to provide a compensated speed signal is never greater than 32,767.

In step **54**, the normalised actual speed in digital form, is multiplied by the digital compensation factor calculated in step **48** to produce a digital output which represents a compensated speed signal **30**. The digital compensated speed signal **30** may then be provided to the motor controller **32** to control the motor operation as discussed above.

In the embodiment of Figure **2** the digital compensation speed signal is first scaled and then limited before it is provided to the motor controller. In Figure **2** the scaling occurs in step **58** where the compensated speed signal is divided by a divisor equal to 2^{13} (8,192) * 2^{7} (128) = 2^{20} (1,048,576), to produce a scaled compensated speed in step **56**. The 2^{13} (8,192) component of the divisor offsets multiplication of the slope by the same number above. The 2^{7} (128) component helps to scale the uncompensated speed down to an 8 (eight) bit range. Adjusting the scaled compensated speed to an 8 bit range is completed by truncating values above eight bits in step **58**. Thus, in the embodiment of Figure **2**, step **58** results in the production of an 8 bit scaled compensated speed signal **30** which is transmitted to the switched reluctance motor controller **32**.

The compensated speed signal **30** functions to provide to the switched reluctance motor controller **32** a way to make adjustments in pulse magnitude, duration and timing based on variations in DC link voltage. The compensated speed signal **30** works within a range of acceptable DC link voltages **24** as normalised and truncated in one embodiment of the present invention described above.

There has been described herein a DC link voltage compensation system and method which adjusts a speed indication signal in response to a variation in DC link voltage.

The program listing attached as Appendix A is a representative listing of a software routine that may be used to construct a DC link voltage compensation system in accordance with the present invention.

A preferred embodiment of the present invention provides a digital DC link voltage compensation system which adjusts a rotor speed signal in response to a variation in DC link voltage. The digital voltage compensation system provides for improved accuracy and better control of rotor speed and torque in a cost-effective manner.

While the invention is susceptible to various modifications and alternative forms, a number of specific embodiments have been shown by way of example in the drawings and have been described in detail. It should be understood, however, that this is not intended to limit the invention to the particular forms disclosed. On the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the scope of the invention as defined by the appended claims.

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APPENDIX A

```
/*==========================================
                dc_link_compensation

function:   applies a scaling factor to the speed sent to the ASIC according to the voltage
            of the dc link.
==========================================*/
void dc_link_compensation()
{
static unsigned int averaging_count , link_sum , link_value;
unsigned char adc_in;
unsigned int multiplier;
unsigned long temp;

    /* first average 256 values read from the ADC measuring the DC link */

adc_in = ADR2;                                          /* read the ADC */
if (adc_in < 123)                                       /* limit compensation to 130 - 210 */
    adc_in = 123;
else if (adc_in > 210)
    adc_in = 210;
link_sum += adc_in;
averaging_count++;
if (averaging_count == 256)
    {
    averaging_count = 0;
    link_value = ((link_sum + 127) >> 8)  * 55;
    link_sum = 0;
    }

    /*  now the latest value of "link_value" can be used as the basis of the
        multiplying factor for the speed */

multiplier = 17652 - link_value;
temp = actual_speed;
if (temp > 0x7fff)                                      /*  limit actual_speed to 2000 rpm*/
    temp = 0x7fff;
temp *= (unsigned long)multiplier;
temp >>= 20;
if (temp > 0xff)
    temp = 0xff;                                        /* limit to maximum scaling */

        /* operate on nominal voltage when generating */

if (generating == TRUE)
    compensated_speed = actual_speed >> 7;
else
    compensated_speed = temp;
}
```

Claims

1. A method for compensating for deviations of actual DC link voltage from a predetermined DC link voltage applied to an electric machine drive, which includes an electric machine having a rotor and a controller for controlling the machine in response to a speed signal, the method comprising the steps of:

   periodically sampling the actual DC link voltage and converting the sampled DC link voltage into a digital link voltage representation;
   periodically sampling the actual rotor speed and converting the sampled rotor speed to a digital speed representation;
   modifying the digital speed representation according to the digital link voltage representation to produce a compensated speed signal; and
   transmitting the compensated speed signal to the electric machine controller and using the compensated speed signal in control of the machine.

2. A method as claimed in claim 1 in which the digital speed representation is multiplied by a compensation factor, generated from the digital link voltage representation, to produce the compensated speed signal.

3. A method as claimed in claim 2, in which the compensation factor corresponds to the predetermined DC link voltage divided by the actual DC link voltage.

4. A method as claimed in any of claims 1 to 3 in which each digital link voltage representation is an average of a plurality of samples.

5. A method as claimed in any of claims 1 to 4 including limiting the digital dc link voltage representation to be within a predetermined range.

6. A method as claimed in any of claims 1 to 5 including limiting the digital speed representation to be within a predetermined range.

7. A compensation system for compensating for a deviation of an actual DC link voltage from a predetermined DC link voltage in an electric drive which includes an electric machine having a rotor, the system comprising:

   means for sampling the actual DC link voltage periodically and converting the sampled DC link voltage into a digital link voltage representation;
   means for sampling an actual rotor speed periodically and converting the sampled rotor speed into a digital speed representation;
   means for modifying the digital speed representation according to the digital link voltage representation to produce a compensated speed signal, and
   means for controlling the machine in accordance with the compensated speed signal.

8. A system as claimed in claim 7 in which the means for sampling the actual DC link voltage are operable to produce, as the digital link voltage representation, an average of a plurality of sampled DC link voltages.

9. A system as claimed in claim 7 or 8 in which the means for modifying the digital speed representation comprise means for limiting the digital link voltage representation to be within a predetermined range.

10. A system as claimed in claim 9 in which the means for modifying the digital speed representation further comprise means for limiting the digital speed representation to be within a predetermined range.

11. A system as claimed in claim 7, including: means for limiting the sampled DC link voltage to be within a predetermined range;

    means for accumulating a plurality of voltage samples; and
    means for averaging the voltage samples.

12. A system as claimed in claim 8 in which the means for generating the compensated rotor speed signal further comprise:

Textron Specialized Vehicles Inc., Exh. 1003, p. 59

digital means for limiting the voltage sampled by making all voltage samples below a lower level equal to the lower level and all voltage samples above an upper level equal to the upper level;
digital means for averaging and rounding a plurality of the voltage samples;
means for multiplying the averaged and rounded voltage samples to produce a compensation factor;
means for detecting the actual rotor speed;
digital means for limiting the digital speed representation for values above a predetermined threshold;
digital means for multiplying the digital speed representation by a compensation factor to produce an interim rotor speed signal;
means for dividing the interim rotor speed signal by a predetermined divisor to produce a scaled interim rotor speed signal; and
means for limiting the scaled interim rotor speed signals which are greater than a predetermined amount to produce the compensated speed signal.

13. A system as claimed in claim 12 in which the means for generating the compensated speed signal include a microprocessor.

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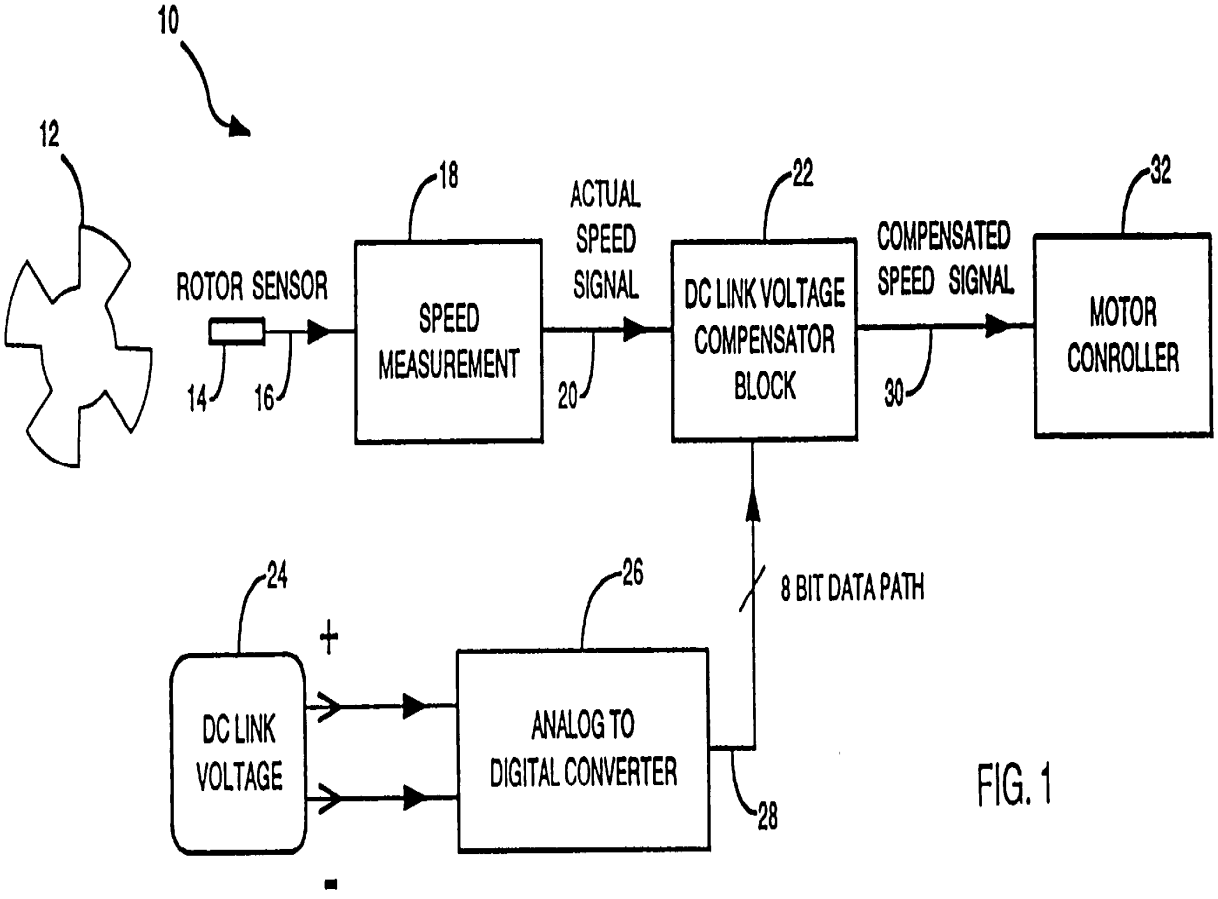


FIG. 1

EP 0 739 085 A2

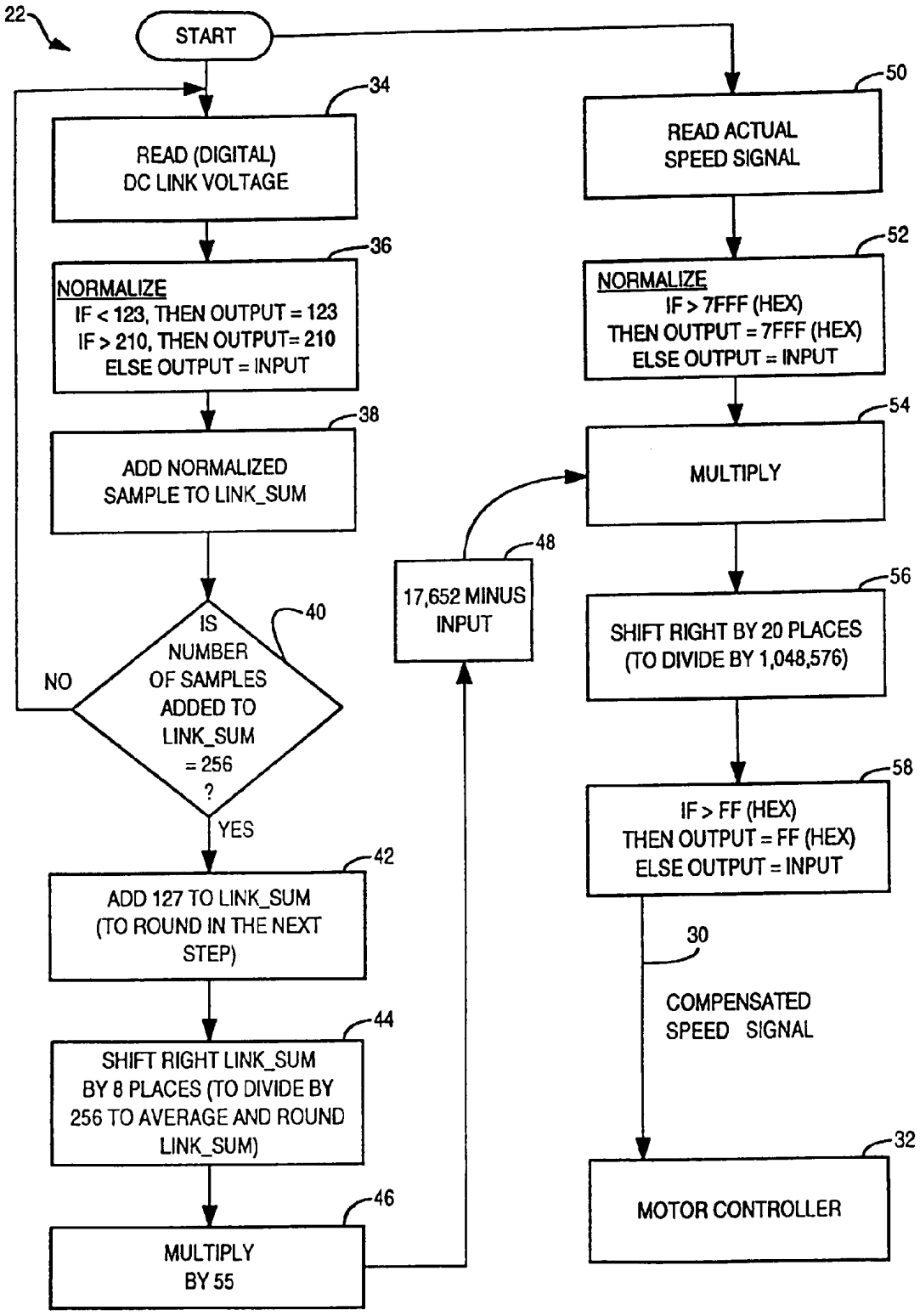


FIG. 2

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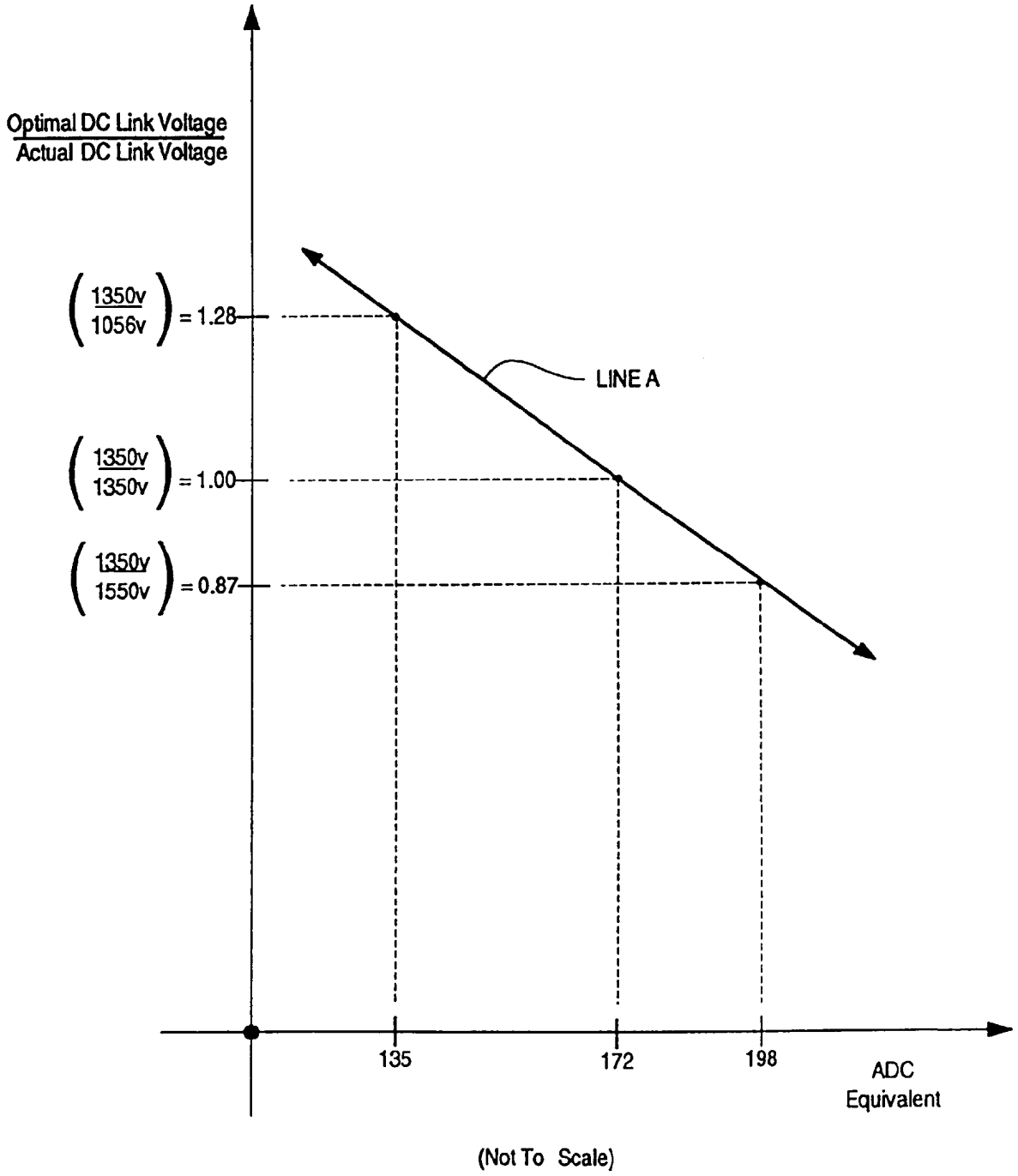


FIG. 3

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SLOPE	OFFSET	LOWER ENDPOINT		UPPER ENDPOINT	
M	C	SCALING	% ERROR	SCALING	% ERROR
53	17308	10153	3.02	6814	4.5
54	17480	10190	2.67	6788	4.86
55	17652	10227	2.31	6762	5.22
56	17824	10264	1.96	6736	5.59
57	17996	10301	1.60	6710	5.96

FIG. 4

Textron Specialized Vehicles Inc., Exh. 1003, p. 64

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

136725 7590 12/10/2019

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

EXAMINER	
RO, BENTSU	

ART UNIT	PAPER NUMBER
2837	

NOTIFICATION DATE	DELIVERY MODE
12/10/2019	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):

uspto.anova@gmail.com
uspto@anovalaw.com

Examiner-Initiated Interview Summary	Application No. 16/116,279	Applicant(s) ZHOU et al.	
	Examiner BENTSU RO	Art Unit 2837	AIA (FITF) Status Yes

All participants (applicant, applicant's representative, PTO personnel):

(1) BENTSU RO. (3) _____.

(2) Colon Santana Eduardo. (4) _____.

Date of Interview: 06 December 2019.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☑ No.
If Yes, brief description: _____.

Issues Discussed ☐ 101 ☐ 112 ☐ 102 ☐ 103 ☑ Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: _____.

Identification of prior art discussed: _____.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

See Continuation Sheet.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/BENTSU RO/ Primary Examiner, Art Unit 2837	/EDUARDO COLON SANTANA/ Supervisory Patent Examiner, Art Unit 2837

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: The purpose of this interview summary is to put applicant on notice that the Corrected Notice of Allowance sent on 11/18 is in error. Since the IDS submitted on Oct. 28, 2019 is incomplete for missing documents (There is nothing to consider). The examiner has contacted the scanning department and it appears that this issue is not related to scanning documents, but more related to an incomplete request for Quick Path Information Disclosure Statement (QPIDs) program. Any comments necessary to make corrections will need to be directed to SPE Eduardo Colon at 571-272-2060. At this moment the Corrected Notice of Allowance dated 11/18 is being vacated.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

136725 7590 11/18/2019

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21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

EXAMINER	
RO, BENTSU	

ART UNIT	PAPER NUMBER
2837	

NOTIFICATION DATE	DELIVERY MODE
11/18/2019	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):

uspto.anova@gmail.com
uspto@anovalaw.com

Corrected ***Notice of Allowability***	**Application No.** 16/116,279	**Applicant(s)** ZHOU et al.	
	Examiner BENTSU RO	**Art Unit** 2837	**AIA (FITF) Status** Yes

-- 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 applicant's filing of IDS on October 28, 2019.
   ☐ 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 1-17 . 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 Examiner's Statement.

/BENTSU RO/
Primary Examiner, Art Unit 2837

Electronic Patent Application Fee Transmittal

Application Number:	16116279
Filing Date:	29-Aug-2018
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Filer:	Li Jiang/Hoi Cheung
Attorney Docket Number:	00203.3030.00US

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PETITION FEE- 37 CFR 1.17(H) (GROUP III)	1464	1	140	140
RCE- 1ST REQUEST	1801	1	1300	1300
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1440**

Doc Code: QPIDS.REQ
Document Description: Quick Path Information Disclosure Statement

PTO/SB/09 (12-16)

CERTIFICATION AND REQUEST FOR CONSIDERATION OF AN INFORMATION DISCLOSURE STATEMENT FILED AFTER PAYMENT OF THE ISSUE FEE UNDER THE QPIDS PILOT PROGRAM

Non-Provisional Application Number: 16/116,279	Filing Date: 2018-08-29
First Named Inventor: Changxing ZHOU	Title of Invention: MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

THE UNDERSIGNED HEREBY CERTIFIES AND REQUESTS THE FOLLOWING FOR THE ABOVE-IDENTIFIED APPLICATION.

1. Consideration is requested of the information disclosure statement (IDS) submitted herewith, which is being filed after payment of the issue fee.
2. Check the box next to the appropriate selection:

   ☑ Each item of information contained in the IDS 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 IDS. See 37 CFR 1.97(e)(1).

   OR

   ☐ No item of information contained in the IDS 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 IDS was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(2).

   OR

   ☐ See attached certification statement in compliance with 37 CFR 1.97(e).
3. Please charge the IDS fee set forth in 37 CFR 1.17(p) to Deposit Account No. 505213.
4. A Petition to Withdraw from Issue After Payment of the Issue Fee (37 CFR 1.313(c)(2)), including the petition fee set forth in 37 CFR 1.17(h), is submitted herewith as a **Web-based ePetition**.
   WARNING: Do not submit the petition as a follow-on paper via EFS-Web. Submit the petition as a Web-based ePetition by signing on to EFS-Web as a registered user, selecting the radio button next to "Existing application/patent," and then selecting the radio button next to "ePetition (for automatic processing and immediate grant, if all petitions requirements are met)." Failure to use the Web-based ePetition interface will result in automatic entry of the RCE.
5. A request for continued examination (RCE) under 37 CFR 1.114 and the RCE fee under 37 CFR 1.17(e) are submitted herewith.
6. The RCE will be treated as a "conditional" RCE. In the event the examiner determines that any item of information contained in the IDS necessitates the reopening of prosecution in the application, the undersigned understands that (i) the RCE will be processed and treated as an RCE under 37 CFR 1.114 and therefore (ii) the IDS fee under 37 CFR 1.17(p) will be returned in accordance with 37 CFR 1.97(b)(4). In the event that no item of information in the IDS necessitates reopening prosecution, the undersigned understands that the RCE will not be processed and the RCE fee under 37 CFR 1.17(e) will be returned.
7. This certification and request is being filed as a **Web-based ePetition** and is not accompanied by an amendment to the application. Inclusion of an amendment will result in automatic entry of the RCE.

Signature /Li Jiang/	Date 2019-10-28
Name (Print/Typed) Li Jiang	Practitioner Registration Number (If applicable) 74191

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below.**

☐ *Total of _____ forms are submitted.

If you need assistance in completing the 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.

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Commissioner for Patents
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www.uspto.gov

Decision Date : October 28, 2019

In re Application of :

Changxing ZHOU

DECISION ON PETITION

UNDER CFR 1.313(c)(2)

Application No : 16116279

Filed : 29-Aug-2018

Attorney Docket No : 00203.3030.00US

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed October 28, 2019 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2837 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

Doc Code: PET.AUTO Document Description: Petition automatically granted by EFS-Web	PTO/SB/140 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**PETITION TO WITHDRAW AN APPLICATION FROM ISSUE AFTER PAYMENT OF THE ISSUE FEE UNDER 37 CFR 1.313(c)**
Application Number	16116279
Filing Date	29-Aug-2018
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	BENTSU RO
Attorney Docket Number	00203.3030.00US
Title	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

An application may be withdrawn from issue for further action upon petition by the applicant. To request that the Office withdraw an application from issue, applicant must file a petition under this section including the fee set forth in § 1.17(h) and a showing of good and sufficient reasons why withdrawal of the application from issue is necessary.

APPLICANT HEREBY PETITIONS TO WITHDRAW THIS APPLICATION FROM ISSUE UNDER 37 CFR 1.313(c).

A grantable petition requires the following items:
(1) Petition fee; and
(2) One of the following reasons:
(a) Unpatentability of one or more claims, which must be accompanied by an unequivocal statement that one or more claims are unpatentable, an amendment to such claim or claims, and an explanation as to how the amendment causes such claim or claims to be patentable;
(b) Consideration of a request for continued examination in compliance with § 1.114 (for a utility or plant application only); or
(c) Express abandonment of the application. Such express abandonment may be in favor of a continuing application, but not a CPA under 37 CFR 1.53(d).

Petition Fee

- ○ Small Entity
- ○ Micro Entity
- ◉ Regular Undiscounted

Reason for withdrawal from issue

○ One or more claims are unpatentable ◉ Consideration of a request for continued examination (RCE) (List of Required Documents and Fees) ○ Applicant hereby expressly abandons the instant application (any attorney/agent signing for this reason must have power of attorney pursuant to 37 CFR 1.32(b)).
RCE request,submission, and fee. ☐ I certify, in accordance with 37 CFR 1.4(d)(4) that : The RCE request ,submission, and fee have already been filed in the above-identified application on ☒ Are attached.
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application. ○ An attorney or agent registered to practice before the Patent and Trademark Office, acting in a representative capacity. ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this e-petition

Signature	/Li Jiang/
Name	Li Jiang
Registration Number	74191

Electronic Acknowledgement Receipt

EFS ID:	37582171
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	28-OCT-2019
Filing Date:	29-AUG-2018
Time Stamp:	17:10:51
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1440
RAM confirmation Number	E20190RH10474963
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition automatically granted by EFS	petition-request.pdf	31555 fd24fc0769df2b3b0dd06b67437a341b74c74ecf	no	2
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	RCE002033030.pdf	1349933 4547be3575bc9b3983b1d0f26821034fa8e5f558	no	3
Warnings:					
Information:					
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4	Foreign Reference	EP0739085A2.pdf	673519 d4533de1727dbd82e43c96ae052782384a37dea5	no	13
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6	Foreign Reference	CN1412934A.pdf	722121 8bde71aa256761f409c9dd843dab975593773835	no	12
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Electronic Acknowledgement Receipt

EFS ID:	37582338
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	28-OCT-2019
Filing Date:	29-AUG-2018
Time Stamp:	17:12:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	QPIDS002033030.pdf	356138 5a57d2da3b51659ab8ae5e65b6c0820a6bd7df74	no	2

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(Not for submission under 37 CFR 1.99)

Application Number	16116279
Filing Date	2018-08-29
First Named Inventor	Changxing ZHOU
Art Unit	2837
Examiner Name	RO, BENTSU
Attorney Docket Number	00203.3030.00US

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	1	0739085	EP	A2	1996-10-23	SWITCHED RELUCTANCE DRIVES LTD		☐
	2	1275382	CN	C	2006-09-13	SWITCHED RELUCTANCE DRIVERS LT		☐
	3	1412934	CN	A	2003-04-23	YUEJIN ELECT TIANJIN ELECT		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16116279
	Filing Date	2018-08-29
	First Named Inventor	Changxing ZHOU
	Art Unit	2837
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16116279
	Filing Date	2018-08-29
	First Named Inventor	Changxing ZHOU
	Art Unit	2837
	Examiner Name	RO, BENTSU
	Attorney Docket Number	00203.3030.00US

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

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☒ 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	/Li Jiang/	Date (YYYY-MM-DD)	2019-10-28
Name/Print	Li Jiang	Registration Number	74191

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Bibliographic data: CN1412934 (A) — 2003-04-23

Switch reluctance machine control device

Inventor(s): ZHENG RUNCHE [CN] ± (RUNCHE ZHENG)

Applicant(s): YUEJIN ELECT TIANJIN ELECT [CN] ± (YUEJIN ELECTRONIC (TIANJIN) ELECTRIC EQUIPMENT CO. LTD, ; YUEJIN ELECTRONIC (TIANJIN) ELECTRIC EQUIPMENT CO., LTD)

Classification: - international: ***H02P6/00; H02P6/08;*** (IPC1-7): H02P6/00; H02P6/08
- cooperative:

Application number: CN20011036339 20011010

Priority number(s): CN20011036339 20011010

Also published as: CN1257604 (C)

Abstract of CN1412934 (A)

The switch reluctance machine control device is formed from AC power supply, commutating circuit, inverter consisting of triodes Q1 and Q2 and diodes D/and D2, drive portion of inverter, rotor detection portion, main control portion and voltage detection circuit. It is characterized by that said AC power supply is divided into two output channels, one of them is connected with first commutating circuit and another output is connected with transformer, said transformer is connected with second commutating circuit. The output end of commutating circuit is parallelly-connnected with a filter capacitor, and the commutated and filtered output voltage is connected with voltage detection circuit for detecting power voltage change, said voltage detection circuit formed from two series-connected divider resistors and low-pass filter consisting of resistor and capacitor is connected with main control portion.

[19] 中华人民共和国国家知识产权局

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H02P 6/08
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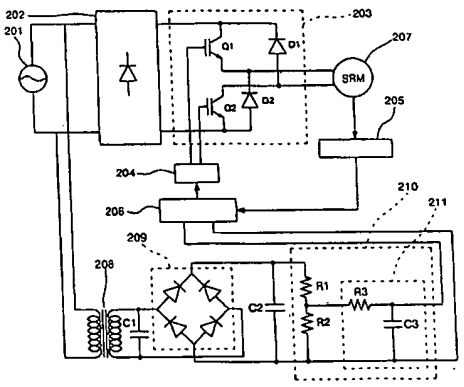
[74] 专利代理机构 天津三元专利事务所
代理人 胡婉明

权利要求书 1 页 说明书 6 页 附图 3 页

[54] 发明名称 开关式磁阻电机控制装置

[57] 摘要

本发明涉及一种当外部电源电压变化时，通过调整加到电机上的电压脉冲的接通时间进行电压补偿，从而使电机转动速度维持不变的开关式磁阻电机控制装置。它由交流电源、整流电路、由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器、逆变器的驱动部分、转子检测部分、主控制部分及电压检测电路组成。其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。电压检测电路是由两个串联的分压电阻 R1、R2 和电阻 R3 与电容 C3 构成的低通滤波器组成。该产品结构简单，成本低，新颖实用。



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1、一种开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。

2、根据权利要求 1 所述的开关式磁阻电机控制装置，其特征在于其中所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。

3、根据权利要求 2 所述的开关式磁阻电机控制装置，其特征在于其中所述的变压器次级两端接有浪涌电容 C1。

4、一种开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于整流电路输出端分成两路，一路接逆变器，另一路接检测电源电压变化的电压检测电路。

5、根据权利要求 4 所述的开关式磁阻电机控制装置，其特征在于其中所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与整流电路的输出端连接，输出端由电容 C2 接主控制部分。

6、根据权利要求 5 所述的开关式磁阻电机控制装置，其特征在于其中所述的分压电阻 R2 两端并联有滤波电容 C1。

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开关式磁阻电机控制装置

技术领域

本发明涉及一种电器领域的电机控制装置，特别是涉及一种当外部供电电源电压变化时，通过调整加到电 机上的电压脉冲的接通时间进行电压补偿,而使电机转动速度维持不变的开关式磁阻电机控制装置。

背景技术

目前， 现有的真空吸尘器等电器所用的电机控制装置，如图 1 所示，它由外部交流电源 101 输入的交流电压变换成直流电压加以输出的整流部分 102；将整流电路 102 输出的直流电压经 2 个晶体三极管 Q1、Q2 和 2 个二极管 D1、D2 构成的逆变器 103 变换成交流电压驱动开关式磁阻电机 107；用以驱动逆变器 103 的驱动部分 104；检测开关式磁阻电机 107 的转子的位置和速度的转子检测部分 105；接收转子检测部分 105 输出信号控制驱动部分 104 的主控制部分 106 构成。

在如此构成的电机控制装置中，交流电源 101 给整流电路 102 输入一交流电压,经整流电路 102 整流变换成直流电压提供给逆变器 103,逆变器 103 将整流电路输入的直流电压变换成适合驱动电机 107 的交流电压。当电机 107 被驱动后，转子检测部 分 105 将检测出 转子的转动速度，并传送到主控制部分 106，主控制部分 106 将转子检测部分 105 输入的检测信号，同设定的基准信号进行比较，把与此 相应的控制命令传送到逆变器驱动部分 104 去，那么逆变器驱动部分 104 将根据控制命令去控制电机 107 上所加的电压，从而控制电机的转动速度。

但是，在如上所述的电机控制装置中，为控制电机 107 的转动速度而加到电机 107 上的电压，通常是用 3 种接通方式去控制。当由外部供给的交流电源 101 的电压变化时，即使是用上述 3 种接通方式中的任意一个相同的运转方式,电机 107 的转动速度还是要变化的。即，当外部交流电源 101 的电压增加时，即使是相同的运转方式，电机的转动速度也要增加，随之逆变器 103 内部的开关元件三极管 Q1、Q2 的耐压极限点也要提高，因而存在有损坏开关元件三 极管 Q1、Q2 的隐患。而且，当外部交流电源 101 的电压下降时,即使是相同的运转方

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式，电机的转动速度也要降低，在这种情况下真空吸尘器的吸入力也要下降，因而得不到满意的吸尘效果。

由此可见，上述现有的电机控制装置存在有诸多的缺陷，而亟待加以改进。

有鉴于上述现有的电机控制装置存在的缺陷，本设计人基于从事此类产品设计制造多年，具有丰富的实务经验及专业知识，积极加以研究创新，以期创设一种新型结构的电机控制装置，能够改进传统现有常规电机控制装置的成型结构，使其更具有竞争性。经过不断的研究、设计，并经反复试作样品及改进后，终于创设出确具实用价值的本发明。

发明内容

本发明所要解决的主要技术问题在于，克服现有的电机控制装置存在的缺陷，而提供一种新型结构的开关式磁阻电机控制装置，使其当外部电源电压变化时，通过调节电机上所加电压脉冲的接通时间进行电压补偿，进而维持电机的转动速度不变。

本发明所要解决的另一技术问题在于，提供一种新型开关式磁阻电机控制装置，使其控制装置具有结构简单，且低成本的优良功效，而更加具有实用性，并能大大提高经济效益，从而在总体上具有增进的功效，且具有产业上的利用价值。

本发明解决其主要技术问题是采用以下技术方案来实现的。依据本发明提出的开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于交流电源分两路输出，一路接第 1 整流电路，另一路接变压器，变压器再与第 2 整流电路连接，整流电路输出端并联一滤波电容，经整流滤波后的输出电压接检测电源电压变化的电压检测电路，电压检测电路接主控制部分。

前所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。

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前所述的变压器次级两端接有浪涌电容 C1。

本发明解决其技术问题还可以采用以下技术措施来进一步实现。依据本发明提出的开关式磁阻电机控制装置，它包括有交流电源，将交流电源输入的交流电压整流滤波成直流电压的整流电路，由晶体三极管 Q1、Q2 和二极管 D1、D2 构成的逆变器，逆变器将整流电路输出的直流电压变换成交流电压驱动开关式磁阻电机，用以驱动逆变器的驱动部分，检测开关式磁阻电机的转子检测部分及接收转子检测部分检测信号的主控制部分，其特征在于整流电路输出端分成两路，一路接逆变器，另一路接检测电源电压变化的电压检测电路。

前所述的电压检测电路是由两部分构成，一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器，电压检测电路的输入端由电阻 R1、R2 分别与整流电路的输出端连接，输出端由电容 C2 接主控制部分。

前所述的分压电阻 R2 两端并联有滤波电容 C1。

本发明与现有技术相比具有明显的优点和有益效果。由以上技术方案可知，本发明在交流电源输出端增加一路整流电路和检测电源电压变化的电压检测电路或在原整流电路输出端加一检测电源电压变化的电压检测电路，检测由外部供给的电源电压的变化，并与此相应地改变电机上供给的电压脉冲的接通时间。因而具有在相同的运转方式上同外部电源的电压变化不相关，可以使电机的转动速度几乎维持不变的优点。该产品结构简单，成本底，可靠实用。

综上所述，本发明开关式磁阻电机控制装置，其在技术发展空间有限的领域中，不论在结构上或功能上皆有较大的改进，且在技术上有较大的进步，并产生了好用及实用的效果，而确实具有增进的功效，从而更加适于实用，诚为一新颖、进步、实用的新设计。

上述说明仅为本发明技术方案特征部份的概述，为使专业技术人员能够更清楚了解本发明的技术手段，并可依照说明书的内容予以实施，以下以本发明的较佳实施例并配合附图详细说明如后。

本发明的具体实施方式由以下实施例及其附图详细给出。

附图说明

图1是现有电机控制装置的电路原理图。

图2是本发明开关式磁阻电机控制装置的第一实施例电路原理图。

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图3是本发明开关式磁阻电机控制装置的第二实施例电路原理图。

具体实施方式

以下结合附图及较佳实施例，对依据本发明提出的其具体实施方式、结构、特征及其功效，详细说明如后。

101. 交流电源　102. 整流电路　103. 逆变器
104. 驱动部分　105. 转子检测部分　106. 主控制部分
107. 开关式磁阻电机
201. 交流电源　202. 第 1 整流电路　203. 逆变器
204. 驱动部分　205. 转子检测部分　206. 主控制部分
208. 变压器　209. 第 2 整流电路　210. 电压检测部分
211. 低通滤波器
301. 交流电源　302. 整流电路　303. 逆变器
304. 驱动部分　305. 转子检测部分　306. 主控制部分
307. 开关式磁阻电机　308. 电压检测部分　309. 低通滤波器

请参阅图 2 所示，本发明开关式磁阻电机控制装置的第 1 实施例具有如下部分：交流电源 201 的交流电压一路送将它变换成直流电压加以输出的第 1 整流电路 202；将由第 1 整流电路 202 来的直流电压变换成交流电压供给开关式磁阻电机用的逆变器 203；用以驱动此逆变器 203 的逆变器驱动部分 204；检测开关式磁阻电机 207 转子的转动速度的转子检测部分 205；接收转子检测部分 205 来的检测信号，再将控制信号送至逆变器驱动部分 204 的主控制部分 206；交流电源 201 的交流电压另一路接变压器 208；变压器 208 次级接第 2 整流电路 209；整流电路 209 接检测电源电压变化的电压检测部分 210。

电压检测部分 210 由两部分构成：一部分是两个串联的分压电阻 R1、R2，另一部分是电阻 R3 与电容 C3 构成的低通滤波器 211，电压检测电路的输入端由电阻 R1、R2 分别与滤波电容 C2 连接，输出端由电容 C3 接主控制部分。接在变压器次级上的电容 C1 是用以消除变压器 208 感应电压中混入的浪涌成分。电容 C2 是用以消除第 2 整流电路输出的直流电压中脉冲成分的滤波电容。

第 1 整流电路 202 是将交流电源 201 输入的交流电压变换成直流电压加以输出。逆变器 203 是将第 1 整流电路 202 输出的直流电压变换成适合驱动开关式磁阻电机的交流电压加以输出。随后，若开关式磁

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阻电机被驱动，转子检测部分 205 就检测转子的转动速度，传送到主控制部分 206，主控制部分 206 则接收由转子检测部分 205 来 的检测信号，同设定的基准信号加以比较后，将与此相应的控制命令传送给逆变器驱动部分 204。那么，逆变器驱动部分 204 将按照控制命令控制开关式磁阻电机 207 上所加的电压，其结果就能控制开关式磁阻电机 207 的转动速度。

而且，变压器 208 是将交流电源 201 输入的交流电压按照初、次级的线圈匝数比，变换成所需的交流电压，第 2 整流电路 209 将变压器次级输出的电压变换成直流电压输出给电压检测部分 210，电压检测部分的电阻 R1、R2 按比例加以分压，主控制部分 206 则是输入分压电阻 R2 上的电压，用以检测电压的变化。

在上所述的工作过程中，当交流电源 201 供 给的交流电压变化时，变压器 208 的次级电压及第 2 整流电路 209 的输出电压也将随之变化。其结果，在电压检测部分 210 的电阻 R2 上的电压也将变化，这些变化立即被主控制部分 206 检测到。就是，主控制部分 206 立即就可以知道由外部供给的电压的变化状态。因此，主控制部分 206 将其电压变化量与在相同运转方式上已经设定的电压值加以比较，当外部供给的电压比设定的电压值要高时，就要控制逆变器驱动部分 204，相应地缩短供给开关式磁阻电机 207 的电压脉冲的接通时间，而当外部供给的电压比设定的电压值低时，就要控制逆变器驱动部分 204，相应地延长供给开关式磁阻电机 207 的电压脉冲的接通时间。因此在相同的运转方式上，同外部电源的电源变化不相关联，可以使开关式磁阻电机维持几乎不变转动速度。

请参阅图 3 所示，是本发明开关式磁阻电机控制装置的第 2 实施例具有如下部分：输入由外部交流电源 301 来的交流电压，将它转变成直流电压加以输出的整流电路 302；将整流电路 302 输出的直流电压变换成交流电压供给开关式磁阻电机 307 用的逆变器 303；用以驱动此逆变器的逆变器驱动部分 304；检测开关式磁阻电机 307 转子转动速度的转子检测部分 305；接收转子检测部分 305 的检测信号，再将控制信号送至逆变器驱动部分 304 的主控制部分 206；以及，接整流电路 302 输出端检测电源电压变化的电压检测部分 308。

电压检测部分 308 由两部分构成：一部分是两个串联的分压电阻

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R1、R2，另一部分是电阻 R3 与电容 C2 构成的低通滤波器 309，电压检测电路的输入端由电阻 R1、R2 分别与整流电路 302 输出端连接，输出端由电容 C2 接主控制部分。接在分压电阻 R2 上的电容 C1 是用以消除直流电压中混入的脉冲成分的滤波电容。

如上所述第 2 实施例的工作原理和连接关系与第 1 实施例相同。因此，省略第 2 实施例的说明。

第 2 实施例的情况与第 1 实施例的情况，在其基本构成上没有大的差异，只是，在第 1 实施例的情况下，其构成是外部的交流电源 201 的电压变化，要经过另外的变压器 208 和第 2 整流电路 209，在电压检测部分 210 上检测的。而在第 2 实施例的情况下，交流电源 301 的电压是经过整流电路 302 输出的，而在整流电路 302 的输出端上正好设置电压检测部分 308，以此检测外部交流电源 301 的电压变化，这样的构成就是特征上的差异。还有，在第 2 实施例的情况下，外部交流电源 301 的输入电压经过整流电路 302 后的输出电压直接施加到后面，因而它将处理比第 1 实施例更大的电压，同时对相关电路元件的影响也就比第 1 实施例的情况更大，但是整体上的电路构成却要比第 1 实施例简单。

以上所述，仅是本发明的较佳实施例而已，并非对本发明作任何形式上的限制，凡是依据本发明的技术实质对以上实施例所作的任何简单修改、等同变化与修饰，均仍属于本发明技术方案的范围内。

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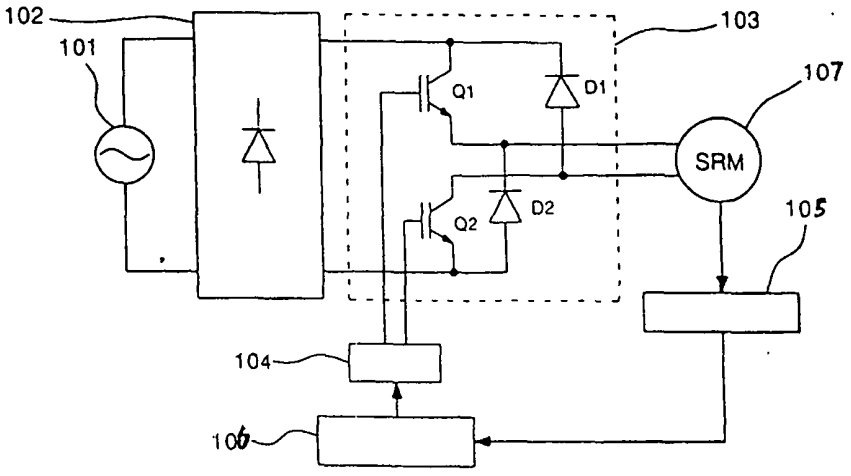


图1

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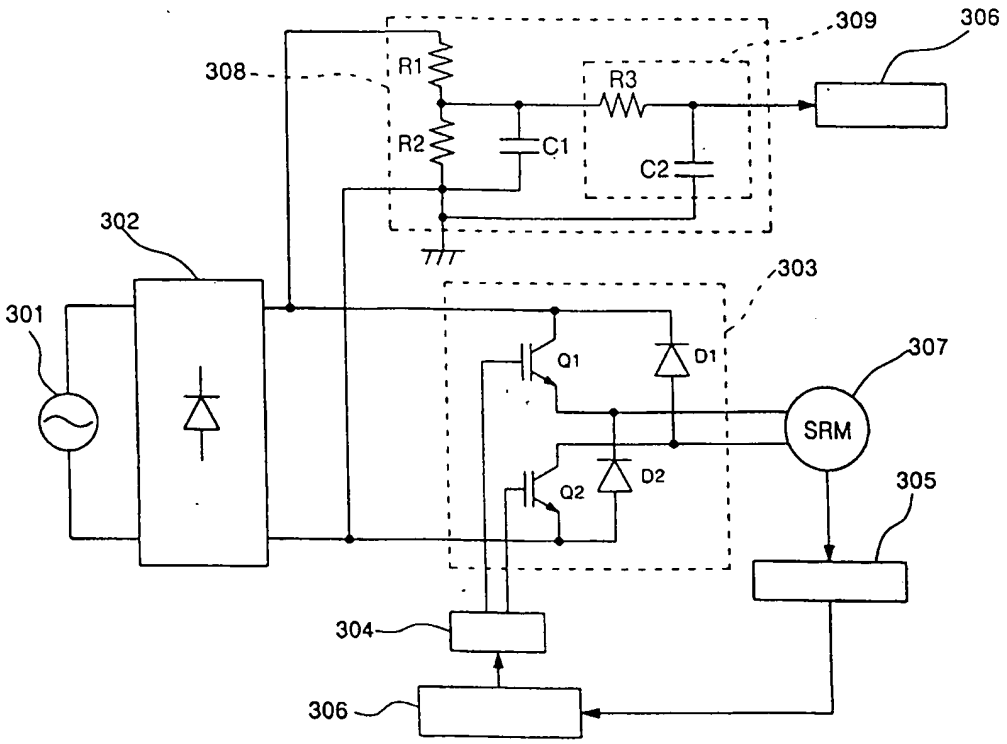


图3

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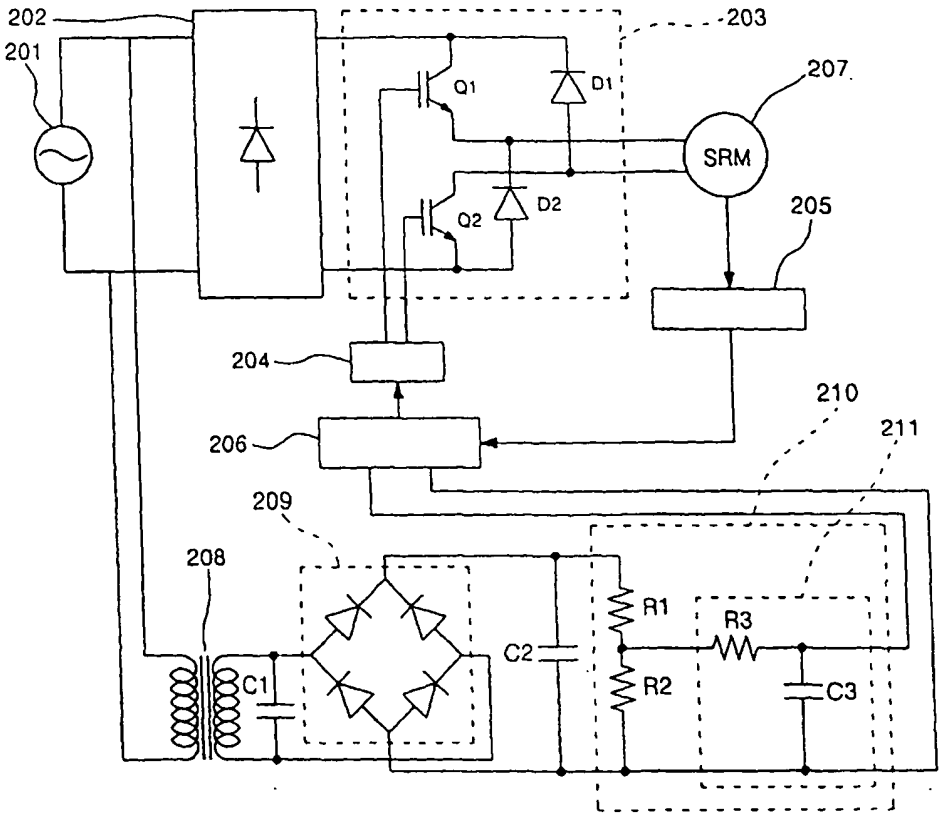


图2

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Espacenet

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Variable voltage compensation

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Applicant(s):	SWITCHED RELUCTANCE DRIVERS LT [GB] + (SWITCHED RELUCTANCE DRIVERS LTD)
Classification:	- international: ***H02P25/08; H02P6/00*** - cooperative: H02P25/08 (EP); Y10S388/902 (EP)
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Priority number(s):	GB20010005502 20010306
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Abstract not available for CN1275382 (C)
Abstract of corresponding document: EP1239581 (A2)

A switched reluctance drive is supplied from a voltage source which varies from the voltage at which the control laws for the drive were determined. The control system compensates for this by modifying both the speed and torque values used to determine the correct firing angles for the demanded load. The system works over a very wide range of voltage variation and is independent of the shape of the torque / speed curve of the drive.

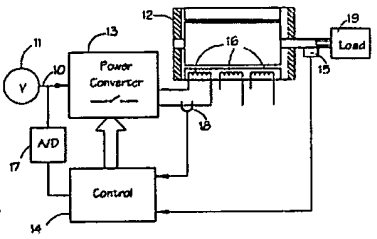


Fig 5

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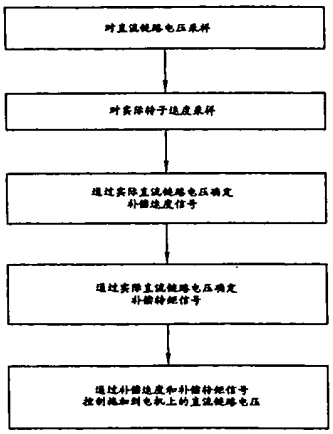
权利要求书 3 页 说明书 8 页 附图 4 页

[54] 发明名称

电力驱动中的可变电压补偿方法和系统

[57] 摘要

本发明涉及可变电压补偿，其中一开关磁阻驱动器由一电压源供电，该电压源与确定的用于驱动器控制规则的电压不同。控制系统通过同时对速度和转矩值进行修正来对上述不同进行补偿，其中速度和转矩值被用来确定驱动所要求的负载的正确触发角。该系统可工作于出现有较宽电压变化范围的环境中并与驱动器的转矩/速度曲线的形状无关。



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1.一种在电力驱动系统中对实际直流链路电压与一参考直流链路电压的偏差进行补偿的方法，所述的电力驱动系统包括一电机控制器，其根据转矩需求信号控制电机，所述的电机包括一转子和一带有绕组的定子，在该电机工作的过程中，转子以实际转子速度旋转，其中电机控制器有选择地将实际直流链路电压加到定子绕组中，该方法包括步骤：

对所述的实际直流链路电压进行采样；

对所述的实际转子速度进行采样；

根据实际直流链路电压确定补偿速度信号；

根据实际直流链路电压确定补偿转矩需求信号；以及

根据所得到的补偿速度和补偿转矩需求信号对施加在定子绕组上的实际直流链路电压进行控制。

2.如权利要求1所述的方法，其特征在于所述的确定补偿速度信号的步骤包括产生一速度补偿因子和通过该速度补偿因子对实际转子速度进行修正的步骤。

3.如权利要求2所述的方法，其特征在于所述的速度补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

4.如前述权利要求中的任一项所述的方法，其特征在于所述的确定补偿转矩需求信号的步骤包括产生一转矩补偿因子和通过该转矩补偿因子对转矩需求信号进行修正的步骤。

5.如权利要求4所述的方法，其特征在于所述的转矩补偿因子对应于参考直流链路电压与实际直流链路电压之间的比率。

6.如权利要求4所述的方法，其特征在于所述的转矩补偿因子取决于在实际转子速度下所允许的最大转矩需求和在对应于补偿速度信号的速度下所允许的最大转矩需求之间的比率。

7.如权利要求6所述的方法，其特征在于作为速度函数的电机的转矩需求值被存储在一控制规则表中，该控制规则表包括多个位置，

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表中的每个位置对应于预先确定的转矩需求值，其中所述的通过转矩补偿因子对转矩需求信号进行修正的步骤被通过转矩补偿因子对转矩需求信号的控制表位置进行修正的步骤所代替，由此确定在对应于补偿速度信号的速度下的补偿转矩需求值的控制表位置。

8.一种在电力驱动系统中对实际直流链路电压与一参考直流链路电压的偏差进行补偿的系统，所述的电力驱动系统包括一电机控制器，其根据转矩需求信号控制电机，所述的电机包括一转子和一带有绕组的定子，在电机的工作过程中，转子以实际转子速度旋转，其中电机控制器有选择地将实际直流链路电压加到定子绕组中，该系统包括：

用于对所述的实际直流链路电压进行采样的装置；

用于对所述的实际转子速度进行采样的装置；

根据所述的实际直流链路电压确定补偿速度信号的装置；

根据所述的实际直流链路电压确定补偿转矩需求信号的装置；

用于将所述的补偿速度信号和所述的补偿转矩需求信号发送到电机控制器的装置；和

使用所述的补偿速度信号和补偿转矩需求信号控制施加于定子绕组上的实际直流链路电压的装置。

9.如权利要求 8 所述的系统，其特征在于所述的确定补偿速度信号的装置包括产生一速度补偿因子的装置和通过所述的速度补偿因子对实际转子速度进行修正的装置。

10.如权利要求 9 所述的系统，其特征在于所述的速度补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

11.如权利要求 8－10 中任一项所述的系统，其特征在于所述的确定补偿转矩需求信号的装置包括产生一转矩补偿因子并通过该转矩补偿因子对转矩需求信号进行修正的装置。

12.如权利要求 11 所述的系统，其特征在于所述的转矩补偿因子对应于参考直流链路电压和实际直流链路电压之间的比率。

13.如权利要求 11 所述的系统，其特征在于所述的转矩补偿因子

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取决于在实际转子速度下的最大转矩需求和在对应于补偿速度信号的速度下的最大转矩需求之间的比率。

14.如权利要求 13 所述的系统，其特征在于还包括将作为速度的函数的电机的转矩需求值存储在一控制规则表中的装置，该控制规则表包括多个位置，表中的每个位置对应于预先设定的转矩需求值，其中所述的通过转矩补偿因子对转矩需求信号进行修正的装置可由通过转矩补偿因子对转矩需求信号的控制表位置进行修正来代替，由此在对应于补偿速度信号的速度下确定补偿转矩需求值的控制表位置。

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电力驱动中的可变电压补偿方法和系统

技术领域

本发明一般涉及电力驱动系统中的直流链路电压偏差的补偿方法和装置．特别的，本发明涉及开关磁阻驱动器的运行方式，该开关磁阻驱动器能周期地读取与某一直流链路电压相对应的一个值，调节一速度指示信号用于补偿在直流链路中出现的电压变化．补偿速度信号被送至一控制器中，在该控制器中，对开关磁阻驱动器线圈中的能量变化做补偿．

背景技术

有关开关磁阻电机的设计和操作方面的理论已广为人知并多有论述，例如，在文章“开关磁阻电动机和驱动器的特点、设计和应用”，作者是Stephenson和Blake，于1993年6月21－24日，在德国Nuremberg举行的PCIM 93年年会及展览会上进行了公开，在此引述;作为参考．下文对开关磁阻驱动控制器的常用结构和操作的理解和描述仅是出于本发明背景技术需要之目的．

开关磁阻电动机在电动机的活动部分(称转子)一般没有绕组或永磁铁．大多数开关磁阻电动机的静止部分(称定子)包括在定子的磁极上缠绕的线圈，其中通有单向电流．在其中一种类型的开关磁阻电动机中，绕在相对定子磁极上的线圈以串联或并联的方式连接以形成实际上是多相的开关磁阻电动机的单向绕组．按事先确定的，即与转子角位置相同步的顺序，对每项绕组加电压产生运动力矩，这样当定子和转子的磁极相接近时就能产生相互吸引的电磁力．同样的，当定子和转子的磁极分开时的周期的某段时间里设置脉冲电压，也可产生作用力．在典型的操作方式中，每次当开关磁阻电机相绕组被激励时，通过相绕组产生磁通量，从而在转子磁极上产生引力．

图 1 示意性地示出了现有技术中一典型的驱动装置，用于驱动负载

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19。其中包括一直流电源 11，可以是电池或是整流并滤波的交流电源。电源 11 经一直流链路，以线 10 所示，输出直流电压。电源转换器 13 在电子控制单元 14 的控制下在电动机 12 的相绕组 16 之间进行切换。电流传感器 18 用于向控制器提供电流反馈信号。在本申请中，向开关磁阻电机中输出的直流电压(或来自一电池，整流器或其它)被称为“直流链路电压”。

为保证驱动器正常工作，切换应与转子的旋转角准确地保持同步。开关磁阻电机的性能在一定程度上取决于与转子位置相关的相激励的精确定时。对转子位置的检测通常通过传感器 15 获得，如图 1 所示，例如通过安装在电机转子上的旋转齿状盘，与安装在定子上的光学传感器或磁性传感器相配合。产生能指示出转子相对于定子的位置的脉冲序列并将其输出给控制电路 14，用于产生精确的相激励。

为维持开关磁阻电机产生的速度和相关转矩，有必要精确控制电压作用在相绕组上的时刻。然而，在交流电压输出中出现的变化以及在驱动系统工作的电力环境中出现的变化，都会造成直流链路电压随时间的变化而变化。由于电源电压的明显变化，因此以忽略电源电压变化的控制方法可明显减弱用户所要求的对电机的控制能力。这是因为，由相绕组产生的磁通量直接与所施加的电压有关。因此，电源电压中的变化就可导致相绕组产生的磁通量多于或少于所希望得到的磁通量。电动机中，磁通量的这种不希望的变化会导致性能的降低。

在众所周知的开关磁阻驱动器中，电动机的速度，所需的转矩和在对相绕组加电压的时间之间的相互关系可通过一被称为是特性化的处理过程凭经验确定，其中，电动机的操作参数是在很宽的工作条件下确定。之后，这些操作参数被存储在一个被称为控制规则表的模拟或数字电路中。

典型地，数字控制规则表只是某种类型存储器中的一系列存储位置，其中每个存储对应于控制图上的一个点。对于此点，典型系统存储有适用于该工作点的启动角、关闭角和可能的自由旋转角。这些参数可存储在表中的相邻位置上。或者，该表可进一步划分并被认为是由一系列的

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子表组成，每个子表中的值对应于其中一个参数。

控制规则表的一个例子如图 2 所示。在这个例子中，转矩在任意速度上被离散成 128 个值，即，在任一个选定的速度上，该速度的 100%的转矩对应于第 128 个存储位置，50%的转矩对应于第 64 个存储位置，等等。类似的，该速度也被离散，在本例子中，速度被离散为 256 个值。表中的每个位置上存储了用于使电机产生相应速度和转矩的控制的多个参数 A。如上所述，参数 A 中的每个或是一系列控制参数或是单个的控制参数，并且表中的每个位置还包含有一可指向其他表格的指针，用于搜寻其他的参数。也可以使用在现有技术中已知的用于存储数据的其他方法，如 16x16 位置的稀疏矩阵以及一些用于实时确定适当参数值的插值方法。

图 3 和图 4 是对应于控制规则表的控制图的例子。其中，水平轴代表速度值，最大到 256 个单位，该值是驱动器所能达到的最大速度。实线代表在任意速度上可得到的最大转矩值。图上任意一点对应于控制规则表上的一个位置，在该位置中，包含有在该点操作所需的参数。图 3 的例子示出了一个具有相对恒定转矩输出的系统，而图 4 的例子示出了转矩输出随速度明显变化的系统。

在驱动器工作过程中，控制系统向控制规则表输入表征电动机速度的信号和所需要的转矩，以寻找出适合此操作状态的触发角。这些触发角用于对切换进行控制，进而实现对相绕组激励的控制。采用具有控制规则表的电动机控制器已被广泛熟知，在此不再详细描述。

为最小化特性化的处理过程的工作量，通常的做法是在该过程中保持直流链路电压恒定。考虑到当把驱动系统安装于一工作环境中时，直流链路电压的变化较有代表性，因此，特性化常是在假设直流电压处于最低期望值时获得的。换句话说，特性化是在假设直流链路电压工作在最差的情况下获得的。这种类型的特性化在一定程度上是不合乎需要的，因为其是在假定最坏的场合下(而这种假定场合是很少发生的)而不是在所需要的最佳直流链路值的情况下做出的对开关磁阻驱动器的特性化，而驱动效率在所需最佳链路值的情况下将达到最高。此外，工作电压的增

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加会导致所得转矩和电流的增加，从而导致驱动器的零部件过热或失效。对于有些驱动器，可在其处于最佳直流链路电压时进行特性化，但对于此类驱动器，必须在运转过程中对直流链路电压发生的变化给予补偿，否则驱动器性能会减弱，特别是在低电源电压情况下。

一些开关磁阻驱动器使用模拟系统对直流链路电压的变化进行补偿。总的来说，这些系统是通过调节输入到控制规则表中的速度信号来对直流链路电压变化进行补偿的，因此输入到控制器中的速度信号不是电动机的实际速度而是由代表直流链路电压的一个信号对实际速度信号进行修正而得到的一个修正速度信号。有些驱动装置采用一些数字方法对电压变化进行补偿。例如，在美国专利 US 5724477 (Webster 等)中(其已转让给本申请人，在此引述作为参考)，公开了一种直流链路补偿方法，其通过一模数转换器 ADC 对直流链路电压进行数字采样来检测电压的变化。

图 5 是 Webster 提出的开关磁阻驱动器的模型，其中通过 ADC17 对直流链路电压进行采样，采样电压反馈给控制中 14，在控制器 14 中，特性化电压与测量的工作电压之间的比率用于修正实际转子速度以产生一补偿速度参数，用此补偿速度参数对控制规则表进行询问，这意味着与所测得的直流链路电压 10 相反地调节补偿速度信号。举例来说，直流链路电压的增加会得到一较小的估计补偿速度信号，而当直流链路电压降低时则会得到一较大的估计补偿速度信号。补偿速度信号进而被控制器 14 使用，作为控制规则表的索引并用于选择适当的触发角。

作为 Webster 所提方法的一个应用实例，假设特性化的处理过程是在直流链路电压为 560V 时完成的，并且驱动器一直以 227 单位表示的速度工作在 538V 电压上，之后对速度信号进行线形换算，[即(560/538)×227]，获得 236 单位的补偿速度。该补偿速度用于询问控制规则表以获得何种转矩水平是所需的。在这个例子中，电压变化相对较小，(大约是 4%的特性化电压)。如果转矩/速度曲线在工作区内相对平坦，如图 3 所示，综合这些因素可知，实际速度和补偿速度之间的转矩变化也小。举例来说，如果所需转矩为 80%(那么使用存储位置为 80/100×128=102 中的触

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发角)，在该补偿速度上的存储位置 102 中触发角所对应的转矩值将非常接近于 80%，以致于其之间的差距可以忽略不计。相比之下，如果转矩速度曲线的斜率大，如图 4 所示，则在该补偿速度对应于存储位置中的转矩值会极大地区别于未补偿速度时的转矩值。图 4 示出了在电压变化40%时在转矩上出现的误差。这使得现有技术中补偿方法在很多场合下是不适合的。

以上所描述的系统在有限范围的电压变化情况下能正常工作取决于转矩/速度曲线的形状，但当遇到电压的广泛变化时，上述系统不能给出好的性能。此类情形常尤其出现在那些不能与公共设施相连的系统但电压变化又常超过 50%的系统中，如航空，海运或机动环境。尽管，这些变化可以通过对系统在不同电压值时进行特性化处理来局部改善，但这个方法耗时，需要控制系统有相当大的存储空间，使得读取控制规则表更困难，最多只能对特定电压进行精确补偿。

发明内容

对于这些已知补偿系统的缺点，需要设计出一精确，适用于大范围的直流链路电压并且相对经济的直流链路电压补偿系统。

随附的独立权利要求是对本发明的限定。从属权利要求是对本发明的其他一些优选特征的描述。

附图说明

以下结合附图对本发明具体实施例中出现的各种方法进行描述，其中：

图 1 是已知开关磁阻电机的方框图；

图 2 是一控制规则表的例子；

图 3 是当系统的转矩恒定或接近恒定时的转矩/速度图；

图 4 是当系统的转矩随速度明显变化时的转矩/速度图；

图 5 是带有直流链路电压补偿装置的已知开关磁阻电机的方框图；

图 6 示出了电压补偿过程的步骤。

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具体实施方式

附图 5 的装置用于实现电压补偿的改进方法。示出了一开关磁阻电机 12，用于驱动负载 19。电压源 11 给驱动器供电，其可以是一直流电源，也可以是整流交流电源。直流链路以连线 10 代表，并通过切换装置 13 切换到在开关磁阻电机 12 的相绕组 16，控制器 14 确定转换装置 13 上的触发角。还包括一转子位置传感器 15(RPT)，响应于通过随开关磁阻电机 12 的转子一同旋转的一个元件，用于产生代表转子位置的转子位置传感器输出信号。可知，位置信息可以通过各种方法得到，如采用对电动机的电流、电压和/或电感进行估计该信息的软件算法。相绕组中的电流一传统类型的电流传感器 18 测得，并输出适当的信号给控制系统 14。

与直流链路电压相连的是一模拟数字转换器(ADC)17，其对直流链路电压 10 采样，之后将采信号转化为能代表直流链路电压的电压幅度的数字输出。ADC 将该数据输入到控制系统 14。在一实施例中，ADC 输出包括 8 个数据比特，可代表 256 不同电压值。

通过在给定时间周期内监测转子位置的变化，可以确定电机 12 的速度。控制器 14 接收转子位置传感器输出信号并产生对应于转子实际旋转速度的实际速度信号。这种速度测量块的结构对领域的技术人员是显而易见的，并取决于特定转子位置传感器的选择。电动机控制领域的技术人员知道实际速度信号可以传统方式用于电动机控制的其它方面(在此不做详述)。

在控制器 14 中有一数字微控制器，其可以是一个来自 Motorola 的 MC68HC11 系列的微控制器，用于实现该改进的直流链路电压补偿方法。同样的微控制器可用于实现电动机控制器 14 的其它控制功能。这样做的优点在于对直流链路电压的补偿的同时，无须明显增加实现电动机控制器 14 所需的额外电路。

电动机的控制通过一补偿速度信号和一改进的换算方法来完成，该补偿速度信号用于确定来自一控制规则表的电机操作参数，而该改进的换算方法包括将换算速度以确定补偿速度并在该补偿速度下换算转矩以

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恢复原来所需的转矩。有大量的方法可以用来实现这一目的。所有这些方法中，第一个步骤是使用 ADC17 周期地读取代表直流链路电压的信号和实际转子速度。每个读入值被转换为数字表达形式用于随后的处理过程。在实际工作中，在一预先设定的时间周期内，对直流链路电压和转子速度中的每个进行多次检测然后取其在该时间段中的均值。采取这种方式，系统不会对测量电压或转子速度中出现的较小波动而对于敏感。

在第一个例子中，速度和转矩均可通过下面的比率进行换算:

$$Vc/Va$$

其中 Vc 是特性化电压，Va 是通过 ADC17 采样获得的实际工作电压。

为实现这一方法，微处理器中的软件计算 Vc/Va 的比率，然后将计算结果与实际速度信号和实际转矩需求相乘，获得补偿速度和补偿转矩值。之后，这些补偿值被用来对控制规则表进行询问以确定操作参数。一旦该步骤完成，这些选定的操作参数将有选择地用将直流链路电压加到定子绕组中。该简化的方法在很多场合下都很有效，并特别适合于具有恒定电源特性的驱动器中。

当转矩/速度曲线具有特殊形状时，上述描述的第一方法将不适用。为了在此种情况下获得良好的性能，应对用作索引控制规则表的转矩值进行重新设定以使重新设定的值更接近于没有补偿速度时的实际转矩需求。在实际操作中，这一步骤是通过重新定义控制规则表中转矩值的位来实现的，即，使重新定义的转矩值位置上的转矩值更接近于在未有补偿速度时的转矩需求。这一做法的优点在于，不论驱动器的转矩/速度曲线的形状如何，都能得到正确的补偿。应当注意，补偿速度采取与第一个例子相同的计算方法，即用实际速度乘以 Vc/Va。

然而，该方法需要知道在每个速度时刻上代表 100%转矩需求的转矩绝对值。该信息可以附加线的形式存储在控制规则表中或采用其它适宜存储的方法存储。这允许要选择的补偿速度值处的转矩位置数大致对应于工作在实际速度时的转矩需求的绝对值。在实际工作中，转矩需求值在控制规则表中是线性分布的，因此补偿速度所对应的位置数可通过下式给出:

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Lc=|Lu*TMu/TMc|

其中，Lc是对应于补偿速度上的补偿转矩需求的位置数，

Lu是对应于未补偿速度上的实际转矩需求的位置数，

TMu是在未补偿速度时的最大转矩需求，

TMc是在补偿速度时的最大转矩需求。

补偿速度和转矩需求值进而被用于对控制规则表进行询问，以确定所需的操作参数。一旦获得操作参数，这些操作参数将有选择地用于将直流链路电压加到定子绕组中。

在以上两个例子中，控制器在考虑到所需转矩水平的情况下，采用了一种新的方法来选择用于补偿直流链路电压变化时所需的正确操作参数。该方法通过一补偿转矩值和一补偿速度值来实现以提供对直流链路电压中出现的波动进行补偿的改进方法。这是有利的。

总的来说，系统进行特性化所选的电压可在系统工作范围内任何地点进行选择。但应当知道，当实际工作电压高于特性化电压时，补偿速度总是低于实际速度(参考附图 4)。同样的，如果工作电压低于特性化电压，补偿速度将高于实际速度。在这种情况下，当实际速度接近于最大工作速度时，有可能不会有足够的数据可以利用来得到补偿速度值，这取决于特性化电压和工作电压之差。除非，在实际操作中，有其它额外的数据能被用来获得超过最大速度的补偿速度值，否则最大补偿速度值应限于最大速度。因此，优选地，驱动器应工作在最低工作电压上，这样，补偿速度就不会超过实际速度，从而避免了没有足够特性化数据使用的情形出现。

在不脱离本发明的情况下，有经验的人员应当知道对本发明公开的内容所做的改变有多种方法。因此，通过举例的方法而对本发明几个实施例的描述不以限制本发明为目的。有经验的技术人员在对上述描述的方法不做明显改变的情况下，可以很容易地对本发明步骤做些小的修改。本发明仅以下述权利要求范围为限。

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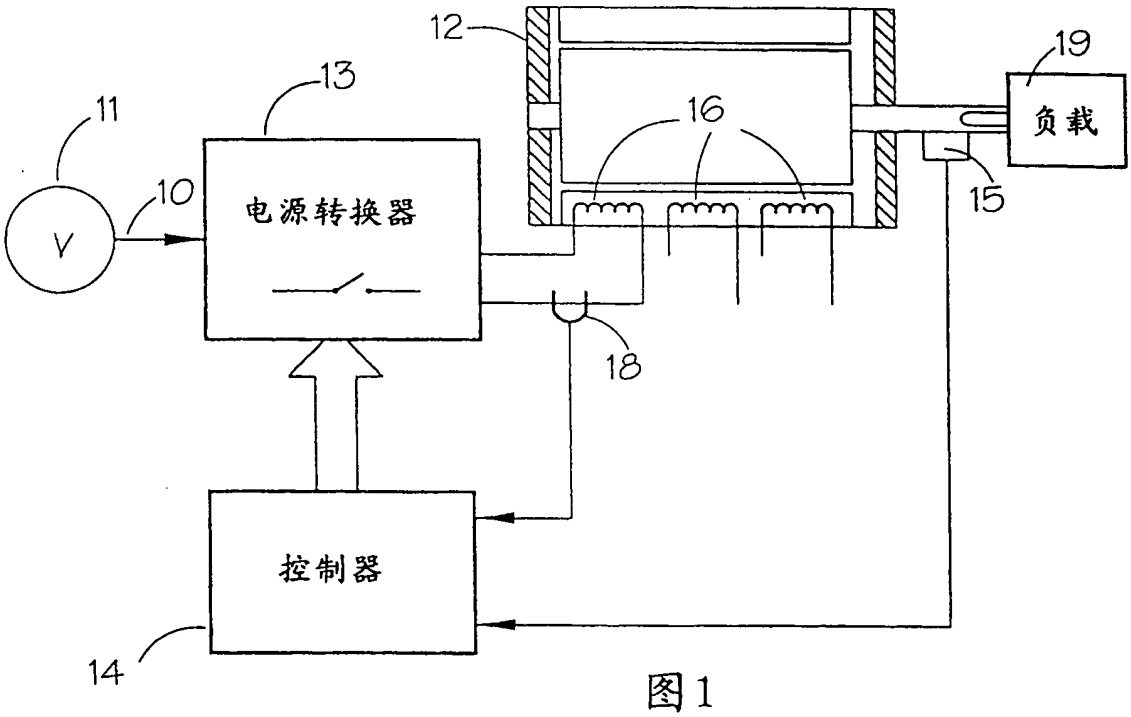


图1

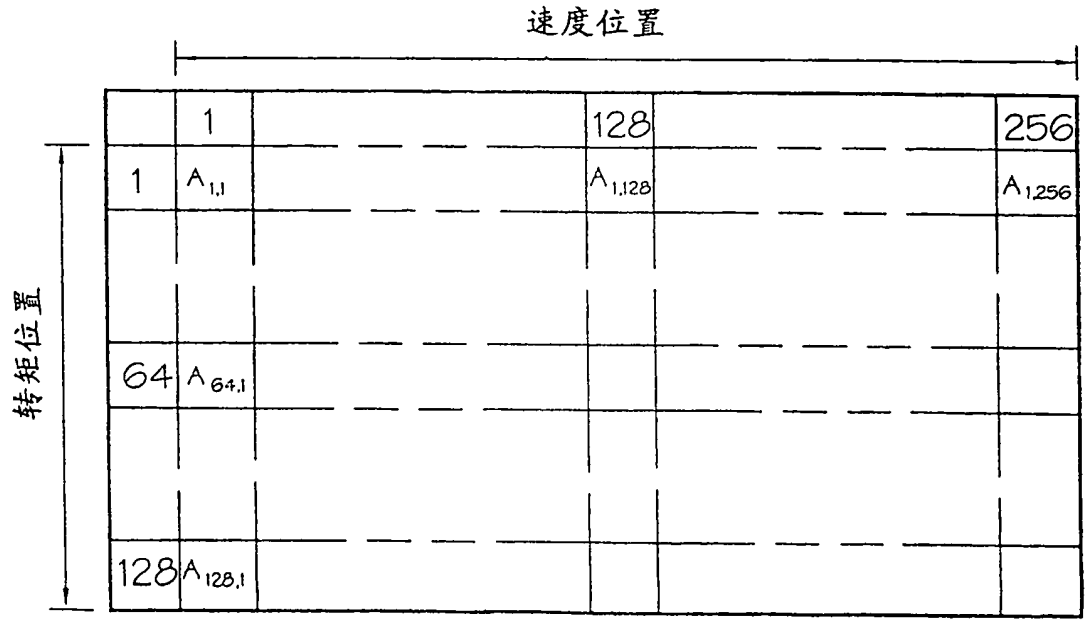


图2

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图3

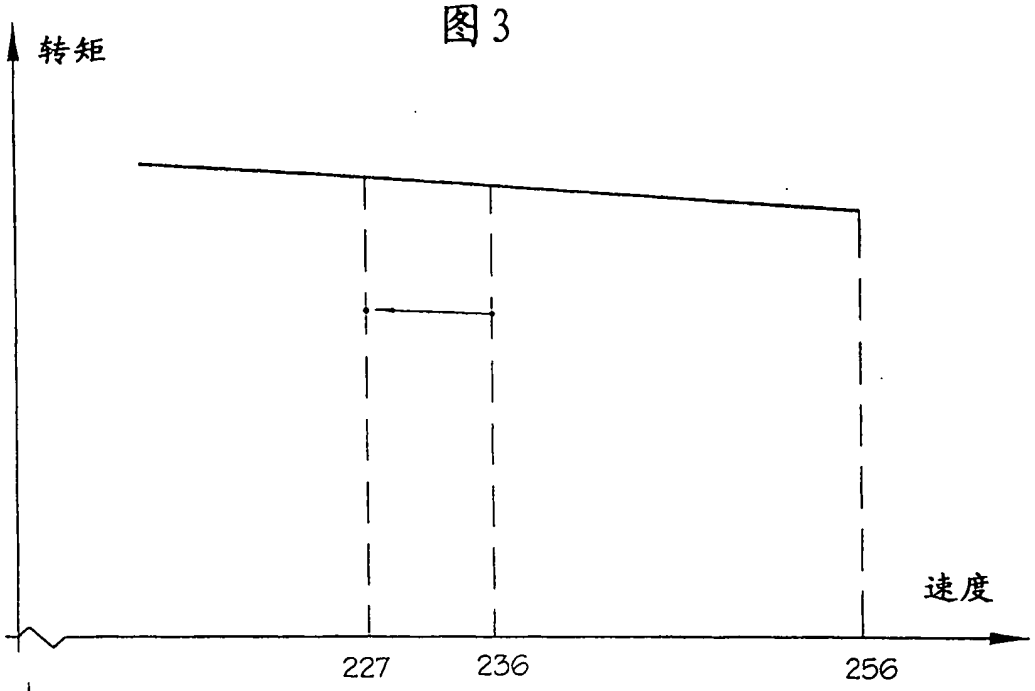
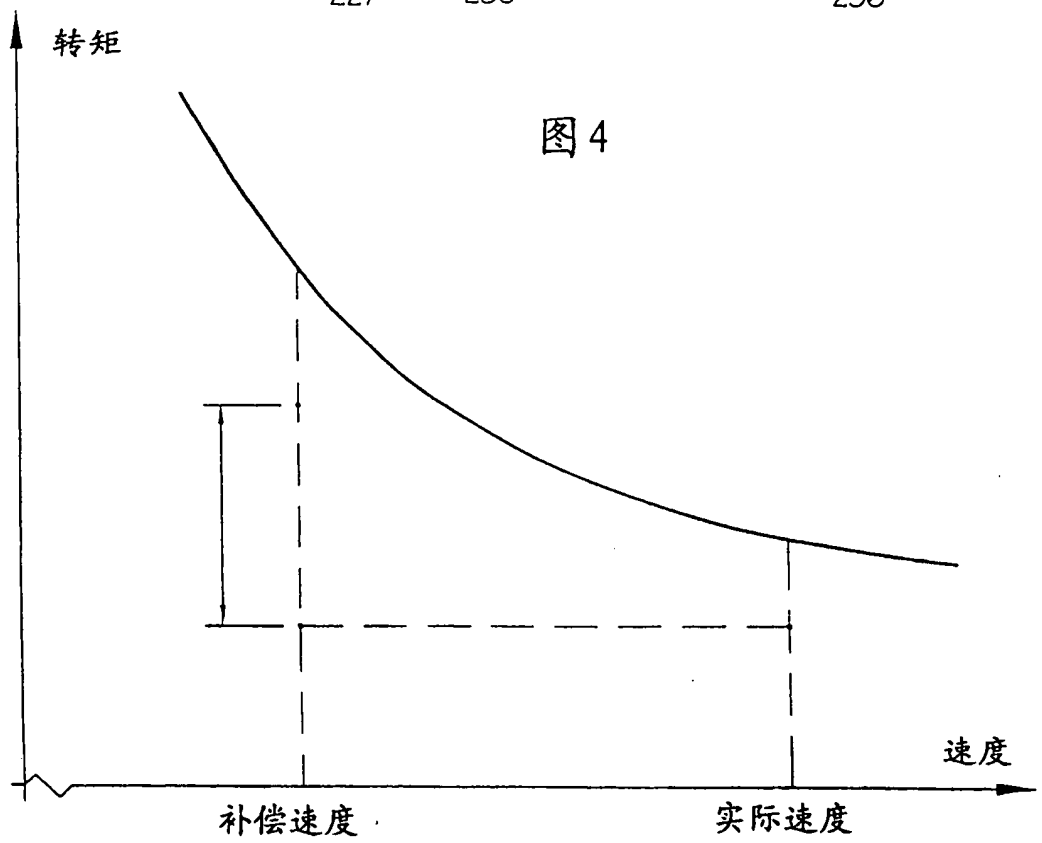


图4



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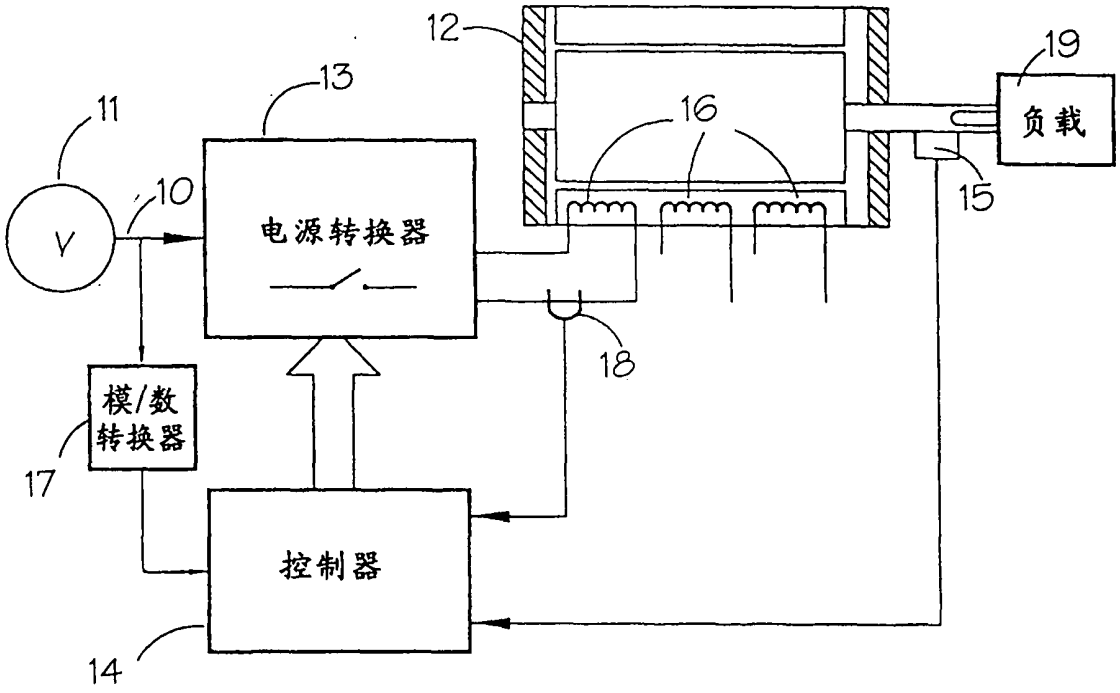


图5

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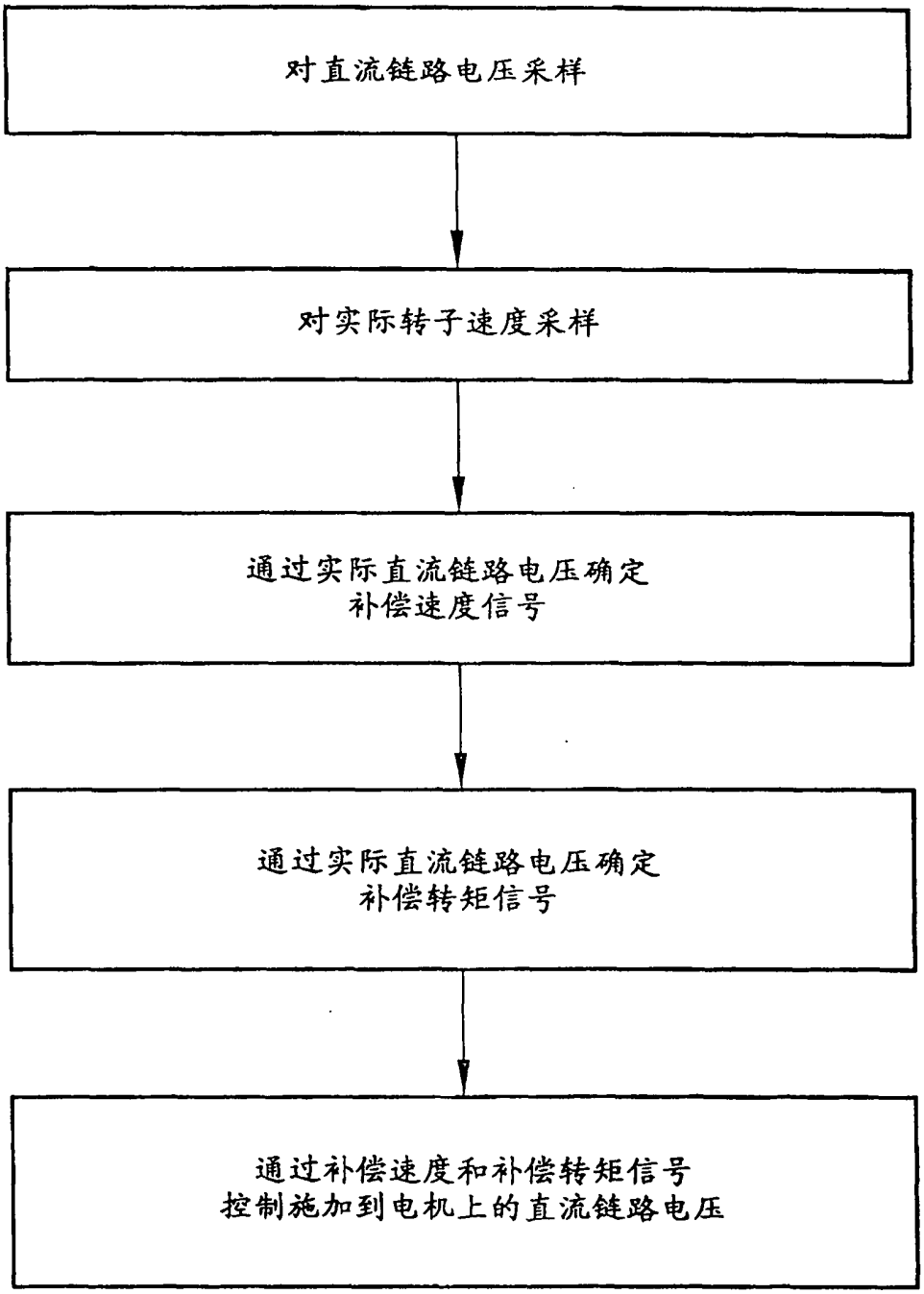


图6

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(54) Compensation for input voltage variation in an electric motor drive

(57) The present invention employs digital circuitry to compensate for variations in DC link voltage transmitted to a switched reluctance machine. The digital voltage compensation system of the present invention periodically samples the DC link voltage and actual rotor speed, then supplies the samples in digital form to a microcontroller that derives a compensated speed signal to compensate for changes in DC link voltage.

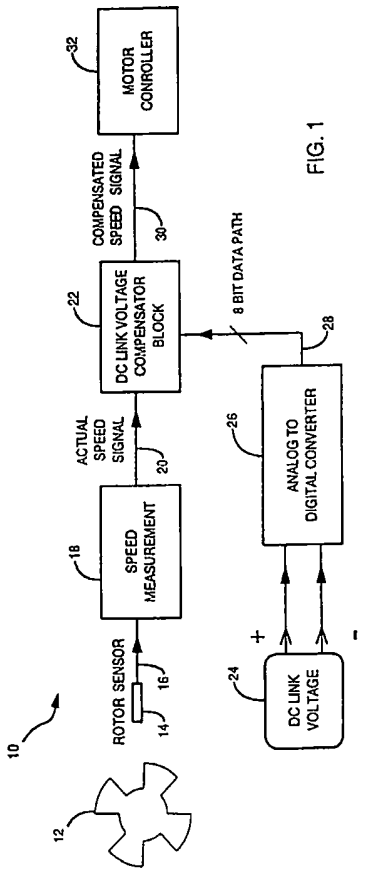


FIG. 1

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Description

The present invention generally relates to an apparatus and method of compensating for DC link voltage variations in an electric motor system. More particularly, the present invention relates to digital circuitry and a method for operating a switched reluctance drive that periodically reads a digital value corresponding to a DC link voltage and adjusts a speed indication signal to compensate for changes in the DC link voltage. The adjusted speed signal is transmitted to a controller where it is used to adjust energisation timing of the switched reluctance drive.

Electric motors turn electrical energy into mechanical energy to produce work. Electric motors work by applying a voltage across one or more windings in the motor thereby energising the windings to produce a resultant magnetic field. Mechanical forces of attraction caused by the magnetic field in turn cause a rotor in the electric motor to move. The efficiency of the electric motor depends in part on the timing and magnitude of each application of voltage to the motor. The magnitude of voltage applied is particularly important in the case of switched reluctance machines.

Historically, the switched reluctance motor was thought to be incapable of competing effectively with other types of motors. Part of the problem was the difficulty in controlling the switched reluctance motor. More recently however, a better understanding of the motor design and application of electronically controlled switching has resulted in robust switched reluctance drives capable of high levels of performance over a wide range of sizes, powers and speeds. Note that the term 'motor' is used here, but it will be appreciated by those skilled in the art that the term covers the same machine in a generating mode unless a particular distinction is made.

The general theory of the design and operation of switched reluctance motors is well known and is discussed, for example, in The Characteristics, Design and Applications of Switched Reluctance Motors and Drives, by Stephenson and Blake and presented at the PCIM '93 Conference and Exhibition at Nüremberg, Germany, June 21-24, 1993.

The switched reluctance motor is generally constructed without windings or permanent magnets on the moving part of the motor (called the rotor). The stationary part of most switched reluctance motors (called the stator) includes coils of wire wound around stator poles that carry unidirectional current. In one type of switched reluctance motor, coils around opposing stator poles are connected in series or parallel to form one phase winding of a potentially multi-phase switched reluctance motor. Motoring torque is produced by applying a voltage across each of the phase windings in a predetermined sequence that is synchronized with the angular position of the rotor so that a magnetic force of attraction results between poles of the rotor and stator as they approach each other. Similarly, generating action is produced by positioning the pulse of voltage in the part of the cycle where the poles are moving away from each other.

In typical operation, each time a phase winding of the switched reluctance motor is switched on (or energised), magnetic flux is produced by the phase winding, thereby turning the two opposing stator poles associated with the phase winding into electro-magnets of opposing polarities. The electro-magnetic field created by the energised phase winding causes a force of attraction on the rotor poles. The general construction and operation of controllers for switched reluctance motors is generally understood and is described herein for background purposes only.

In order to maintain the speed and related torque developed by a switched reluctance motor, it is necessary to carefully control when and how much voltage is applied to the phase windings of the motor. Because the supply voltage can vary significantly, a control scheme that ignores changes in supply voltage may experience a significant reduction in ability to control the machine as demanded by the user. This is because the flux produced by the phase windings is directly related to the amount of voltage applied. Accordingly, a change in the supply voltage may result in more or less flux produced by the phase windings than would otherwise be desired. This undesirable change in the flux in the motor can result in the electro-magnets created by energisation of the phase windings being too strong or too weak resulting in degraded motor performance.

Many switched reluctance motors are run from either battery supplies or, more commonly, from a DC voltage that is derived by rectifying or otherwise converting an AC supply voltage into a DC voltage. In the present application the DC voltage provided to the switched reluctance motor (from a battery, rectifier or otherwise) is referred to as the "DC link voltage". As those skilled in the art will recognize, the DC link voltage available to a switched reluctance motor system is often not constant. Changes in the voltage of the AC supply, changes in the electrical environment in which the motor system operates, and changes in the electrical components used to provide the DC link voltage often result in a DC link voltage that varies over time. These variations in the DC link voltage, if uncompensated, can diminish the performance of a switched reluctance drive.

As discussed above, in switched reluctance drives when and how voltage is applied to the phase windings is very important. In most known switched reluctance drives, the relationship between the speed of the motor, the desired torque, and the time and amount of voltage that is applied to the phase windings is determined empirically through a process referred to as characterisation. In characterisation, the operating parameters of the motor are determined over a wide variety of operating conditions. These operating parameters are then stored in an analogue or digital circuit (called a control law table). During operation of the drive, the control system provides the control law table with signals representing the speed of the motor and the desired torque. Circuitry including the control law table in turn produces signals that control the energisation of the phase windings. The use of motor controllers with control law tables is

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generally understood and is not discussed in detail herein.

For some motors, the characterisation is accomplished in a process that assumes that the DC link voltage available to the motor system is unchanging. Realizing that the DC link voltage will typically vary, characterisation is sometimes done assuming that the DC link voltage is at its lowest expected value. In other words, characterisation is done assuming the "worst case" DC link voltage. This type of characterisation is undesirable to the extent that it characterises the switched reluctance drive to run in a worst-case scenario (which may seldom occur) rather than at the desired optimum DC link value. Other motors are characterised at their optimum DC link voltage. For these motors, there must be some compensation for changes in the DC link value during operation or the drive will suffer diminished performance.

Some known switched reluctance drives do not compensate for changes in DC link voltage. These systems necessarily suffer from the operating problems and loss of efficiency that results from such changes. Other switched reluctance drives use an analogue system to compensate for DC link voltage variations. In general, these systems compensate for the changes in the DC link voltage by adjusting the speed signal provided to the control law table so that the speed signal provided to the controller is not the actual speed of the motor but a modified speed signal that represents the actual speed signal modified by a signal representative of the DC link voltage.

In typical analogue DC link compensation circuits, an analogue feedback signal that corresponds to the rotational speed of the motor is sampled at a fixed frequency using pulses having a duty cycle that corresponds to the DC link voltage. This sampling produces a modified analogue speed signal that is provided to the control circuit, which may include a control law table. For example, if the DC link value is at or near the desired DC link value, the speed feedback signal may be sampled using pulses with a duty cycle of approximately 90%. This will produce a modified speed signal of a first value. If the DC link value drops below the desired DC link voltage, the duty cycle of the sampling pulses may increase up to 100%, which correspondingly increases the modified analogue speed signal provided to the controller. Conversely, if the DC link voltage increases, the duty cycle of the sampling pulses will decrease, reducing the value of the modified analogue speed signal provided to the controller. The controller, which may include a control law table, receives the modified signals and produces the signals that control the energisation of the motor windings in a manner that compensates for the variations in the DC link voltage.

These analogue DC link compensation systems typically suffer from several disadvantages. In particular, these analogue systems suffer from the poor accuracy and performance limitations inherent in all analogue systems. Moreover, these analogue systems require components that are costly and can only operate within a limited operating range. For example, the use of the analogue sampling technique discussed above is limited to the extent that the sampling pulses cannot have a duty cycle of greater than 100%. Still further, as digital controllers are integrated into motor control systems, the requirement of an analogue DC link compensator results in the need for additional, costly circuitry.

Given the disadvantages of the known analogue systems, it is desirable to have a DC link voltage compensation system that is accurate, covers a considerable range of DC link voltages, and is relatively inexpensive.

The present invention is defined in the accompanying independent claims. Preferably features of the invention are recited in the claims respectively dependent thereon.

The present invention generally relates to an apparatus and method of compensating for DC link voltage variations in an electric drive system. More particularly, the present invention relates to a digital system for accurately and efficiently implementing DC link compensation in a manner that overcomes many of the disadvantages associated with known analogue DC link compensation systems. In one embodiment of the present invention, digital circuitry is used to periodically read digital signals representing the DC link voltage and actual rotor speed. The digital circuitry then uses a novel approach to adjust the digital representation of the rotor speed to compensate for changes in the DC link voltage. The compensated speed signal is then transmitted to a controller, which may include a control law table, where it is used to adjust coil energisation timing of the switched reluctance drive.

In accordance with a preferred embodiment of the present invention, the foregoing disadvantages of known switched reluctance drive controllers are overcome by utilizing a microcontroller to digitally process signals representing DC link voltage to achieve compensation for DC link voltage variations.

Other aspects and advantages of the invention will become apparent upon reading the following detailed description of exemplary embodiments of the invention and upon reference to the accompanying drawings, in which:

Figure 1 is a block diagram of a DC link voltage compensation system according to one embodiment of the present invention;

Figure **2** is a flow chart illustrating a method of implementing a DC link voltage compensation system according to one embodiment of the present invention;

Figure **3** is a graph illustrating one possible relationship between the DC link voltage and a compensation factor that may be implemented through the use of the present invention; and

Figure **4** is a table used to determine an acceptable relationship between the digital representation of the average DC link voltage and a compensation factor.

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Figure 1 illustrates a representative block diagram of a digital DC link voltage compensation system **10** for a switched reluctance motor (partially represented by a rotor **12**). The voltage compensation system **10** further includes a rotor position sensor **14** (RPT), which is influenced by a member attached to rotate with the rotor, for creating a rotor position sensor output signal **16** representative of the position of rotor **12**. It will be appreciated by those skilled in the art that rotor position information can be derived by several alternative means, including a rotor position transducer (RPT) or by estimating the information from motor current, voltage and/or inductance. The sensor **14** is shown in block form in Figure **1** for illustrative purposes.

By monitoring the changes in the rotor position over a given time period it is possible to determine the speed of the motor. In Figure 1, a speed measurement block **18** performs the function of receiving the rotor sensor output signal **16** and providing an actual speed signal **20** that corresponds to the actual rotational speed of the rotor **12**. Construction of the speed measurement block **18** will be straightforward to one skilled in the art and depends on the particular RPT selected. The actual speed signal **20** is provided to a digital DC link voltage compensator block **22**.

In addition to sensing the rotational speed of the rotor, the circuit of the present invention also senses the DC link voltage **24**. In the embodiment of Figure **1**, an analogue to digital converter (ADC) **26** samples the DC link voltage **24** and converts it into a digital output **28** that represents the voltage magnitude of the DC link voltage. The ADC **26** transmits its output **28** to the digital DC link voltage compensator block **22**. In one embodiment the ADC output **28** comprises 8 (eight) data bits, allowing for 2^8 (= 256) different voltage levels to be represented.

The digital DC link voltage compensator block **22** receives the actual speed signal **20** and the ADC voltage output **28** and generates a digital compensated speed signal **30** which is passed to a motor controller **32** associated with the switched reluctance motor. In one embodiment, the digital compensated speed signal **30** is adjusted inversely to changes in DC link voltage **24**. For example, a rise in DC link voltage **24** will produce a smaller valued, compensated speed signal **30**, while a fall in DC link voltage **24** will produce a larger valued, compensated speed signal **30**. The digital compensated speed signal **30** from the digital DC link voltage compensator **22** is then applied to the motor controller **32** that in one embodiment includes a control law table. Control of the motor is accomplished using the compensated speed signal.

It will be appreciated by those skilled in the art of motor control that the actual speed signal will be used for other aspects of control of the motor (not discussed here) in conventional fashion.

The digital DC link voltage compensator **22** may be implemented in a number of different ways. For example, discrete digital components, or an application specific digital integrated circuit may be used to implement the DC link voltage compensator. In one embodiment of the present invention a digital microcontroller, such as a microcontroller from Motorola's MC68HC11 family of microcontrollers, may be used to implement the DC link voltage compensation method of the present invention. In that embodiment the same microcontroller may be used as the motor controller **32**. This embodiment has the advantage of performing DC link voltage compensation without the need for significant additional circuitry over that already required to implement the motor controller **32**.

Turning now to Figure **2**, there is shown a flow chart illustrating a preferred method of implementing the digital DC link voltage compensator **22** within the DC link voltage compensation system **10**. In particular, Figure **2** illustrates a method in accordance with the present invention by which the digital DC link voltage compensator **22** may convert the actual speed signal **20** into the compensated speed signal **30**.

At the beginning of the process, the digital DC link voltage compensator must first determine the actual DC link voltage. This is accomplished by reading the digital value provided by the ADC **26** that corresponds to the actual DC link voltage. To avoid having transient changes in the DC link voltage **24** affect the motor operation, the DC link voltage **24** is averaged over a given period of time. In the embodiment of the present invention illustrated in Figure **2** this reading and averaging is accomplished as follows:

At step **34** the digital DC link voltage compensator **22** reads an eight bit digital output of the ADC **26**. At step **36** the digital value corresponding to the DC link voltage is normalised to values corresponding to decimal values between 123 and 210. The normalisation range corresponds to a range of DC link voltages that the digital DC link voltage compensator **22** can compensate for and still allow the control system of the drive to accurately control speed and torque.

To accomplish the averaging of the DC link voltage over time, the process of reading the digital signal from the ADC **26** is repeated 256 times. The 256 readings are then added together and divided by 256 to get an average DC link voltage. In the present invention this adding and dividing is accomplished through the use of a binary storage register called link_sum. Each normalised DC link voltage reading is added to link_sum, a binary variable representing a running total, in step **38**. In next step **40**, a counter tracks whether 256 readings have been added to link_sum, if not, then the process repeats and another set of DC link voltage readings is taken. However, if exactly 256 readings have been added to link_sum, then 127 is added to link_sum in step **42**. Adding 127 to link_sum effectively allows link_sum to be rounded in step **42**, instead of merely truncating it. The counter is then reset to zero in anticipation of another round of voltage sampling **42**. In step **44** link_sum is shifted to the right 8 (eight) spaces, effectively dividing link_sum by 2^8 (= 256), thereby averaging link_sum to derive an average DC link voltage. The advantage to shifting link_sum

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to the right eight spaces as opposed to dividing by 256 is that the same result is achieved in far less time. Division is much more time consuming that mere shifting of numbers. Saving time is particularly important in real time systems where the present invention finds particular application.

Once the average DC link voltage has been determined, the digital DC link compensator **22** of the present invention then determines the compensation factor to adjust the actual motor speed signal **20** to compensate for any variations in the DC link voltage. Because the present invention uses digital circuitry, the compensation factor may be selected according to any arbitrary relationship between actual DC link voltage and the compensation factor. In one embodiment of the present invention, the relationship between the actual DC link value and the compensation factor is set such that the compensation factor increases with decreasing actual DC link voltage, and decreases with increasing actual DC link voltage.

Line **A** of Figure **3** illustrates one desirable relationship between DC link voltage (represented on the horizontal axis in terms of normalised ADC values) and the compensation factor (represented on the vertical axis). In Figure 3, the relationship between the DC link values and the compensation factor is as follows: the compensation factor is equal to the optimum DC link voltage divided by the actual DC link voltage. For example, in one embodiment of the present invention the optimum DC link voltage may be 1350 V_{DC}, which translates into a normalised ADC value of 172 (based on a 2000 volt scale divided into 256 digital representations). If the actual DC link voltage is 1350 V_{DC} (with an ADC of 172) then the compensation factor should be 1.0 since the actual speed signal does not need to be modified since there is no DC link voltage variation. Using the same example, if the actual DC link voltage is 1550 (with an ADC value of 198) the compensation factor should be (1350/1550) or approximately 0.87. Two examples are illustrated with respect to line **A** of Figure **3**; when the actual DC link voltage is 1056 volts (with an ADC value of 135) the compensation factor should be approximately 1.28. When the actual DC link voltage is 1550 volts (with an ADC value of 198) the compensation factor should be approximately 0.87. It should be noted that the relationship between DC link voltages and the compensation factors represented by line **A** of Figure 3 is but one of many possible relationships that may be used to implement the present invention.

The actual derivation of the compensation factor given the normalised ADC value representing the actual DC link voltage may be accomplished in a variety of ways. For example, a simple look-up table may be used, or the compensation factor may be calculated in some other manner. In the embodiment represented by Figure **2**, the compensation factor is calculated.

Line **A** of Figure **3** represents a constant-slope approximation to a non-linear optimal compensation factor. As those skilled in the art will recognize, it is often difficult to exactly describe complex mathematical relationships, and as such, more simple approximations are often used as good, practical substitutes that may be implemented in digital systems. Accordingly, the embodiment represented by Figure **2** does not implement a precise non-linear optimal relationship between compensation factor and voltage variance, but implements a linear approximation related to the relationship represented by line **A** as described below.

First it was realized that the relationship represented by Line **A** can be expressed as $Y = MX + C$ where Y represents the compensation factor, M represents the slope of line **A**, X represents a digital value corresponding to the actual DC link voltage, and C represents an offset. To determine the characteristics of line **A**, the slope of line **A** was calculated. In the example of Figure 3 this slope M came out to be approximately - 0.00646. Because the fractional number 0.00646 was inconvenient to represent digitally, it was multiplied by a large multiplying factor (in this example 2^{13} or 8192) to produce a whole decimal integer that could be used in a digital system. In this example the initial slope was approximately - 53. Because the right hand side of the equation was multiplied by 2^{13} the left hand side must also be multiplied by the same number so that the calculated compensation factor Y when the actual DC link value equalled the desired DC link value (or when the normalised ADC value was 172) would now be 2^{13} or 8192 rather than 1. Using those numbers the value C was calculated to be -17308.

It was then noted that, while selecting the offset C at -17308 produces the desired compensation factor when the actual DC link voltage is equal to the optimum DC link voltage, it also produced offset errors at DC link voltages that were either greatly above or greatly below the optimum DC link voltage. This would have resulted in the compensation factor being slightly different from the desired compensation factor illustrated by line **A**. Accordingly, it was decided to select other slopes and compare the relative offset errors at the highest and lowest expected DC link values for the different slopes. A tradeoff between percentage error and overcompensation at the high end was then made.

Figure **4** illustrates one example of these calculations for slopes of -53, -54, -55, -56 and -57. The chart in Figure **4** illustrates absolute value of the slope M, the calculated offset C, and absolute value of the percent error from the desired compensation factor represented by line **A** for the highest and lowest expected DC link voltages. The slope of -55 was selected in the present example, because it represents the preferable tradeoff between percentage error and overcompensation at high voltage. The lowest expected DC link voltage was used to determine the slope because it is believed that it is better to have too much DC link compensation at high actual DC link voltages than not enough at low actual DC link voltages. When a slope of -55 is used, the calculated offset factor C comes out to be 17,652.

The selection of the slope -55 was made for the specific example described herein. Depending on the construction

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of the motor, the desired operating points and the goals of the system designer, other suitable slopes can easily be selected.

Referring back to Figure 2, which illustrates an embodiment using a slope of - 55, the average DC link voltage that was derived in step **44** (which corresponds to X in the equation provided above) is multiplied by slope value 55 (fifty-five) in step **46**. The negative nature of the slope is understood and is not used in the example of Figure 2. Multiplying the average link voltage by 55 in step **46** enables determination of a corresponding DC link voltage variation. In order to complete the equation Y = MX + C it is necessary to subtract the value obtained by multiplying the average DC link voltage by 55 from 17,652 in step **48**, to produce Y the compensation factor.

Having calculated the compensation factor, the digital DC link voltage compensator of the present invention then needs to adjust the measured motor speed **20** to reflect the compensation factor. This is accomplished, generally, by multiplying the actual motor speed **20** by the compensation factor to produce a compensated speed signal **30**. That is applied to the controller **32** as discussed above.

In the embodiment of Figure **2** scaling, normalisation and multiplication factors are used to convert the actual speed signal **20** into the compensated speed signal **30**. These scaling factors, normalisation factors, and multipliers are used to optimize the implementation of the present method in a digital system and to compensate for the scaling and offset factors used to calculate the compensation factor from the actual DC link voltage. Those skilled in the art will recognize that these factors and multipliers may be changed and altered without deviating from the present invention.

In the embodiment of Figure **2**, the actual speed signal **20** is received from the speed measurement block **18** and read by the digital DC link voltage compensator block **22** in step **50**. Knowing the actual speed provides a baseline which is altered according to DC link voltage variations. Once the actual speed signal is read in step **50**, it is normalised in step **52**. Here normalisation requires limiting of values greater than 2^{15}-1 = 32767 to be equal to 32,767. This step ensures that the maximum speed signal used to provide a compensated speed signal is never greater than 32,767.

In step **54**, the normalised actual speed in digital form, is multiplied by the digital compensation factor calculated in step **48** to produce a digital output which represents a compensated speed signal **30**. The digital compensated speed signal **30** may then be provided to the motor controller **32** to control the motor operation as discussed above.

In the embodiment of Figure **2** the digital compensation speed signal is first scaled and then limited before it is provided to the motor controller. In Figure **2** the scaling occurs in step **58** where the compensated speed signal is divided by a divisor equal to 2^{13} (8,192) * 2^{7} (128) = 2^{20} (1,048,576), to produce a scaled compensated speed in step **56**. The 2^{13} (8,192) component of the divisor offsets multiplication of the slope by the same number above. The 2^{7} (128) component helps to scale the uncompensated speed down to an 8 (eight) bit range. Adjusting the scaled compensated speed to an 8 bit range is completed by truncating values above eight bits in step **58**. Thus, in the embodiment of Figure **2**, step **58** results in the production of an 8 bit scaled compensated speed signal **30** which is transmitted to the switched reluctance motor controller **32**.

The compensated speed signal **30** functions to provide to the switched reluctance motor controller **32** a way to make adjustments in pulse magnitude, duration and timing based on variations in DC link voltage. The compensated speed signal **30** works within a range of acceptable DC link voltages **24** as normalised and truncated in one embodiment of the present invention described above.

There has been described herein a DC link voltage compensation system and method which adjusts a speed indication signal in response to a variation in DC link voltage.

The program listing attached as Appendix A is a representative listing of a software routine that may be used to construct a DC link voltage compensation system in accordance with the present invention.

A preferred embodiment of the present invention provides a digital DC link voltage compensation system which adjusts a rotor speed signal in response to a variation in DC link voltage. The digital voltage compensation system provides for improved accuracy and better control of rotor speed and torque in a cost-effective manner.

While the invention is susceptible to various modifications and alternative forms, a number of specific embodiments have been shown by way of example in the drawings and have been described in detail. It should be understood, however, that this is not intended to limit the invention to the particular forms disclosed. On the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the scope of the invention as defined by the appended claims.

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APPENDIX A

```
/*==========================================
                dc_link_compensation

function:   applies a scaling factor to the speed sent to the ASIC according to the voltage
            of the dc link.
==========================================*/
void dc_link_compensation()
{
static unsigned int averaging_count , link_sum , link_value;
unsigned char adc_in;
unsigned int multiplier;
unsigned long temp;

    /* first average 256 values read from the ADC measuring the DC link */

adc_in = ADR2;                                          /* read the ADC */
if (adc_in < 123)                                       /* limit compensation to 130 - 210 */
    adc_in = 123;
else if (adc_in > 210)
    adc_in = 210;
link_sum += adc_in;
averaging_count++;
if (averaging_count == 256)
    {
    averaging_count = 0;
    link_value = ((link_sum + 127) >> 8)  * 55;
    link_sum = 0;
    }
    /*  now the latest value of "link_value" can be used as the basis of the
        multiplying factor for the speed */
multiplier = 17652 - link_value;
temp = actual_speed;
if (temp > 0x7fff)                                      /*  limit actual_speed to 2000 rpm*/
    temp = 0x7fff;
temp *= (unsigned long)multiplier;
temp >>= 20;
if (temp > 0xff)
    temp = 0xff;                                        /* limit to maximum scaling */

    /* operate on nominal voltage when generating */

if (generating == TRUE)
    compensated_speed = actual_speed >> 7;
else
    compensated_speed = temp;
}
```


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Claims

1. A method for compensating for deviations of actual DC link voltage from a predetermined DC link voltage applied to an electric machine drive, which includes an electric machine having a rotor and a controller for controlling the machine in response to a speed signal, the method comprising the steps of:

   periodically sampling the actual DC link voltage and converting the sampled DC link voltage into a digital link voltage representation;
   periodically sampling the actual rotor speed and converting the sampled rotor speed to a digital speed representation;
   modifying the digital speed representation according to the digital link voltage representation to produce a compensated speed signal; and
   transmitting the compensated speed signal to the electric machine controller and using the compensated speed signal in control of the machine.

2. A method as claimed in claim 1 in which the digital speed representation is multiplied by a compensation factor, generated from the digital link voltage representation, to produce the compensated speed signal.

3. A method as claimed in claim 2, in which the compensation factor corresponds to the predetermined DC link voltage divided by the actual DC link voltage.

4. A method as claimed in any of claims 1 to 3 in which each digital link voltage representation is an average of a plurality of samples.

5. A method as claimed in any of claims 1 to 4 including limiting the digital dc link voltage representation to be within a predetermined range.

6. A method as claimed in any of claims 1 to 5 including limiting the digital speed representation to be within a predetermined range.

7. A compensation system for compensating for a deviation of an actual DC link voltage from a predetermined DC link voltage in an electric drive which includes an electric machine having a rotor, the system comprising:

   means for sampling the actual DC link voltage periodically and converting the sampled DC link voltage into a digital link voltage representation;
   means for sampling an actual rotor speed periodically and converting the sampled rotor speed into a digital speed representation;
   means for modifying the digital speed representation according to the digital link voltage representation to produce a compensated speed signal, and
   means for controlling the machine in accordance with the compensated speed signal.

8. A system as claimed in claim 7 in which the means for sampling the actual DC link voltage are operable to produce, as the digital link voltage representation, an average of a plurality of sampled DC link voltages.

9. A system as claimed in claim 7 or 8 in which the means for modifying the digital speed representation comprise means for limiting the digital link voltage representation to be within a predetermined range.

10. A system as claimed in claim 9 in which the means for modifying the digital speed representation further comprise means for limiting the digital speed representation to be within a predetermined range.

11. A system as claimed in claim 7, including: means for limiting the sampled DC link voltage to be within a predetermined range;

    means for accumulating a plurality of voltage samples; and
    means for averaging the voltage samples.

12. A system as claimed in claim 8 in which the means for generating the compensated rotor speed signal further comprise:

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digital means for limiting the voltage sampled by making all voltage samples below a lower level equal to the lower level and all voltage samples above an upper level equal to the upper level;
digital means for averaging and rounding a plurality of the voltage samples;
means for multiplying the averaged and rounded voltage samples to produce a compensation factor;
means for detecting the actual rotor speed;
digital means for limiting the digital speed representation for values above a predetermined threshold;
digital means for multiplying the digital speed representation by a compensation factor to produce an interim rotor speed signal;
means for dividing the interim rotor speed signal by a predetermined divisor to produce a scaled interim rotor speed signal; and
means for limiting the scaled interim rotor speed signals which are greater than a predetermined amount to produce the compensated speed signal.

13. A system as claimed in claim 12 in which the means for generating the compensated speed signal include a microprocessor.

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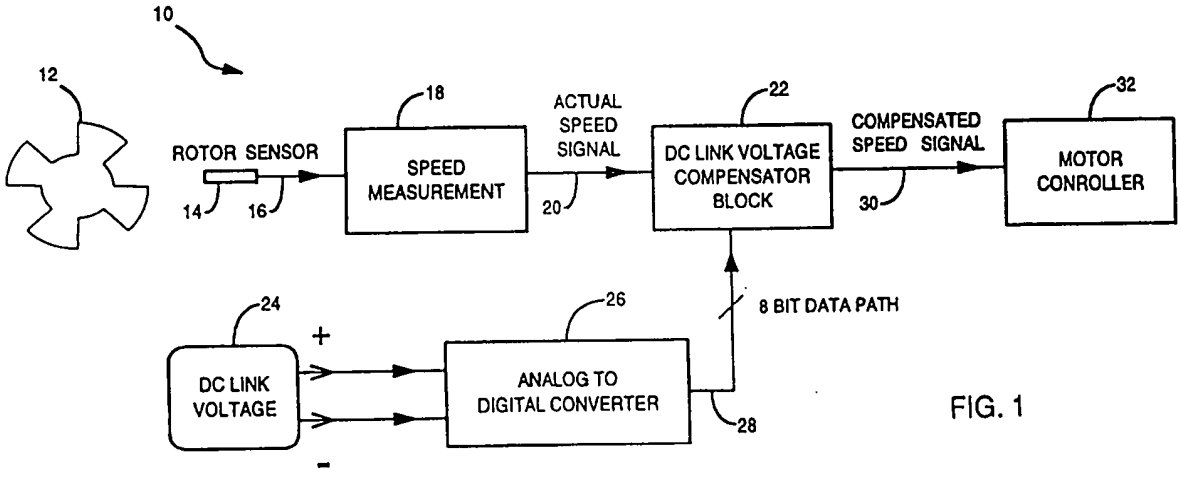


FIG. 1

EP 0 739 085 A2

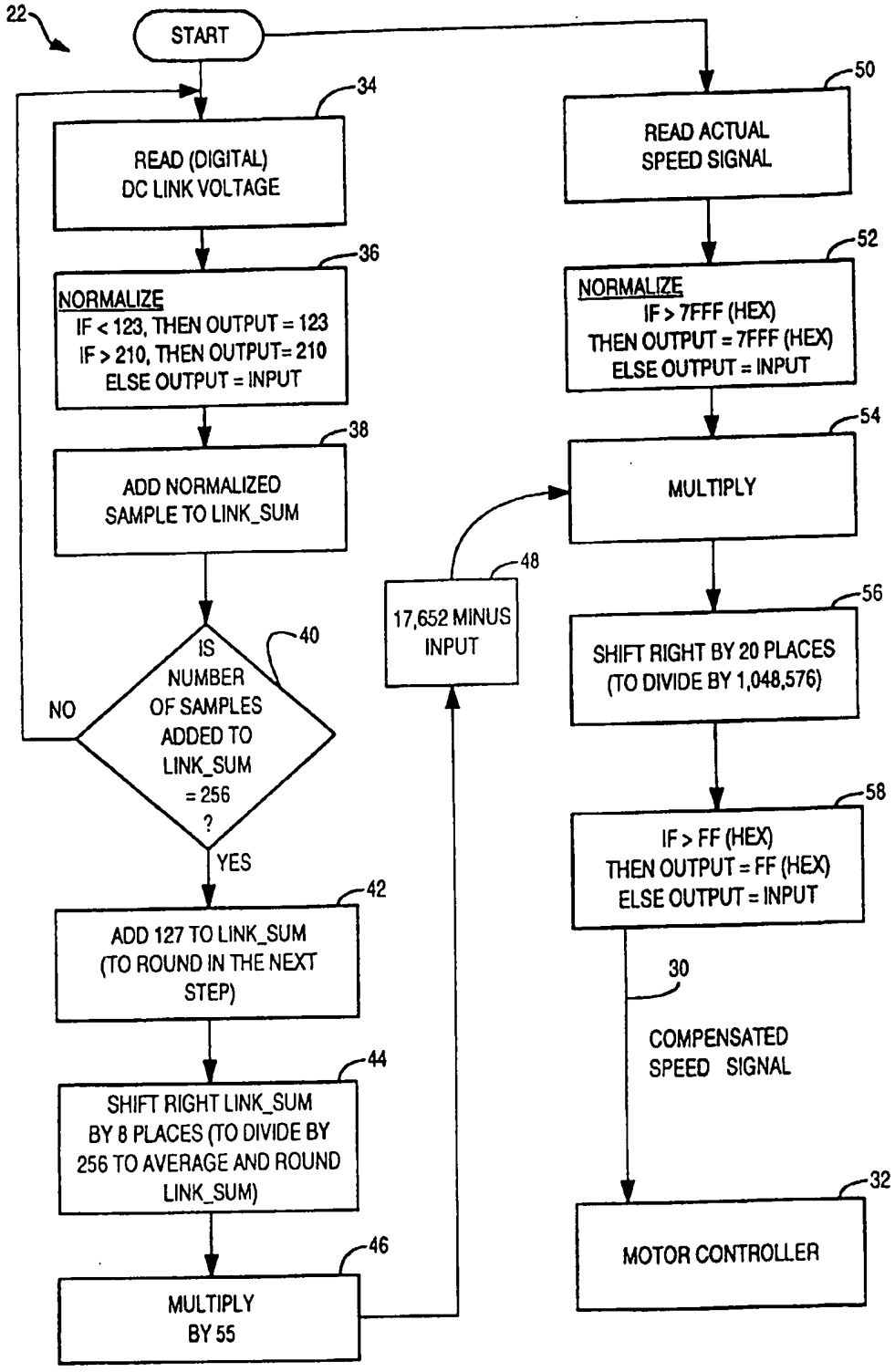


FIG. 2

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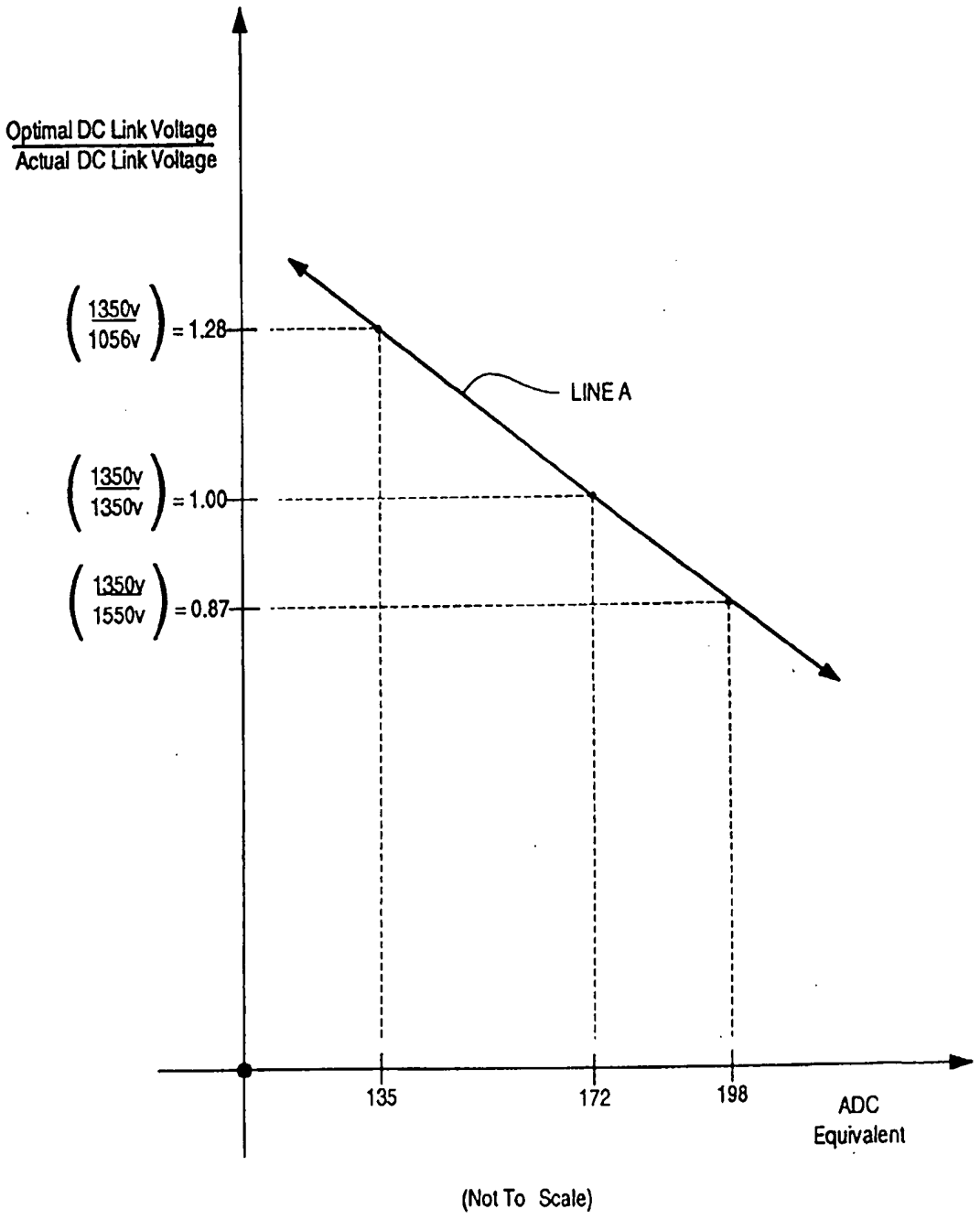


FIG. 3

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SLOPE	OFFSET	LOWER ENDPOINT		UPPER ENDPOINT	
M	C	SCALING	% ERROR	SCALING	% ERROR
53	17308	10153	3.02	6814	4.5
54	17480	10190	2.67	6788	4.86
55	17652	10227	2.31	6762	5.22
56	17824	10264	1.96	6736	5.59
57	17996	10301	1.60	6710	5.96

FIG. 4

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Electronic Patent Application Fee Transmittal

Application Number:	16116279
Filing Date:	29-Aug-2018
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Filer:	Li Jiang/Hoi Cheung
Attorney Docket Number:	00203.3030.00US

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1000**

Electronic Acknowledgement Receipt

EFS ID:	37463050
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Hoi Cheung
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	15-OCT-2019
Filing Date:	29-AUG-2018
Time Stamp:	16:48:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
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1	Issue Fee Payment (PTO-85B)	Web85b.pdf	45972 fb9b1b0513f72c934d5a7b3b5ff1a3f6057c7b18	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	31866 1eee8cfb2e163baa8514cda4ca9a6c0d6b8049c1	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	77838		

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Document Description: Issue Fee Payment (PTO-85B)

Issue Fee Transmittal Form

Application Number	Filing Date	First Named Inventor	Atty. Docket No.	Confirmation No.
16116279	29-Aug-2018	Changxing ZHOU	00203.3030.00US	6124

TITLE OF INVENTION :

MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

Entity Status	Application Type	Art Unit	Class - Subclass	EXAMINER
Regular Undiscounted	Utility under 35 USC 111(a)	2837	632000	BENTSU RO

Issue Fee Due	Publication Due	Total Fee(s) Due	Date Due	Prev. Paid Fee
$1000	$0	$1000	17-Oct-2019	$0

1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

Current Correspondence Address:	Current Indicated Fee Address :
136725 Anova Law Group, PLLC 21495 Ridgetop Circle, Suite 300 Sterling VA 20166 UNITED STATES 5713799468 uspto.anova@gmail.com	
☐ Change of correspondence address requested, system generated AIA/122-EFS form attached	☐ Fee Address indication requested, system generated SB/47-EFS form attached

2.Entity Status

Change in Entity Status

○ Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.
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○ 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.

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Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

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☐ I authorize USPTO to apply my previously paid issue fee to the current fees due

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4.Firm and/or Attorney Names To Be Printed

NOTE: If no name is listed, no name will be printed
For printing on the patent front page, list to be displayed as entered

1. ANOVA LAW GROUP, PLLC
2.
3.

5.Assignee Name(s) and Residence Data To Be Printed

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Name	City	State	Country	Category
SZ DJI TECHNOLOGY CO., LTD.	Shenzhen		china	corporation

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I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

Signature	/Li Jiang/	**Date**	10-15-2019
Name	Li Jiang	**Registration Number**	74191

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EAST Search History

EAST Search History (Prior Art)

< This search history is empty>

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	417	(battery and compensation).ab.	US-PGPUB; USPAT	OR	OFF	2019/07/12 10:10
L2	2056563	motor	US-PGPUB; USPAT	OR	OFF	2019/07/12 10:10
L3	1970024	control$5.ab.	US-PGPUB; USPAT	OR	OFF	2019/07/12 10:10
L4	61	1 and 2 and 3	US-PGPUB; USPAT	OR	OFF	2019/07/12 10:10

7/ 12/ 2019 10:29:31 AM
C:\ Users\ bro\ Documents\ EAST\ Workspaces\ default.wsp

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2503568	motor	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:35
L2	150350	battery.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:35
L3	64634	voltage adj (sensor or detector)	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:36
L4	92078	current adj (sensor or detector)	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:36
L5	1702013	compensat$6	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:37
L6	441	1 and 2 and 3 and 4 and 5	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 12:38
L7	132595	compensat$6.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 13:03
L8	19	6 and 7	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 13:03
L9	53257	compensat$6.ti.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 13:26
L10	315366	motor.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 13:26
L11	31	2 and 9 and 10	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 13:27

EAST Search History (Interference)

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7/ 11/ 2019 2:04:35 PM

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1309001	battery	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:34
L2	41589	(voltage or current) adj detector	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:35
L3	4138	compensation adj circuit.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:36
L4	150350	battery.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:36
L5	1	1 and 2 and 3 and 4	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:37
L6	878	voltage adj compensation.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:40
L7	12794	(battery and motor).ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:40
L8	1	6 and 7	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:41
L9	600	current adj compensation.ab.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:42
L10	0	7 and 9	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:43
L11	389894	(battery and motor)	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:43
L12	21	9 and 11	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:44
L13	22	6 and 11	US-PGPUB; USPAT; USOCR	OR	OFF	2019/07/11 15:54

EAST Search History (Interference)

< This search history is empty>

7/ 11/ 2019 4:03:01 PM

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/116,279	ZHOU et al.
	Examiner	Art Unit
	BENTSU RO	2837

CPC - Searched*		
Symbol	Date	Examiner
H02P	07/10/2019	/rob/

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
318	632	07/11/2019	/rob/

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Text and key-words searches.	07/10/2019	/rob/

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
318	632	07/11/2019	/rob/

/BENTSU RO/ Primary Examiner, Art Unit 2837	

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136725 7590 07/17/2019

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

EXAMINER
RO, BENTSU

ART UNIT	PAPER NUMBER
2837	

DATE MAILED: 07/17/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

TITLE OF INVENTION: MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	10/17/2019

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.

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By fax, send to: (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)

136725 7590 07/17/2019

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

TITLE OF INVENTION: MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	10/17/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
RO, BENTSU	2837	318-632000

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 03-09 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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). 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. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

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.
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.
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. _____

Textron Specialized Vehicles Inc., Exh. 1003, p. 139

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US	6124

136725 7590 07/17/2019

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

EXAMINER	
RO, BENTSU	
ART UNIT	PAPER NUMBER
2837	

DATE MAILED: 07/17/2019

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.

Textron Specialized Vehicles Inc., Exh. 1003, p. 140

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.

Textron Specialized Vehicles Inc., Exh. 1003, p. 141

Notice of Allowability	Application No. 16/116,279	Applicant(s) ZHOU et al.	
	Examiner BENTSU RO	Art Unit 2837	AIA (FITF) Status Yes

-- 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 filing of application on August 29, 2018.
   ☐ 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 1-17 . 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 areply 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 08/29/2018 & 11/07/2018.
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 _____.

/BENTSU RO/
Primary Examiner, Art Unit 2837

Examiner's Statement of Reasons for Allowance

1. The 7-sheet drawings filed on August 29, 2018 are acceptable.

2. Claims 1-17 are allowable because no prior art has taught an identical or a similar method or apparatus of controlling a motor that includes a compensation circuit. The compensation circuit has a compensation control signal to compensate the voltage, or the current, or the charge, or the internal resistance of the battery. See independent claim 1 for example.

3. Examiner's Information:

Examiner's Name: Bentsu Ro
Title: Primary Examiner
Art Unit: GAU 2837
Phone: 571-272-2072
Hours: Monday through Thursday from 8:00AM to 4:00PM, Eastern Time.

4. Supervisor's Information:

Name: Colon Santana Eduardo
Phone: 571-272-2060

/BENTSU RO/
Primary Examiner, Art Unit 2837
Friday, July 12, 2019

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/116,279	ZHOU et al.
	Examiner	**Art Unit**
	BENTSU RO	2837

CPC						
Symbol					**Type**	**Version**
B64D	/	31	/	02	F	2013-01-01
G01R	/	31	/	389	I	2019-01-01
G01R	/	31	/	3648	I	2013-01-01
H02P	/	6	/	08	I	2013-01-01
H02P	/	27	/	06	I	2013-01-01
H02P	/	27	/	14	I	2013-01-01
H02P	/	4	/	00	I	2013-01-01
B64D	/	31	/	00	A	2013-01-01
B64C	/	39	/	024	A	2013-01-01
B64C	/	2201	/	024	A	2013-01-01
B64C	/	2201	/	042	A	2013-01-01
H02P	/	2205	/	03	A	2013-01-01
H02P	/	2201	/	00	A	2013-01-01

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

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	17	
/BENTSU RO/ Primary Examiner, Art Unit 2837	12 July 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1 and 12	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/116,279	ZHOU et al.
	Examiner	**Art Unit**
	BENTSU RO	2837

INTERNATIONAL CLASSIFICATION					
CLAIMED					
H02P	/	6	/	08	
H02P	/	7	/	298	

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
318	632

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					
318	568.22					

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 17	
/BENTSU RO/ Primary Examiner, Art Unit 2837 (Primary Examiner) 12 July 2019 (Date)	O.G. Print Claim(s) 1 and 12	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No.: 20190712

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/116,279	ZHOU et al.
	Examiner	**Art Unit**
	BENTSU RO	2837

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

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	10	10												
2	2	11	11												
3	3	12	12												
4	4	13	13												
5	5	14	14												
6	6	15	15												
7	7	16	16												
8	8	17	17												
9	9														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 17	
/BENTSU RO/ Primary Examiner, Art Unit 2837 (Primary Examiner)	12 July 2019 (Date)	O.G. Print Claim(s) 1 and 12	O.G. Print Figure 1

U.S. Patent and Trademark Office

Part of Paper No.: 20190712

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Alexandria, Virginia 22313-1450
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BIB DATA SHEET

CONFIRMATION NO. 6124

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
16/116,279	08/29/2018	318	2837	00203.3030.00US

APPLICANTS

SZ DJI TECHNOLOGY CO., LTD., Shenzhen, CHINA;

INVENTORS

Changxing ZHOU, Shenzhen, CHINA;
Qiu LAN, Shenzhen, CHINA;
Jinyun NI, Shenzhen, CHINA;

**** CONTINUING DATA ***************************

This application is a CON of PCT/CN2016/075097 03/01/2016

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

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

10/03/2018

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /BENTSU RO/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CHINA	7	17	3

ADDRESS

Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166
UNITED STATES

TITLE

MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

FILING FEE RECEIVED		
1720	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

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Changxing ZHOU
Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

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					

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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
/B.R/	1	20120197471	A1	2012-08-02	IRISAWA YASUYUKI et al.	

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]
/B.R/	1	105093130	CN	A	2015-11-25	YANG SHANSHAN		
/B.R/	2	101159340	CN	A	2008-04-09	SAIC CHERY AUTOMOBILE CO LTD		
/B.R/	3	102522796	CN	A	2012-06-27	HUIZHOU EPOWER ELECTRONIC CO		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Changxing ZHOU
Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

/B.R/	4	103527338	CN	A	2014-01-22	WEICHAI POWER CO LTD		
/B.R/	5	104333068	CN	A	2015-02-04	STATE GRID CORP CHINA; STATE GRID BEIJING ELECTRIC		

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]
/B.R/	1	THE WORLD INTELLECTUAL PROPERTY ORGANIZATION (WIPO) International Search Report for PCT/CN2016/075097 November 30, 2016 6 pages	

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

EXAMINER SIGNATURE

Examiner Signature	/BENTSU RO/	Date Considered	07/12/2019

*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.

[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. /B.R/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Changxing ZHOU
Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

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	/LI JIANG/	Date (YYYY-MM-DD)	2018-08-29
Name/Print	LI JIANG	Registration Number	74191

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

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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.

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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.

Doc code: IDS
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First Named Inventor	Changxing ZHOU
Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

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/B.R/	3	102208890	CN	A	2011-10-05	HYUNDAI MOTOR CO LTD		

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Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

/B.R/	4	2013115867	JP	A	2013-06-10	TOYOTA MOTOR CORP		
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Filing Date	
First Named Inventor	Changxing ZHOU
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See attached certification statement.

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☒ A certification statement is not submitted herewith.

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Signature	/Li Jiang/	Date (YYYY-MM-DD)	2018-11-07
Name/Print	Li Jiang	Registration Number	74191

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Notice of References Cited	Application/Control No. 16/116,279	Applicant(s)/Patent Under Reexamination ZHOU et al.	
	Examiner BENTSU RO	Art Unit 2837	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-4558281-A	12-1985	Codd; Roger D.	G01R31/36	324/433
*	B	US-5467281-A	11-1995	Iwashita; Shigeo	B62D5/065	180/422
*	C	US-7541756-B1	06-2009	Parent; Jeanne Marie	H02P23/0077	318/139
*	D	US-20080309289-A1	12-2008	White; Daniel J.	H02J7/0063	320/136
*	E	US-20090183714-A1	07-2009	MAYUZUMI; Takuya	F02D41/20	123/490
*	F	US-20120287687-A1	11-2012	LIN; SHU-CHIA	H02M7/53871	363/95
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/116,279	08/29/2018	Changxing ZHOU	00203.3030.00US

CONFIRMATION NO. 6124

136725
Anova Law Group, PLLC
21495 Ridgetop Circle, Suite 300
Sterling, VA 20166

PUBLICATION NOTICE

OC000000105008946

Title:MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

Publication No.US-2019-0009919-A1
Publication Date:01/10/2019

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EFS ID:	34242984
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Li Jiang/Ting Xue
Filer Authorized By:	Li Jiang
Attorney Docket Number:	00203.3030.00US
Receipt Date:	07-NOV-2018
Filing Date:	29-AUG-2018
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Application Type:	Utility under 35 USC 111(a)

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	
First Named Inventor	Changxing ZHOU
Art Unit	
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Signature	/Li Jiang/	Date (YYYY-MM-DD)	2018-11-07
Name/Print	Li Jiang	Registration Number	74191

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Espacenet

Bibliographic data: CN101806867 (A) — 2010-08-18

Method and device for measuring electric quantity of mobile phone battery

Inventor(s): KANG QIN; MING ZHAN; ZIQIANG ZUO ± (QIN KANG, ; ZHAN MING, ; ZUO ZIQIANG)

Applicant(s): ZTE CORP ± (ZTE CORPORATION)

Classification: - international: *G01R19/00; G01R31/36*
- cooperative: G01R31/362; G01R31/3651

Application number: CN20101144163 20100312 Global Dossier

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Abstract of CN101806867 (A)

The invention discloses a method and a device for measuring the electric quantity of a mobile phone battery. The method comprises the following steps of: measuring the voltages of the battery in real time at one stage of an application scene; compensating the voltage measured in real time by using a voltage compensation value corresponding to the stage; and determining the electric quantity of the battery according to the compensated voltage. By adopting the invention, the effect of accurately measuring the electric quantity of the mobile phone battery is achieved.

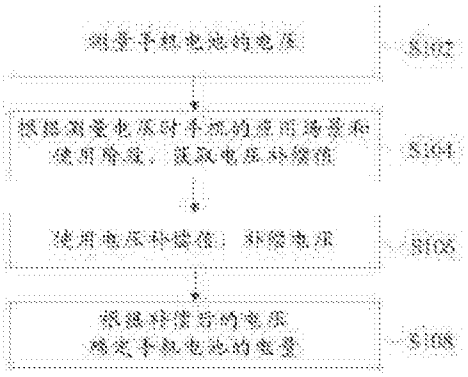


图 1 / Fig. 1

S102 MEASURING VOLTAGE OF BATTERY FOR MOBILE PHONE
S104 ACQUIRING VOLTAGE COMPENSATION VALUE ACCORDING TO APPLICATION CONTEXT AND SERVICE STAGE OF MOBILE PHONE WHEN VOLTAGE IS MEASURED
S106 COMPENSATING VOLTAGE BY VOLTAGE COMPENSATION VALUE
S108 DETERMINING BATTERY CAPACITY FOR MOBILE PHONE ACCORDING TO COMPENSATED VOLTAGE

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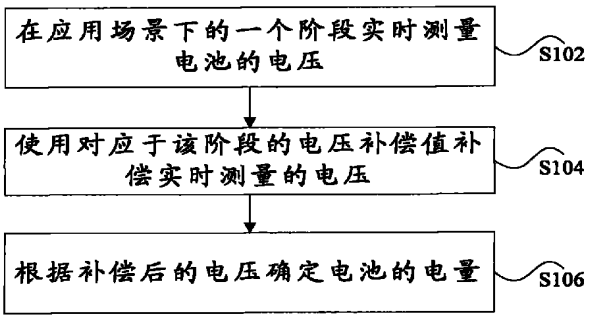
权利要求书 2 页 说明书 8 页 附图 5 页

(54)发明名称

测量手机电池电量的方法及装置

(57)摘要

本发明公开了一种测量手机电池电量的方法及装置，该方法包括：在应用场景下的一个阶段实时测量电池的电压；使用对应于上述阶段的电压补偿值补偿实时测量的电压；以及根据补偿后的电压确定电池的电量。采用本发明，达到了准确测量手机电池电量的效果。



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1. 一种测量手机电池电量的方法，其特征在于，包括以下步骤：

在应用场景下的一个阶段实时测量电池的电压；

使用对应于所述阶段的电压补偿值补偿所述实时测量的电压；以及

根据所述补偿后的电压确定所述电池的电量。

2. 根据权利要求 1 所述的方法，其特征在于，还包括：

测量所述电池在所述应用场景下的各个阶段的电压波动；以及

根据所述电压波动确定对应于所述各个阶段的电压补偿值。

3. 根据权利要求 2 所述的方法，其特征在于，使用对应于所述阶段的电压补偿值补偿所述实时测量的电压包括：

查找预先设置的所述各个阶段与电压补偿值的对应关系表，获得对应于所述阶段的电压补偿值；

使用所述获得的电压补偿值补偿所述实时测量的电压。

4. 根据权利要求 1 所述的方法，其特征在于，使用对应于所述阶段的所述电压补偿值补偿所述实时测量的电压包括：

获取所述电池的使用时间；

使用对应于所述使用时间的第一调整比例调整所述电压补偿值；以及

使用所述调整后的电压补偿值补偿所述实时测量的电压。

5. 根据权利要求 1 所述的方法，其特征在于，使用对应于所述阶

段的所述电压补偿值补偿所述实时测量的电压包括：

获取所述电池进入所述应用场景前的电压值；

使用对应于所述电压值的第二调整比例调整所述电压补偿值；以及

使用所述调整后的电压补偿值补偿实时测量的所述电压。

6. 根据权利要求 1 至 4 中任一项所述的方法，其特征在于，在所述阶段实时测量所述电压包括：

在所述阶段多次实时测量所述电池的电压；

对所述多次实时测量的电压取平均，得到所述实时测量的电压。

7. 根据权利要求 6 所述的方法，其特征在于，对多次实时测量的电压取平均，得到所述实时测量的电池的电压包括：

排除所述多次实时测量的电压中的异常电压；

对排除异常电压后的所述多次实时测量的电压取平均，得到所述实时测量的电压。

8. 一种测量手机电池电量的装置，其特征在于，包括：

测量模块，用于在应用场景下的一个阶段实时测量电池的电压；

第一补偿模块，用于使用对应于所述阶段的电压补偿值补偿所述实时测量的电压；以及

确定模块，用于根据所述补偿后的电压确定所述电池的电量。

9. 根据权利要求 8 所述的装置，其特征在于，所述第一补偿模块包括：

第一获取模块，用于获取所述电池的使用时间；

第一调整模块，用于使用对应于所述使用时间的第一调整比例调整所述电压补偿值；以及

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第二补偿模块，用于使用所述调整后的电压补偿值补偿所述实时测量的电压。

10. 根据权利要求 8 所述的装置，其特征在于，所述第一补偿模块包括：

第二获取模块，用于获取所述电池进入所述应用场景前的电压值；

第二调整模块，用于使用对应于所述电压值的第二调整比例调整所述电压补偿值；以及

第三补偿模块，用于使用所述调整后的电压补偿值补偿实时测量的所述电压。

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测量手机电池电量的方法及装置

技术领域

[0001] 本发明涉及到通讯领域，尤其涉及到一种测量手机电池电量的方法及装置。

背景技术

[0002] 随着通信技术的快速发展，手机逐渐发展成为集通话、播放音乐、视频，拍照，摄像以及上网等多种功能于一体的综合性电子产品。目前，大多数手机使用锂离子电池进行供电，手机功能的增多使得进行各种应用场景时的输出电流的情况越发复杂。手机在进行大电流的操作时，电池电压会随着输出电流的波动而变化，一般的规律是：输出电流大则输出电压低、输出电流低则输出电压稍大。

[0003] 在相关技术中，测量电池电量的方法是：实时测量电池电压，根据预先设置的电压与电量的关系确定当前的电池电量，并通过手机显示屏上将当前电池电量显示给用户。

[0004] 但是，采用上述方法测量手机电池电量，在相同电量的情况下，手机在实现各种功能（即，各种应用场景）的不同阶段时实际测量的电量与手机在待机状态测量到的电量是不同的，进而造成用户对手机电量的误判断，影响手机电池的实际使用时间。

发明内容

[0005] 本发明的主要目的在于提供一种测量手机电池电量的方案，以至少解决上述问题。

[0006] 为了实现上述目的，根据本发明的一个方面，提供了一种测量手机电池电量的方法。

[0007] 根据本发明的测量手机电池电量的方法包括：在应用场景下的一个阶段实时测量电池的电压；使用对应于上述阶段的电压补偿值补偿实时测量的电压；以及根据补偿后的电压确定电池的电量。

[0008] 进一步地，该方法还包括：测量电池在应用场景下的各个阶段的电压波动；以及根据电压波动确定对应于各个阶段的电压补偿值。

[0009] 进一步地，使用对应于阶段的电压补偿值补偿实时测量的电压包括：查找预先设置的各个阶段与电压补偿值的对应关系表，获得对应于阶段的电压补偿值；使用获得的电压补偿值补偿实时测量的电压。

[0010] 进一步地，使用对应于上述阶段的电压补偿值补偿实时测量的电压包括：获取电池的使用时间；使用对应于使用时间的第一调整比例调整电压补偿值；以及使用调整后的电压补偿值补偿实时测量的电压。

[0011] 进一步地，使用对应于上述阶段的电压补偿值补偿实时测量的电压包括：获取电池进入应用场景前的电压值；使用对应于电压值的第二调整比例调整电压补偿值；以及使用调整后的电压补偿值补偿实时测量的电压。

[0012] 进一步地，在上述阶段实时测量电压包括：在上述阶段多次实时测量电池的电压；对多次实时测量的电压取平均，得到实时测量的电压。

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[0013] 进一步地，对多次实时测量的电压取平均，得到实时测量的电池的电压包括：排除多次实时测量的电压中的异常电压；对排除异常电压后的多次实时测量的电压取平均，得到实时测量的电压。

[0014] 为了实现上述目的，根据本发明的另一方面，提供了一种测量手机电池电量的装置。

[0015] 根据本发明的测量手机电池电量的装置包括：测量模块，用于在应用场景下的一个阶段实时测量电池的电压；第一补偿模块，用于使用对应于上述阶段的电压补偿值补偿实时测量的电压；以及确定模块，用于根据补偿后的电压确定电池的电量。

[0016] 进一步地，第一补偿模块包括：第一获取模块，用于获取电池的使用时间；第一调整模块，用于使用对应于使用时间的第一调整比例调整电压补偿值；以及第二补偿模块，用于使用调整后的电压补偿值补偿实时测量的电压。

[0017] 进一步地，第一补偿模块包括：第二获取模块，用于获取电池进入应用场景前的电压值；第二调整模块，用于使用对应于电压值的第二调整比例调整电压补偿值；以及第三补偿模块，用于使用调整后的电压补偿值补偿实时测量的电压。

[0018] 通过本发明，采用使用对应于应用场景下相应阶段的电压补偿值补偿在该阶段实时测量的电压，解决了相关技术中手机在应用场景不同阶段时实际测量的电量与手机在待机状态测量到的电量不同的问题，进而达到了准确测量手机电池电量的效果。

附图说明

[0019] 此处所说明的附图用来提供对本发明的进一步理解，构成本申请的一部分，本发明的示意性实施例及其说明用于解释本发明，并不构成对本发明的不当限定。在附图中：

[0020] 图 1 是根据本发明实施例的测量手机电池电量的方法的流程图；

[0021] 图 2 是根据本发明实施例的测量手机电池电量的方法的示意图一；

[0022] 图 3 是根据本发明实施例的语音通话过程中电池电压波动的示意图；

[0023] 图 4 是根据本发明实施例的测量手机电池电量的方法的示意图二；

[0024] 图 5 是根据本发明实施例的测量手机电池电量的方法的示意图三；

[0025] 图 6 是根据本发明实施例的测量手机电池电量的方法的示意图四；

[0026] 图 7 是根据本发明实施例的测量手机电池电量的装置的结构框图；

[0027] 图 8 是根据本发明实施例的测量手机电池电量的装置的具体的结构框图一；以及

[0028] 图 9 是根据本发明实施例的测量手机电池电量的装置的具体的结构框图二。

具体实施方式

[0029] 下文中将参考附图并结合实施例来详细说明本发明。需要说明的是，在不冲突的情况下，本申请中的实施例及实施例中的特征可以相互组合。

[0030] 图 1 是根据本发明实施例的测量手机电池电量的方法的流程图，该方法包括以下步骤：

[0031] 步骤 S102，在应用场景下的一个阶段实时测量电池的电压；

[0032] 步骤 S104，使用对应于该阶段的电压补偿值补偿实时测量的电压；以及

[0033] 步骤 S106，根据补偿后的电压确定电池的电量。

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[0034] 该实施例利用对应于应用场景的阶段的电压补偿值补偿实时测量的手机电池的电压，并根据补偿后的电压确定电量，解决了相关技术中手机在应用场景不同阶段时实际测量的电量与手机在待机状态测量到的电量不同的问题，实现了准确测量手机电池电量的目的，使得用户能够准确判断手机电池的实际使用时间。

[0035] 优选的，该方法还包括：测量电池在应用场景下的各个阶段的电压波动；以及根据电压波动确定对应于各个阶段的电压补偿值。

[0036] 该实施例根据应用场景的各个阶段的电压波动获得电压补偿值，使得电压补偿值的选取更为准确，从而实现了准确测量手机电池电量的目的。

[0037] 优选的，使用对应于实时测量电池的电压的上述阶段的电压补偿值补偿实时测量的电压包括：获取阶段；查找预先设置的各个阶段与电压补偿值的对应关系表，获得对应于实时测量电池的电压的上述阶段的电压补偿值；使用获得的电压补偿值补偿实时测量的电压。

[0038] 该实施例利用了应用场景的阶段和电压补偿值的对应关系表，使得获取电压补偿值更为简便。

[0039] 下面以语音通话这一场景为例说明上述优选实施例的实现过程。图 2 是根据上述优选实施例的测量手机电池电量的方法的示意图，该方法包括：

[0040] 步骤 S201，获得手机在进行语音通话时的电池电压的实时值。进入电池电压检测阶段。

[0041] 步骤 S202，可以采样 1 次，也可以采样多次，例如，电压采样 12 次得到 12 个电池电压数据。

[0042] 步骤 S203，去掉检测的电压数据中 2 个最高值及 2 个最低值，剩下 8 个数据平均后的数值。

[0043] 步骤 S204，对剩下的 8 个数据取平均，之后得到的数值为当前电压的平均值。

[0044] 在采样一次的情况下，步骤 S202 至 S204 是可选的步骤，在采样多次的情况下，步骤 S203 也是可选的。

[0045] 步骤 S205，判断当前通话所处状态。本实施例中该阶段是语音通话中，对应的状态是 Call_hold。

[0046] 步骤 S206，获得手机在语音通话时对应的电压波动补偿值。

[0047] 图 3 是根据本发明实施例的语音通话过程中电池电压波动的示意图，通话前的电池电压比较平稳，在接通的瞬间电池电压会有一个低压峰值出现，在通话中电池电压相对稳定，但是会有规律的低压脉冲出现，在挂断电话时电池电压又有一个低压峰值出现，在挂断之后 10 秒左右电压恢复平稳。表 1 是语音通话中电池电压波动补偿表，可以在软件中使用相应的标志位标识对应通话的不同阶段，不同的标志位对应不同的补偿数值。

[0048] 表 1

[0049]

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应用情况	标志位	补偿值
呼叫	Call_Start	10mV
接通	Call_Connected	30mV
通话中	Call_hold	20mV
挂断	Call_stop	25mV
待机	Call_end_idle	5mV

[0050] 本实施例中获得的状态是 Call_hold，查找表 1 得到对应的电压补偿值是 20mV。

[0051] 步骤 S207，根据电压补偿值对实际测量的电池电压进行补偿。语音通话中的电压检测中得到的电池电压的值为 3.76+0.02 = 3.78V。然后，根据预先设置的电压和电量的关系确定电池的电量。

[0052] 该实施例利用对应于应用场景的阶段的电压补偿值补偿实时测量的手机电池的电压，并根据补偿后的电压确定电量，实现了准确测量手机电池电量的目的，使得用户能够准确判断手机电池的实际使用时间。

[0053] 优选的，使用电压补偿值补偿实时测量的电压包括：获取电池的使用时间；使用对应于使用时间的第一调整比例调整电压补偿值；以及使用调整后的电压补偿值补偿实时测量的电压。

[0054] 该实施例根据电池的使用时间调整电压补偿值，使得测量得到的电池电量更为准确。

[0055] 下面以语音通话这一场景为例说明上述优选实施例的实现过程，图 4 是根据本发明上述优选实施例的测量手机电池电量的方法的示意图，该方法包括：

[0056] 步骤 S401，获得手机在进行语音通话时的电池电压的实时值。进入电池电压检测阶段。

[0057] 步骤 S402，可以采样 1 次，也可以采样多次，例如，电压采样 12 次得到 12 个电池电压数据。

[0058] 步骤 S403，去掉检测的电压数据中 2 个最高值及 2 个最低值，剩下 8 个数据平均后的数值。

[0059] 步骤 S404，对剩下的 8 个数据取平均，之后得到的数值为当前电压的平均值。

[0060] 在采样一次的情况下，步骤 S402 至 S404 是可选的步骤，在采样多次的情况下，步骤 S403 也是可选的。

[0061] 步骤 S405，判断当前通话所处状态。本实施例中该阶段是语音通话中，对应的状态是 Call_hold。

[0062] 步骤 S406，获得手机在语音通话时对应的电压波动补偿值。

[0063] 获得的状态是 Call_hold，查找表 1 得到对应的电压补偿值是 20mV。

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[0064] 步骤 S407，判断电池的使用时间。假设电池使用时间为半年。

[0065] 步骤 S408，获得手机在语音通话时对应的电压波动补偿值。表 3 是电池电压随使用时间的补偿比例表。

[0066] 表 3

[0067]

时间	3 各月	6 个月	9 个月	12 个月	15 个月	18 个月及以上
补偿比例	1.0	1.05	1.1	1.2	1.5	1.8

[0068] 电池使用时间为半年对应的电池电压补偿比例为 1.05。

[0069] 步骤 S409，电压补偿值变为 20*1.05 = 21mV。

[0070] 步骤 S410，根据电压补偿值对实际测量的电池电压进行补偿。语音通话中的电压检测中得到的电池电压的值为 3.76+0.021 = 3.781V。然后，根据预先设置的电压和电量的关系确定电池的电量。

[0071] 该实施例根据电池的使用时间调整电压补偿值，使得测量得到的电池电量更为准确。

[0072] 优选的，使用电压补偿值补偿实时测量的电压包括：获取电池进入应用场景前的电压值；使用对应于电压值的第二调整比例调整电压补偿值；以及使用调整后的电压补偿值补偿实时测量的电压。

[0073] 该实施例根据电池进入应用场景前的电压值调整电压补偿值，使得测量得到的电池电量更为准确。

[0074] 根据电池进入应用场景前的电压值调整电压补偿值和根据电池的使用时间调整电压补偿值这两个实施例可以单独使用，也可以结合使用，从而得到更为准确的电压补偿值。

[0075] 下面以语音通话这一场景为例说明上述优选实施例的实现过程，图 5 是根据上述优选实施例的测量手机电池电量的方法的示意图，该方法包括：

[0076] 步骤 S501，获得手机在进行语音通话时的电池电压的实时值。进入电池电压检测阶段。

[0077] 步骤 S502，可以采样 1 次，也可以采样多次，例如，电压采样 12 次得到 12 个电池电压数据。

[0078] 步骤 S503，去掉检测的电压数据中 2 个最高值及 2 个最低值，剩下 8 个数据平均后的数值。

[0079] 步骤 S504，对剩下的 8 个数据取平均，之后得到的数值为当前电压的平均值。

[0080] 在采样一次的情况下，步骤 S502 至 S504 是可选的步骤，在采样多次的情况下，步骤 S503 也是可选的。

[0081] 步骤 S505，判断当前通话所处状态。本实施例中该阶段是语音通话中，对应的状态是 Call_hold。

[0082] 步骤 S506，获得手机在语音通话时对应的电压波动补偿值。获得的状态是 Call_

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hold，查找表 1 得到对应的电压补偿值是 20mV。

[0083] 步骤 S507，判断进入语音通话前电池电压的稳定值。假设进入通话前的电池电压为 3.8V。

[0084] 步骤 S508，获得手机在语音通话时对应的电压波动补偿值。表 2 是电池电压随进入通话前电压的补偿比例表。语音通话前电池电压越高，对应的进入语音通话后各阶段的电压补偿值应相应降低。

[0085] 表 2

[0086]

进入应用前电压	4.0V 及以上	3.9～4.0V	3.8～3.9V	3.7～3.8V	3.6～3.7V	3.6V 及以上下
补偿比例	1.1	1.05	1.0	1.0	1.1	1.2

[0087] 查找表 2 中 3.8V 对应的电压补偿比例是 1.0，因此，实际的补偿值为 20×1.0 = 20mV。

[0088] 步骤 S509，电压补偿值变为 20*1 = 20mV。

[0089] 步骤 S510，根据电压补偿值对实际测量的电池电压进行补偿。语音通话中的电压检测中得到的电池电压的值为 3.76+0.02 = 3.78V。然后，根据预先设置的电压和电量的关系确定电池的电量。

[0090] 该实施例根据电池进入应用场景前的电压值调整电压补偿值，使得测量得到的电池电量更为准确。

[0091] 优选的，在实时测量电池的电压的上述阶段实时测量电压包括：在实时测量电池的电压的上述阶段多次实时测量电池的电压；对多次实时测量的电压取平均，得到实时测量的电压。

[0092] 该实施例利用多次采样取平均值的方法测量实时的电压，提高了实时测量电压的准确性。

[0093] 优选的，对多次实时测量的电压取平均，得到实时测量的电池的电压包括：排除多次实时测量的电压中的异常电压；对排除异常电压后的多次实时测量的电压取平均，得到实时测量的电压。

[0094] 该实施例利用去除异常值后再取平均的方法测量实时测量的电压，进一步提高了实时测量电压的准确性。

[0095] 图 2- 图 5 说明了上述多次测量和求平均的优选实施例的实现方法。

[0096] 本发明的一个优选实施例提供了一种在手机进行消耗电流差异较大的业务的时候，能够准确测量电池电量的方法，其中，电池电量通过测量电池的实际电压获得。在测量电池电量之前需要进行的准备工作包括：测量手机在实现各种功能（即，各种应用场景）的不同阶段下电池电压的波动，根据测试的数据给出手机在各种应用条件下的电压波动补偿表，并据此得到手机在各种应用场景下的电压补偿表，记录应用场景的各个阶段和电压补

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偿值之间的对应关系。测量电池随进入应用场景前的电压而变化的电压波动，根据测试的数据得到手机在进入应用场景前的电压不同的情况下的电压调整比例，并据此得到相应的电压调整补偿表，记录进入应用场景前的电压和电压调整值之间的对应关系。测量电池随使用时间而变化的电压波动，根据测试的数据得到手机在使用时间不同的情况下的电压调整比例，并据此得到相应的电压调整补偿表，记录使用时间和电压调整值之间的对应关系。在实际应用时，使用此处得到的电压调整比例调整第一步骤的电压补偿值。本实施例以语音通话为例说明本发明的实现过程。图 6 是根据下面优选实施例的测量手机电池电量的方法的示意图，该方法包括：

[0097] 步骤 S601，获得手机在进行语音通话时的电池电压的实时值。进入电池电压检测阶段。

[0098] 步骤 S602，可以采样 1 次，也可以采样多次，例如，电压采样 12 次得到 12 个电池电压数据。

[0099] 步骤 S603，去掉检测的电压数据中 2 个最高值及 2 个最低值，剩下 8 个数据平均后的数值。

[0100] 步骤 S604，对剩下的 8 个数据取平均，之后得到的数值为当前电压的平均值。

[0101] 在采样一次的情况下，步骤 S602 至 S604 是可选的步骤，在采样多次的情况下，步骤 S603 也是可选的。

[0102] 步骤 S605，判断当前通话所处状态。本实施例中该阶段是语音通话中，对应的状态是 Call_hold。

[0103] 步骤 S606，获得手机在语音通话时对应的电压波动补偿值。

[0104] 获得的状态是 Call_hold，查找表 1 得到对应的电压补偿值是 20mV。

[0105] 步骤 S607，判断进入语音通话前电池电压的稳定值。假设进入通话前的电池电压为 3.8V。

[0106] 步骤 S608，获得手机在语音通话时对应的电压波动补偿值。查找表 2 中 3.8V 对应的电压补偿比例是 1.0，因此，实际的补偿值为 20×1.0 = 20mV。

[0107] 步骤 S609，电压补偿值变为 20*1 = 20mV。

[0108] 步骤 S610，判断电池的使用时间。假设电池使用时间为半年。

[0109] 步骤 S611，查表 3 电池使用时间为半年对应的电池电压补偿比例为 1.05。

[0110] 步骤 S612，电压补偿值变为 20*1.05 = 21mV。

[0111] 步骤 S613，根据电压补偿值对实际测量的电池电压进行补偿。语音通话中的电压检测中得到的电池电压的值为 3.76+0.021 = 3.781V。然后，根据预先设置的电压和电量的关系确定电池的电量。

[0112] 使用本发明提供的方法，在检测电压的过程中通过补偿实时测量的电压抵消了部分电池电压波动的影响，所测量的电池电压更接近电池的实际电压，避免了电池电压的剧烈波动导致检测到过低的电压值，使得用户误以为电池电量已经耗尽而低估手机实际的使用时间。本发明的方法通过简单的变换，即可应用到手机在进行摄像、播放 MP3、MP4 等功耗较大的应用的场合。

[0113] 图 7 是根据本发明实施例的测量手机电池电量的装置的结构框图，该装置包括：测量模块 72，第一补偿模块 74，确定模块 76。其中，测量模块 72，用于在应用场景下的一个

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阶段实时测量电池的电压；第一补偿模块 74 耦合至测量模块 72，用于使用对应于阶段的电压补偿值补偿实时测量的电压；确定模块 76 耦合至第一补偿模块 74，用于根据补偿后的电压确定电池的电量。

[0114] 该实施例利用对应于应用场景的相应阶段的电压补偿值补偿实时测量的手机电池的电压，并根据补偿后的电压确定电量，解决了相关技术中手机在应用场景不同阶段时实际测量的电量与手机在待机状态测量到的电量不同的问题，实现了准确测量手机电池电量的目的，使得用户能够准确判断手机电池的实际使用时间。

[0115] 图 8 是根据本发明实施例的测量手机电池电量的装置的具体的结构框图一，第一补偿模块 74 包括：第一获取模块 82，第一调整模块 84，第二补偿模块 86。其中，第一获取模块 82，用于获取电池的使用时间；第一调整模块 84 耦合至第一获取模块 82，用于使用对应于使用时间的第一调整比例调整电压补偿值；第二补偿模块 86 耦合至第一调整模块 84，用于使用调整后的电压补偿值补偿实时测量的电压。

[0116] 该实施例根据电池进入应用场景前的电压值调整电压补偿值，使得测量得到的电池电量更为准确。

[0117] 图 9 是根据本发明实施例的测量手机电池电量的装置的具体的结构框图二，第一补偿模块 74 包括：第二获取模块 92，第二调整模块 94，第三补偿模块 96。其中，第二获取模块 92，用于获取电池进入应用场景前的电压值；第二调整模块 94 耦合至第二获取模块 92，用于使用对应于电压值的第二调整比例调整电压补偿值；以及第三补偿模块 96 耦合至第二调整模块 94，用于使用调整后的电压补偿值补偿实时测量的电压。

[0118] 该实施例根据电池进入应用场景前的电压值调整电压补偿值，使得测量得到的电池电量更为准确。

[0119] 综上所述，通过本发明，解决了相关技术中手机在应用场景不同阶段时实际测量的电量与手机在待机状态测量到的电量不同的问题，进而达到了准确测量手机电池电量的效果。

[0120] 显然，本领域的技术人员应该明白，上述的本发明的各模块或各步骤可以用通用的计算装置来实现，它们可以集中在单个的计算装置上，或者分布在多个计算装置所组成的网络上，可选地，它们可以用计算装置可执行的程序代码来实现，从而，可以将它们存储在存储装置中由计算装置来执行，并且在某些情况下，可以以不同于此处的顺序执行所示出或描述的步骤，或者将它们分别制作成各个集成电路模块，或者将它们中的多个模块或步骤制作成单个集成电路模块来实现。这样，本发明不限制于任何特定的硬件和软件结合。

[0121] 以上所述仅为本发明的优选实施例而已，并不用于限制本发明，对于本领域的技术人员来说，本发明可以有各种更改和变化。凡在本发明的精神和原则之内，所作的任何修改、等同替换、改进等，均应包含在本发明的保护范围之内。

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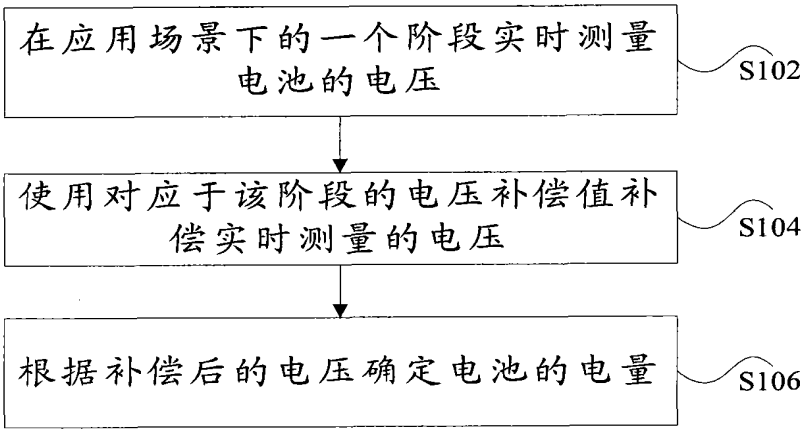


图 1

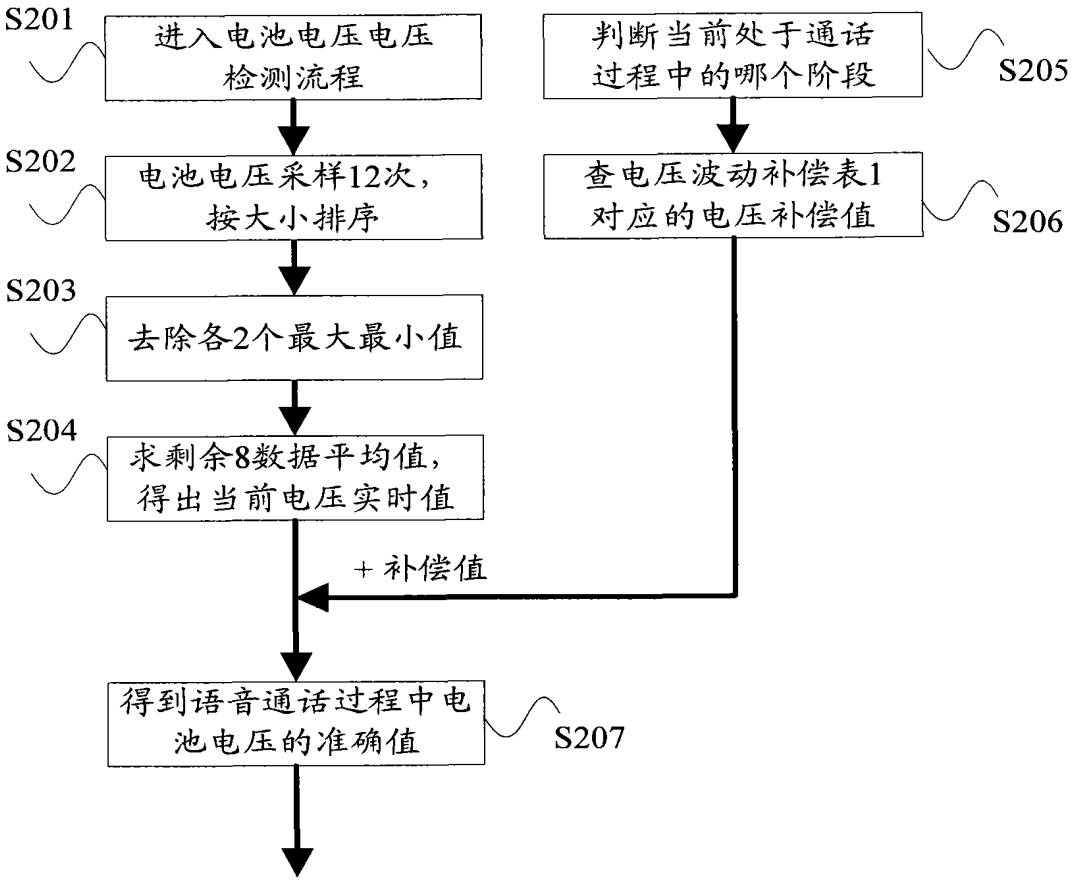


图 2

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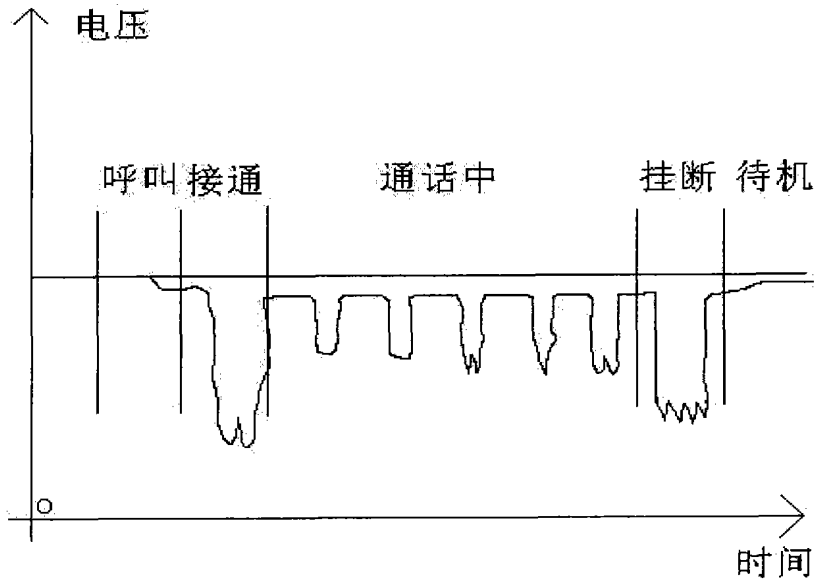


图 3

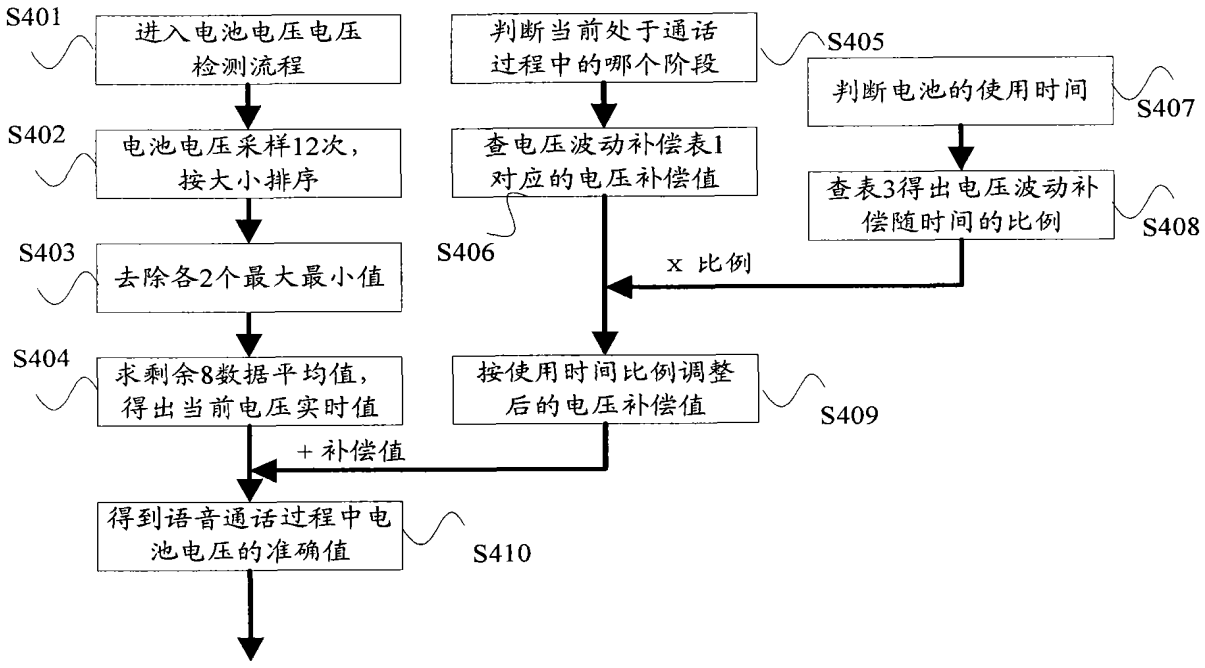


图 4

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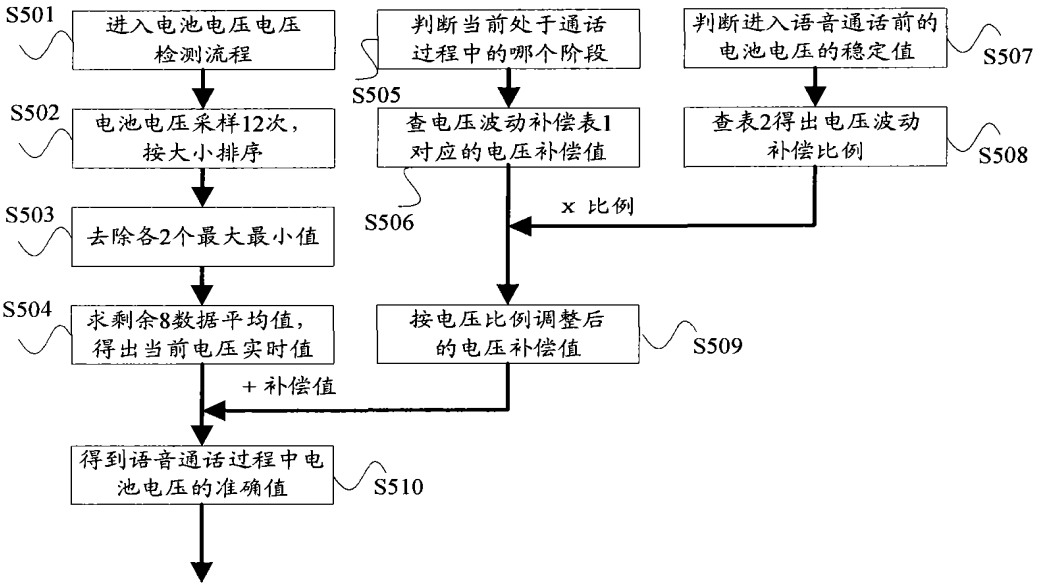


图 5

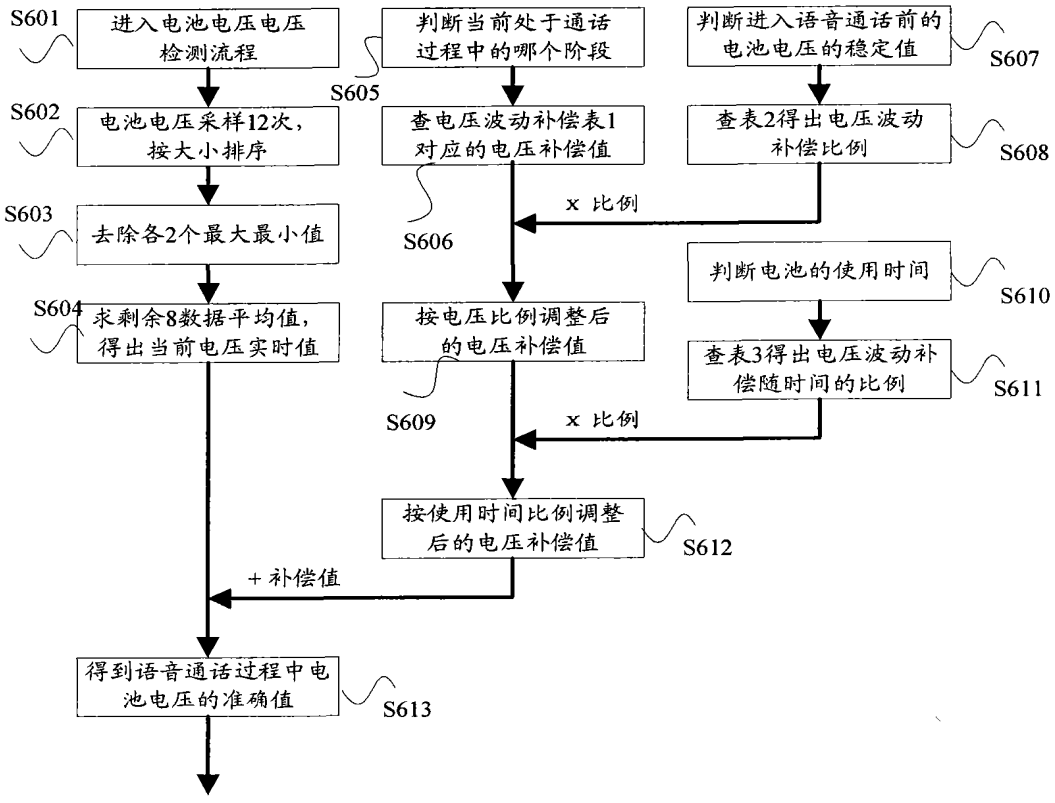


图 6

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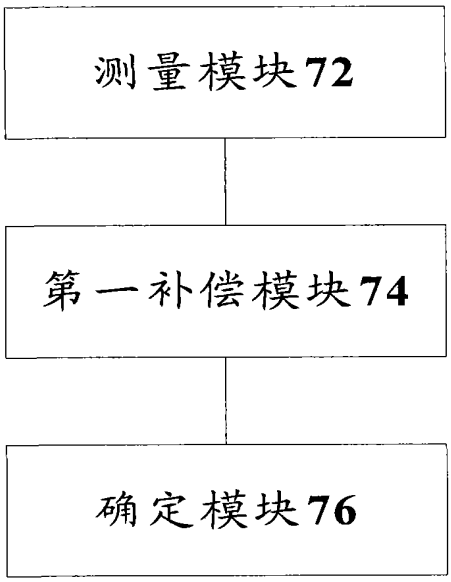


图 7

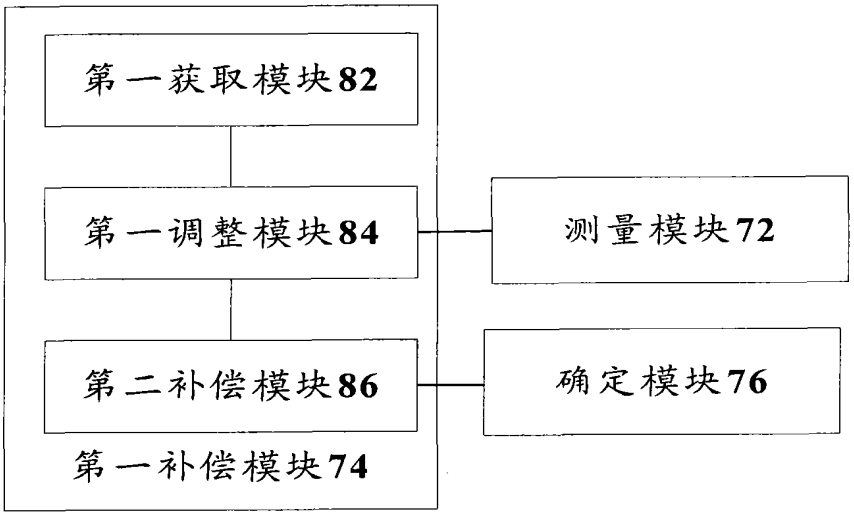


图 8

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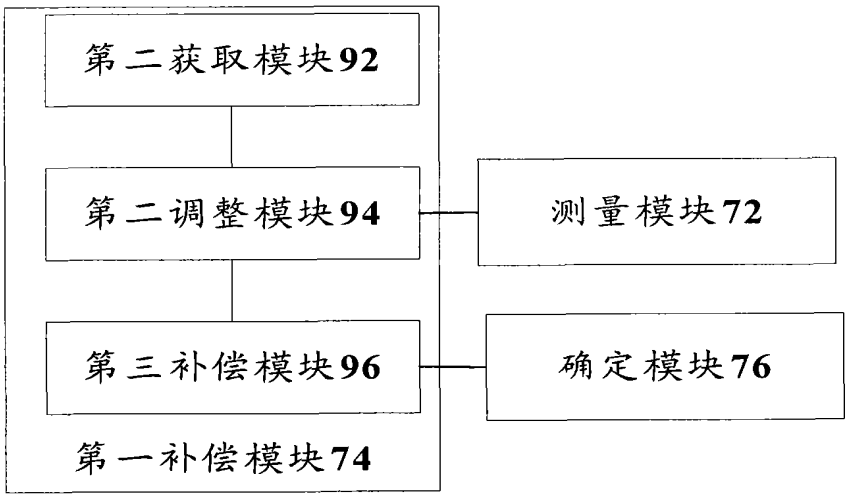


图 9

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Espacenet

Bibliographic data: JP2013115867 (A) — 2013-06-10

DRIVE DEVICE

Inventor(s): SUHAMA MASAYOSHI; MORISAKI KEISUKE ± (SUHAMA MASAYOSHI, ; MORISAKI KEISUKE)

Applicant(s): TOYOTA MOTOR CORP ± (TOYOTA MOTOR CORP)

Classification: - international: ***B60L11/18; B60L3/00; B60L9/18; H02P27/06***
- cooperative: Y02T10/7005

Application number: JP20110257652 20111125 Global Dossier

Priority number(s): JP20110257652 20111125

Abstract of JP2013115867 (A)

PROBLEM TO BE SOLVED: To use a secondary battery properly while restraining a drive system including an electric motor from resonating.SOLUTION: A target correction amount Taj* is calculated as a correction amount in feedback control so that when a battery voltage Vb exceeds a compensation voltage Vref as an upper limit voltage in a proper battery usage range, the battery voltage Vb will be equal to or less than the compensation voltage Vref (S170). The calculated target correction amount Taj* is used basically as a correction amount Taj in setting a total torque command Tm*, and when the target correction amount Taj* decreases, a value of the target correction amount Taj* before it began to decrease is retained as a correction amount Taj over a prescribed time which was predetermined as a time different than the resonance frequency cycle of a drive system including a motor, which value is used when the motor torque command Tm* is set (S220, S230). This makes it possible to restrain the drive system including the motor from resonating, as well as to use the battery properly.

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B60L 3/00	(2006.01)	B60L	3/00	S	5H505
B60L 11/18	(2006.01)	B60L	11/18	A	
B60L 9/18	(2006.01)	B60L	9/18	J	

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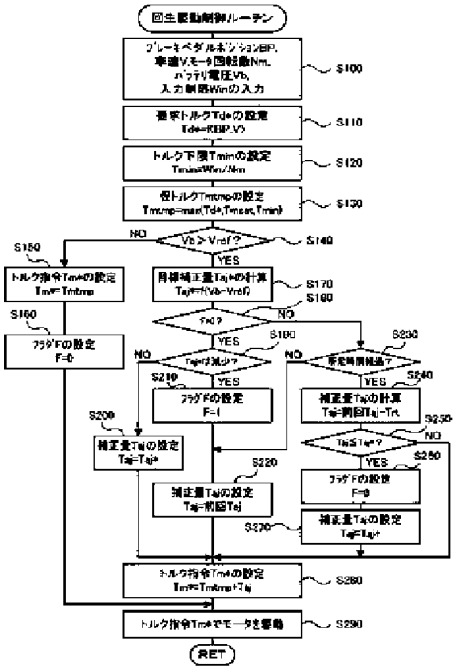
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(54)【発明の名称】駆動装置

(57)【要約】
【課題】電動機を含む駆動系の共振の発生を抑制しつつ二次電池を適正使用する。
【解決手段】バッテリ電圧Ｖｂがバッテリの適正な使用範囲における電圧上限値としての補償電圧Ｖｒｅｆを超えているときには、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆ以下になるようフィードバック制御における補正量として目標補正量Ｔａｊ＊を計算し（Ｓ１７０）、計算した目標補正量Ｔａｊ＊を基本的には補正量Ｔａｊとしてモータトルク指令Ｔｍ＊を設定する際に用い、目標補正量Ｔａｊ＊が減少したときには、モータを含む駆動系の共振周波数の周期とは異なる時間として予め定められた所定時間に亘って、目標補正量Ｔａｊ＊が減少する前の値を補正量Ｔａｊとして保持してモータトルク指令Ｔｍ＊を設定する際に用いる（Ｓ２２０，Ｓ２３０）。これにより、モータを含む駆動系が共振するのを抑制することができると共にバッテリを適正使用することができる。
【選択図】図２



【特許請求の範囲】
【請求項１】
充放電可能な電動機と、前記電動機と電力のやりとりを行なう二次電池と、前記電動機からの回生電力により前記二次電池を充電する際に該二次電池の管理に用いる電池用パラメータが前記二次電池を適正使用するために設けられた上限値を超えるときには前記電池用パラメータと前記上限値との差に基づく目標補正量を用いて前記電動機の駆動に用いる制御量を補正する制御手段と、を備える駆動装置であって、
前記制御手段は、前記目標補正量の絶対値が小さく変化するときには、所定時間に亘って変化する前の補正量を用いて前記電動機の駆動に用いる制御量を補正する手段である、
ことを特徴とする駆動装置。
【請求項２】
請求項１記載の駆動装置であって、
前記所定時間は、前記電動機を含む駆動系の共振周波数における周期とは異なる時間として予め設定されてなる、
駆動装置。
【請求項３】
請求項１または２記載の駆動装置であって、
前記制御手段は、前記目標補正量の絶対値が小さく変化して前記所定時間経過した以降は、前記所定時間に亘って用いた補正量を前記目標補正量に向けて単調に変化させた単調変化値が前記目標補正量に一致するまで該単調変化値を補正量として用いて前記電動機の駆動に用いる制御量を補正する手段である、
駆動装置。
【請求項４】
請求項１ないし３のうちのいずれか一つの請求項に記載の駆動装置であって、
前記電池用パラメータは、前記二次電池の許容最大電圧，前記二次電池の許容最大入力電流，前記二次電池の許容最大入力電力のうちのいずれかである、
駆動装置。
【請求項５】
請求項１ないし４のうちのいずれか一つの請求項に記載の駆動装置であって、
前記制御量は、前記電動機のトルク指令である、
駆動装置。
【請求項６】
請求項１ないし４のうちのいずれか一つの請求項に記載の駆動装置であって、
前記制御量は、前記電動機の駆動に用いる制御用の前記二次電池の入力電力制限である、
駆動装置。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、駆動装置に関し、詳しくは、充放電可能な電動機と、電動機と電力のやりとりを行なう二次電池と、電動機からの回生電力により二次電池を充電する際に二次電池の管理に用いる電池用パラメータが二次電池を適正使用するために設けられた上限値を超えるときには電池用パラメータと上限値との差に基づく目標補正量を用いて電動機の駆動に用いる制御量を補正する制御手段と、を備える駆動装置に関する。
【背景技術】
【０００２】
従来、この種の駆動装置としては、二次電池の蓄電量（ＳＯＣ）と二次電池の温度に対して決定された二次電池の充電の際に上限値としての充電上限パワーをモータ回転数で除して得られる回生トルク上限値とモータ定格と比較することによって回生トルク目標値を求め、二次電池の電圧が許容電圧を超えたときには、二次電池の電圧と許容電圧との差に

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基づくフィードバック制御により回生トルク目標値を補正するものが提案されている（例えば、特許文献１参照）。この装置では、回生トルク目標値をフィードバック制御により補正することにより、二次電池の電圧が許容電圧を超えるのを抑制している。

【先行技術文献】

【特許文献】

【０００３】

【特許文献１】特開２００３－１２５５０２号公報

【発明の概要】

【発明が解決しようとする課題】

【０００４】

しかしながら、上述の駆動装置では、フィードバック制御によりモータの回生トルク目標値を補正することから、回生トルク目標値が変動し、モータを含む駆動系に共振が生じる場合がある。フィードバック制御によって補正される回生トルク目標値の変動周期がモータを含む駆動系の固有の共振周波数に一致すると、モータからの出力トルクの変動により駆動系が共振してしまう。駆動装置を搭載する車両では、駆動系の共振は乗員に違和感を与えてしまう。

【０００５】

本発明の駆動装置は、電動機を含む駆動系の共振の発生を抑制しつつ二次電池を適正使用することを主目的とする。

【課題を解決するための手段】

【０００６】

本発明の駆動装置は、上述の主目的を達成するために以下の手段を採った。

【０００７】

本発明の駆動装置は、

充放電可能な電動機と、前記電動機と電力のやりとりを行なう二次電池と、前記電動機からの回生電力により前記二次電池を充電する際に該二次電池の管理に用いる電池用パラメータが前記二次電池を適正使用するために設けられた上限値を超えるときには前記電池用パラメータと前記上限値との差に基づく目標補正量を用いて前記電動機の駆動に用いる制御量を補正する制御手段と、を備える駆動装置であって、

前記制御手段は、前記目標補正量の絶対値が小さく変化するときには、所定時間に亘って変化する前の補正量を用いて前記電動機の駆動に用いる制御量を補正する手段である、

ことを特徴とする。

【０００８】

この本発明の駆動装置では、二次電池の管理に用いる電池用パラメータと二次電池を適正使用するために設けられた上限値との差に基づく目標補正量の絶対値が小さく変化するときには、所定時間に亘って変化する前の補正量を用いて電動機の駆動に用いる制御量を補正する。これにより、電動機の駆動に用いる制御量の変動周期が電動機を含む駆動系の共振周波数に一致するのを抑制することができ、駆動系の共振を抑制することができる。もとより、電池用パラメータと上限値との差に基づく目標補正量を用いて電動機の駆動に用いる制御量を補正するから、二次電池を適正使用することができる。ここで、所定時間としては、電動機を含む駆動系の共振周波数における周期とは異なる時間として予め定められてなるものとすることができ、例えば、１００ｍｓｅｃや２００ｍｓｅｃ，３００ｍｓｅｃなどを用いることができる。

【０００９】

こうした本発明の駆動装置において、前記制御手段は、前記目標補正量の絶対値が小さく変化して前記所定時間経過した以降は、前記所定時間に亘って用いた補正量を前記目標補正量に向けて単調に変化させた単調変化値が前記目標補正量に一致するまで該単調変化値を補正量として用いて前記電動機の駆動に用いる制御量を補正する手段である、ものとすることもできる。こうすれば、補正量が急変するのを抑制することができる。ここで単調に変化させる程度としては、電動機を十分に駆動することができる程度が好ましい。

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【００１０】
また、本発明の駆動装置において、前記電池用パラメータは、前記二次電池の許容最大電圧，前記二次電池の許容最大入力電流，前記二次電池の許容最大入力電力のうちのいずれかであるものとすることもできる。また、前記制御量は前記電動機のトルク指令であるものとすることもできる。さらに、前記制御量は、前記電動機の駆動に用いる制御用の前記二次電池の入力電力制限であるものとすることもできる。制御用の二次電池の入力電力制限を超えないように電動機を駆動制御することにより、電池用パラメータが上限値を超えないように抑制することができる。
【図面の簡単な説明】
【００１１】
【図１】第１実施例の電気自動車２０の構成の概略を示す構成図である。
【図２】第１実施例の電子制御ユニット５０により実行される回生駆動制御ルーチンの一例を示すフローチャートである。
【図３】要求トルク設定用マップの一例を示す説明図である。
【図４】バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えたときの目標補正量Ｔａｊ＊と補正量Ｔａｊの時間的変化の一例を示す説明図である。
【図５】第２実施例の電子制御ユニット５０により実行される回生駆動制御ルーチンの一例を示すフローチャートである。
【図６】変形例のハイブリッド自動車１２０の構成の概略を示す構成図である。
【図７】変形例のハイブリッド自動車２２０の構成の概略を示す構成図である。
【発明を実施するための形態】
【００１２】
次に、本発明を実施するための形態を実施例を用いて説明する。
【実施例１】
【００１３】
図１は、本発明の第１実施例の駆動装置を搭載する電気自動車２０の構成の概略を示す構成図である。第１実施例の電気自動車２０は、図示するように、例えば同期発電電動機として構成されて駆動輪２６ａ，２６ｂにデファレンシャルギヤ２４を介して接続された駆動軸２２に動力を入出力可能なモータ３２と、モータ３２を駆動するためのインバータ３４と、例えばリチウムイオン二次電池として構成されたバッテリ３６と、インバータ３４が接続された電力ライン（以下、高電圧系電力ラインという）４４とバッテリ３６が接続された電力ライン（以下、電池電圧系電力ラインという）４２とに接続されて高電圧系電力ライン４４の電圧ＶＨを電池電圧系電力ライン２２の電圧ＶＬ以上かつ最大許容電圧ＶＨｍａｘ以下の範囲内で調節すると共に高電圧系電力ライン４４と電池電圧系電力ライン４２との間で電力のやりとりを行なう昇圧コンバータ４０と、駆動輪２６ａ，２６ｂや図示しない従動輪のブレーキを制御するためのブレーキアクチュエータ７２と、車両全体をコントロールする電子制御ユニット５０と、を備える。また、電池電圧系電力ライン４２には、バッテリ３６を遮断するためのシステムメインリレー（ＳＭＲ）４１が取り付けられていると共にシステムメインリレー５２と昇圧コンバータ４０との間には平滑用のコンデンサ４６が取り付けられており、高電圧系電力ライン４４にも平滑用のコンデンサ４８が取り付けられている。
【００１４】
モータ３２は、永久磁石が埋め込まれたロータと三相コイルが巻回されたステータとを備える周知の同期発電電動機として構成されており、回転に伴って逆起電圧を発生する。インバータ３４は、図示しないが、６つのスイッチング素子としてのトランジスタと、６つのトランジスタの各々に逆方向に並列接続された６つのダイオードと、により周知のインバータとして構成されている。昇圧コンバータ４０は、図示しないが、２つのトランジスタとこの２つのトランジスタに逆方向に並列接続された２つのダイオードとリアクトルとからなる周知の昇圧コンバータとして構成されている。
【００１５】

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ブレーキアクチュエータ７２は、ブレーキペダル６５の踏み込みに応じて生じるブレーキマスターシリンダ７０の圧力（ブレーキ圧）と車速Ｖとにより車両に作用させる制動力におけるブレーキの分担分に応じた制動力が駆動輪２６ａ，２６ｂや図示しない従動輪に作用するよう各車輪に取り付けられた図示しないブレーキホイールシリンダの油圧を調整したり、ブレーキペダル８５の踏み込みに無関係に、駆動輪２６ａ，２６ｂや従動輪に制動力が作用するようブレーキホイールシリンダの油圧を調整したりすることができるように構成されている。以下、ブレーキアクチュエータ７２の作動により駆動輪２６ａ，２６ｂや従動輪に作用させる制動力を油圧ブレーキと称することがある。このブレーキアクチュエータ７２は、ブレーキ用電子制御ユニット（以下、ブレーキＥＣＵという）７４により制御されている。ブレーキＥＣＵ７４は、電子制御ユニット５０と通信しており、電子制御ユニット５０からの制御信号によってブレーキアクチュエータ７２を駆動制御したり、必要に応じてブレーキアクチュエータ７２の状態に関するデータを電子制御ユニット５０に出力する。

【００１６】

電子制御ユニット５０は、ＣＰＵ５２を中心とするマイクロプロセッサとして構成されており、ＣＰＵ５２の他に処理プログラムを記憶するＲＯＭ５４と、データを一時的に記憶するＲＡＭ５６と、図示しない入出力ポートと、を備える。電子制御ユニット５０には、モータ３２のロータの回転位置を検出する回転位置検出センサ３２ａからのモータ３２のロータの回転位置や、モータ３２とインバータ３４との接続ライン（電力ライン）に取り付けられた図示しない電流センサからの相電流，バッテリ３６の端子間に設置された図示しない電圧センサからの端子間電圧Ｖｂ，バッテリ３６の出力端子に接続された電力ラインに取り付けられた図示しない電流センサからの充放電電流，バッテリ３６に取り付けられた図示しない温度センサからの電池温度，コンデンサ４６の端子間に取り付けられた電圧センサ４６ａからのコンデンサ４６の電圧（電池電圧系電力ライン４２の電圧）ＶＬ，コンデンサ４８の端子間に取り付けられた電圧センサ４８ａからのコンデンサ４８の電圧（高電圧系電力ライン４４の電圧）ＶＨ，低圧側電力ライン４２に取り付けられた電流センサ４６ｂからの電流Ｉｂ，スタートスイッチ６０からのスタート信号，シフトレバー６１の操作位置を検出するシフトポジションセンサ６２からのシフトポジションＳＰ，アクセルペダル６３の踏み込み量を検出するアクセルペダルポジションセンサ６４からのアクセル開度Ａｃｃ，ブレーキペダル６５の踏み込み量を検出するブレーキペダルポジションセンサ６６からのブレーキペダルポジションＢＰ，車速センサ６８からの車速Ｖなどが入力ポートを介して入力されている。電子制御ユニット５０からは、インバータ３４のトランジスタへのスイッチング制御信号や昇圧コンバータ４０のトランジスタへのスイッチング制御信号，システムメインリレー４１への駆動信号などが出力ポートを介して出力されている。なお、電子制御ユニット５０は、回転位置検出センサ３２ａからのモータ３２のロータの回転位置に基づいてモータ３２の回転数Ｎｍを演算したり、電圧センサ４６ａからの電圧ＶＬや電流センサ４６ｂからの電流Ｉｂに基づいてバッテリ３６から放電可能な電力量の全容量に対する割合としての蓄電割合ＳＯＣを演算したり、蓄電割合ＳＯＣやバッテリ３６の温度に基づいてバッテリ３６を充放電してもよい最大電力としての入出力制限Ｗｉｎ，Ｗｏｕｔを演算したりしている。

【００１７】

こうして構成された第１実施例の電気自動車２０は、図示しない駆動制御ルーチンにより駆動制御されている。駆動制御では、アクセルペダルポジションセンサ６４からのアクセル開度Ａｃｃと車速センサ６８からの車速Ｖとに応じて駆動軸２２に出力すべき要求トルクＴｒ＊を設定し、設定した要求トルクＴｒ＊をモータ３２から出力すべきトルク指令Ｔｍ＊として設定し、設定したトルク指令Ｔｍ＊と回転数Ｎｍとからなる動作点でモータ３２を駆動するのに必要な電圧を高電圧系電力ライン４４の目標電圧ＶＨ＊として設定し、設定したトルク指令Ｔｍ＊でモータ３２が駆動されるようインバータ３４のトランジスタをスイッチング制御すると共に高電圧系電力ライン４４の電圧ＶＨが目標電圧ＶＨ＊となるよう昇圧コンバータ４０のトランジスタをスイッチング制御する。走行中にアクセオ

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フして減速するときには、ブレーキペダル６５の踏み込み量と車速Ｖとに応じて制動力としての要求トルクＴｒ＊（負の値のトルク）を設定し、設定した要求トルクＴｒ＊のうちモータ３２の定格値の範囲内で出力可能なトルクをトルク指令Ｔｍ＊として設定し、設定したトルク指令Ｔｍ＊と回転数Ｎｍとからなる動作点でモータ３２を駆動するのに必要な電圧を高電圧系電力ライン４４の目標電圧ＶＨ＊として設定し、設定したトルク指令Ｔｍ＊でモータ３２が駆動されるようインバータ３４のトランジスタをスイッチング制御すると共に高電圧系電力ライン４４の電圧ＶＨが目標電圧ＶＨ＊となるよう昇圧コンバータ４０のトランジスタをスイッチング制御する。制動力としての要求トルクＴｒ＊のうちモータ３２からの制動トルク出力では不足する制動トルクは、これに相当する制動力が図示しない油圧ブレーキ装置から出力されるよう油圧ブレーキ装置を制御する。そして、車速が小さくなると車両にショックなどを生じさせずに車両をスムーズに停止するために、モータ３２による制動力を油圧ブレーキ装置による制動力に置き換える処理が行なわれる。

【００１８】

次に、第１実施例の電気自動車２０の制動時におけるモータ３２の駆動制御について説明する。図２は、制動時に電子制御ユニット５０により実行される回生駆動制御ルーチンの一例を示すフローチャートである。このルーチンは、アクセルオフ時に所定時間毎（例えば、数ｍｓｅｃ毎）に繰り返し実行される。

【００１９】

回生駆動制御ルーチンが実行されると、電子制御ユニット５０のＣＰＵ５２は、まず、ブレーキペダルポジションセンサ６６からのブレーキペダルポジションＢＰや車速センサ６８からの車速Ｖ，モータ３２の回転数Ｎｍ，バッテリ電圧Ｖｂ，バッテリ３６の入力制限Ｗｉｎなどのモータ３２の駆動制御に用いるデータを入力する処理を実行する（ステップＳ１００）。ここで、モータ３２の回転数Ｎｍは、回転位置検出センサ３２ａからのモータ３２のロータの回転位置に基づいて演算されてＲＡＭ５６の所定領域に記憶された回転数Ｎｍを読み込むことにより入力するものとした。バッテリ電圧Ｖｂは、電圧センサ４６により検出された電圧ＶＬを用いるものとした。バッテリ３６の入力制限Ｗｉｎは、蓄電割合ＳＯＣやバッテリ３６の温度に基づいて演算されてＲＡＭ５６の所定領域に記憶された入力制限Ｗｉｎを読み込むことにより入力するものとした。

【００２０】

こうしてデータを入力すると、入力したブレーキペダルポジションＢＰと車速Ｖとに基づいて駆動軸２２に出力すべき制動トルクとしての要求トルクＴｄ＊を設定すると共に（ステップＳ１１０）、入力した入力制限Ｗｉｎをモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定し（ステップＳ１２０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２から出力すべき仮のトルク（仮トルク）Ｔｍｔｍｐとして設定する（ステップＳ１３０）。ここで、要求トルクＴｄ＊は、第１実施例では、ブレーキペダルポジションＢＰと車速Ｖと要求トルクＴｄ＊との関係を予め定めて要求トルク設定用マップとしてＲＯＭ５４に記憶しておき、ブレーキペダルポジションＢＰと車速Ｖとが与えられるとマップから対応する要求トルクＴｄ＊を導出することにより設定するものとした。要求トルク設定用マップの一例を図３に示す。図示するように、第１実施例では、要求トルクＴｄ＊は制動トルクのときには負の値として設定される。また、回生側の定格トルクＴｍｓｅｔもトルク下限Ｔｍｉｎも負の値であるから、要求トルクＴｄ＊と定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものを仮トルクＴｍｔｍｐとして設定する処理は、要求トルクＴｄ＊と定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎのそれぞれの絶対値が最も小さいものを仮トルクＴｍｔｍｐとして設定するとなる。この処理は、要求トルクＴｄ＊を入力制限Ｗｉｎと定格トルクＴｍｓｅｔにより制限する処理ということもできる。

【００２１】

続いて、バッテリ電圧Ｖｂをバッテリ３６の適正な使用範囲における電圧上限値として予め定められている補償電圧Ｖｒｅｆと比較し（ステップＳ１４０）、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆ以下のときには、バッテリ３６は適正使用範囲で使用されていると判

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断し、仮トルクＴｍｔｍｐをモータ３２のトルク指令Ｔｍ＊として設定すると共に（ステップＳ１５０）、補正量減少フラグＦに値０をセットし（ステップＳ１６０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。このようにモータ３２を制御することにより、バッテリ３６を適正使用しつつ、駆動軸２２に要求される要求トルクＴｄ＊をバッテリ３６の入力制限Ｗｉｎとモータ３２の定格トルクＴｍｓｅｔで制限した回生トルクをモータ３２から出力することができる。モータ３２から出力するトルクと要求トルクＴｄ＊との差分については、油圧ブレーキにより補われる。なお、補正量減少フラグＦについては後述する。

【００２２】

ステップＳ１４０でバッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えていると判定されたときには、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆになるようにバッテリ電圧Ｖｂと補償電圧Ｖｒｅｆとの差に基づいて次式（１）によりモータ３２から出力するトルクを制限するよう補正するための目標補正量Ｔａｊ＊を計算する（ステップＳ１８０）。式（１）は、フィードバック制御における補正量を計算する式であり、右辺第１項のＫｐは比例項のゲインであり、右辺第２項のＫｉは積分項のゲインである。第１実施例では、目標補正量Ｔａｊ＊は正の値となるよう計算するものとした。即ち、バッテリ電圧Ｖｂと補償電圧Ｖｒｅｆとの差が大きいほど大きな正の値となるよう計算するのである。

【００２３】

$$Taj^*=Kp(Vb-Vref)+Ki\int(Vb-Vref)dt \quad (1)$$

【００２４】

続いて、補正量減少フラグＦの値を調べ（ステップＳ１８０）、補正量減少フラグＦが値０のときには、前回このルーチンが実行されたときに設定された目標補正量Ｔａｊ＊（以下、前回目標補正量Ｔａｊ＊という）から目標補正量Ｔａｊ＊が減少しているか否かを判定する（ステップＳ１９０）。目標補正量Ｔａｊ＊は、モータ３２から出力するトルクを制限するために補正するものであるから、大きくなるとより大きな制限を課すことになり、小さくなるとより小さな制限を課すことになる。したがって、目標補正量Ｔａｊ＊の減少の判定は、制限を解除する方向か否かの判定となる。目標補正量Ｔａｊ＊が減少していないとき、即ち、制限を解除する方向ではないときには、目標補正量Ｔａｊ＊を補正量Ｔａｊとして設定し（ステップＳ２００）、仮トルクＴｍｔｍｐに補正量Ｔａｊを加えた値としてモータ３２のトルク指令Ｔｍ＊を設定し（ステップＳ２８０）、設定したトルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。ここで、仮トルクＴｍｔｍｐは、回生トルクであるため負の値であり、補正量Ｔａｊは正の値であるから、仮トルクＴｍｔｍｐに補正量Ｔａｊを加えて得られるトルク指令Ｔｍ＊は、絶対値としては仮トルクＴｍｔｍｐより小さなものとなる。このように、モータ３２の回生トルクを小さく補正することにより、バッテリ３６の充電電力は小さくなり、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆ以下になるようにすることができる。

【００２５】

ステップＳ１９０で目標補正量Ｔａｊ＊が減少しているとき、即ち、制限を解除する方向であるときには、補正量減少フラグＦに値１をセットすると共に（ステップＳ２１０）、前回このルーチンが実行されたときに設定された補正量Ｔａｊ（以下、前回補正量Ｔａｊという。）を新たな補正量Ｔａｊに設定し（ステップＳ２２０）、仮トルクＴｍｔｍｐに設定した補正量Ｔａｊを加えた値としてモータ３２のトルク指令Ｔｍ＊を設定し（ステップＳ２８０）、設定したトルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。即ち、目標補正量Ｔａｊ＊が減少しているときには、制限の解除を遅らせるために、目標補正量Ｔａｊ＊が減少する前の値を保持するのである。このように、目標補正量Ｔａｊ＊が減少したときに補正量減少フラグＦに値１がセットされるから、次回このルーチンが実行されたときには、ステップＳ１８０では、補正量減少フラグＦは値１であると判定される。

【００２６】

ステップＳ１８０で補正量減少フラグＦは値１であると判定されると、補正量減少フラ

グＦに値１をセットしてから所定時間経過したか否かを判定し（ステップＳ２３０）、補正量減少フラグＦに値１をセットしてから所定時間経過していないときには前回補正量Ｔａｊを新たな補正量Ｔａｊに設定すると共に（ステップＳ２２０）、仮トルクＴｍｔｍｐに設定した補正量Ｔａｊを加えた値としてモータ３２のトルク指令Ｔｍ＊を設定し（ステップＳ２８０）、設定したトルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。即ち、補正量減少フラグＦに値１をセットしてから所定時間経過するまで、目標補正量Ｔａｊ＊が減少する前の値を補正量Ｔａｊとして保持するのである。ここで、所定時間としては、モータ３２を含む駆動系の共振周波数の周期とは異なる時間として設定されており、実験などにより、例えば１００ｍｓｅｃや２００ｍｓｅｃ，３００ｍｓｅｃなどを用いることができる。

【００２７】

ステップＳ１８０で補正量減少フラグＦが値１であると判定され、且つ、ステップＳ２３０で補正量減少フラグＦに値１がセットされてから所定時間経過したと判定されたときには、前回補正量Ｔａｊからレート値Ｔｒｔを減じた値を新たな補正量Ｔａｊとして計算し（ステップＳ２４０）、計算した補正量Ｔａｊが目標補正量Ｔａｊ＊以下であるか否かを判定し（ステップＳ２５０）、補正量Ｔａｊが目標補正量Ｔａｊ＊より大きいときには、仮トルクＴｍｔｍｐに設定した補正量Ｔａｊを加えた値としてモータ３２のトルク指令Ｔｍ＊を設定し（ステップＳ２８０）、設定したトルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。この処理を繰り返し実行することにより、補正量Ｔａｊは、レート値Ｔｒｔずつ目標補正量Ｔａｊ＊の方向に小さくなる。即ち、補正量Ｔａｊは、目標補正量Ｔａｊに一致するかそれより小さくなるまで目標補正量Ｔａｊ＊に向けて単調に変化するものとなる。ここで、レート値Ｔｒｔは、補正量Ｔａｊを単調に変化させると共にモータ３２を十分に制御することができる程度の値として設定されるものである。

【００２８】

一方、ステップＳ２５０で計算した補正量Ｔａｊが目標補正量Ｔａｊ＊以下であると判定されたときには、補正量減少フラグＦに値０をセットすると共に（ステップＳ２６０）、目標補正量Ｔａｊ＊を補正量Ｔａｊに設定し（ステップＳ２７０）、仮トルクＴｍｔｍｐに設定した補正量Ｔａｊを加えた値としてモータ３２のトルク指令Ｔｍ＊を設定し（ステップＳ２８０）、設定したトルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ２９０）、本ルーチンを終了する。このように、補正量減少フラグＦに値０がセットされるから、次回本ルーチンが実行されたときには、ステップＳ１８０では補正量減少フラグＦは値０と判定されることになる。補正量減少フラグＦは、以上の説明から明らかなように、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆ以下のときには値０がセットされ、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えており、且つ、バッテリ電圧Ｖｂを補償電圧Ｖｒｅｆ以下にするためのフィードバック制御における補正量として計算される目標補正量Ｔａｊ＊が減少したときに値１がセットされ、値１がセットされてから所定時間経過し、且つ、補正量Ｔａｊをレート値Ｔｒｔを用いて単調に目標補正量Ｔａｊ＊に向けて変化させたときに補正量Ｔａｊが目標補正量Ｔａｊ以下に至ったときに値０がセットされるものとなる。

【００２９】

図４は、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えたときの目標補正量Ｔａｊ＊と補正量Ｔａｊの時間的変化の一例を示す説明図である。図中、一点鎖線が目標補正量Ｔａｊ＊を示し、実線が補正量Ｔａｊを示す。補正量Ｔａｊは、図示するように、目標補正量Ｔａｊ＊が減少する時間Ｔ１までは目標補正量Ｔａｊ＊と同様に増加するが、時間Ｔ１から時間Ｔ２までの所定時間（例えば１００ｍｓｅｃや２００ｍｓｅｃ，３００ｍｓｅｃ）は、目標補正量Ｔａｊ＊が減少する前の値を保持する。そして、時間Ｔ２から補正量Ｔａｊが目標補正量Ｔａｊ＊に一致する時間Ｔ３までは、時間の経過に対してレート値Ｔｒｔずつ単調に減少し、時間Ｔ３以降は目標補正量Ｔａｊ＊が減少するまで目標補正量Ｔａｊ＊と同様に増加する。

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【００３０】
以上説明した第１実施例の電気自動車２０が搭載する駆動装置によれば、バッテリ電圧Ｖｂがバッテリ３６の適正な使用範囲における電圧上限値として予め定められている補償電圧Ｖｒｅｆを超えているときには、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆ以下になるようフィードバック制御における補正量として目標補正量Ｔａｊ＊を計算し、計算した目標補正量Ｔａｊ＊を基本的には補正量Ｔａｊとしてモータ３２から出力すべきトルク指令Ｔｍ＊を設定する際に用い、目標補正量Ｔａｊ＊が減少したときには、モータ３２を含む駆動系の共振周波数の周期とは異なる時間として予め定められた所定時間に亘って、目標補正量Ｔａｊ＊が減少する前の値を補正量Ｔａｊとして保持してモータ３２から出力すべきトルク指令Ｔｍ＊を設定する際に用いるから、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えたときにモータ３２から出力されるトルクの変動に伴ってモータ３２を含む駆動系が共振するのを抑制することができる。しかも、補正量Ｔａｊを保持した後は、補正量Ｔａｊを、目標補正量Ｔａｊ＊に一致するまでレート値Ｔｒｔずつ目標補正量Ｔａｊ＊に向けて単調に変化させるから、補正量Ｔａｊの急変に伴ってモータ３２の出力トルクが急変することによる不都合、例えば、ショックによる乗り心地の悪化などの不都合を抑制することができる。もとより、バッテリ電圧Ｖｂを補償電圧Ｖｒｅｆ以下にすることができる。

【００３１】
第１実施例の電気自動車２０が搭載する駆動装置では、バッテリ電圧Ｖｂがバッテリ３６の適正な使用範囲における電圧上限値として予め定められている補償電圧Ｖｒｅｆを超えているか否かによって、バッテリ電圧Ｖｂを補償電圧Ｖｒｅｆ以下となるようフィードバック制御における補正量としてモータ３２のトルク指令Ｔｍ＊を設定する際に用いる目標補正量Ｔａｊ＊を計算するものとしたが、バッテリ３６に流れるバッテリ電流Ｉｂがバッテリ３６の適正な使用範囲における電流上限値として予め定められている補償電流Ｉｒｅｆを超えているか否かによって、バッテリ電流Ｉｂを補償電流Ｉｒｅｆ以下となるようフィードバック制御における補正量としてモータ３２のトルク指令Ｔｍ＊を設定する際に用いる目標補正量Ｔａｊ＊を計算するものとしてもよい。また、バッテリ３６に入力されるバッテリ入力電力Ｗｂがバッテリ３６の適正な使用範囲における入力電力上限値として予め定められている補償電力Ｗｒｅｆを超えているか否かによって、バッテリ入力電力Ｗｂを補償電力Ｗｒｅｆ以下となるようフィードバック制御における補正量としてモータ３２のトルク指令Ｔｍ＊を設定する際に用いる目標補正量Ｔａｊ＊を計算するものとしてもよい。

【００３２】
第１実施例の電気自動車２０が搭載する駆動装置では、バッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えているときには、補正量Ｔａｊを求めてモータ３２のトルク指令Ｔｍ＊を補正するものとしたが、モータ３２を電流指令によって駆動する場合には、電流指令用の補正量を求めて電流指令を補正するものとしてもよい。

【実施例２】

【００３３】
次に、本発明の第２実施例の駆動装置について説明する。第２実施例の駆動装置は、図１を用いて説明した第２実施例の電気自動車２０に搭載された駆動装置と同一のハード構成をしている。したがって、重複する説明を回避するため、第２実施例の駆動装置のハード構成についての説明は、第１実施例の駆動装置のハード構成についての説明をもって省略する。以下、図１の電気自動車２０は第２実施例の駆動装置を搭載する電気自動車２０として用いる。

【００３４】
また、第２実施例の電気自動車２０でも、第１実施例の電気自動車２０と同様に、駆動制御では、アクセルペダルポジションセンサ６４からのアクセル開度Ａｃｃと車速センサ６８からの車速Ｖとに応じて駆動軸２２に出力すべき要求トルクＴｒ＊を設定し、設定した要求トルクＴｒ＊をモータ３２から出力すべきトルク指令Ｔｍ＊として設定し、設定したトルク指令Ｔｍ＊と回転数Ｎｍとからなる動作点でモータ３２を駆動するのに必要な電

圧を高電圧系電力ライン４４の目標電圧ＶＨ＊として設定し、設定したトルク指令Ｔｍ＊でモータ３２が駆動されるようインバータ３４のトランジスタをスイッチング制御すると共に高電圧系電力ライン４４の電圧ＶＨが目標電圧ＶＨ＊となるよう昇圧コンバータ４０のトランジスタをスイッチング制御する。走行中にアクセオフして減速するときには、ブレーキペダル６５の踏み込み量と車速Ｖとに応じて制動力としての要求トルクＴｒ＊（負の値のトルク）を設定し、設定した要求トルクＴｒ＊のうちモータ３２の定格値の範囲内で出力可能なトルクをトルク指令Ｔｍ＊として設定し、設定したトルク指令Ｔｍ＊と回転数Ｎｍとからなる動作点でモータ３２を駆動するのに必要な電圧を高電圧系電力ライン４４の目標電圧ＶＨ＊として設定し、設定したトルク指令Ｔｍ＊でモータ３２が駆動されるようインバータ３４のトランジスタをスイッチング制御すると共に高電圧系電力ライン４４の電圧ＶＨが目標電圧ＶＨ＊となるよう昇圧コンバータ４０のトランジスタをスイッチング制御する。制動力としての要求トルクＴｒ＊のうちモータ３２からの制動トルク出力では不足する制動トルクは、これに相当する制動力が図示しない油圧ブレーキ装置から出力されるよう油圧ブレーキ装置を制御する。そして、車速が小さくなると車両にショックなどを生じさせずに車両をスムーズに停止するために、モータ３２による制動力を油圧ブレーキ装置による制動力に置き換える処理が行なわれる。

【００３５】

次に、第２実施例の電気自動車２０の制動時におけるモータ３２の駆動制御について説明する。図５は、制動時に電子制御ユニット５０により実行される回生駆動制御ルーチンの一例を示すフローチャートである。このルーチンは、アクセルオフ時に所定時間毎（例えば、数ｍｓｅｃ毎）に繰り返し実行される。

【００３６】

回生駆動制御ルーチンが実行されると、電子制御ユニット５０のＣＰＵ５２は、まず、ブレーキペダルポジションセンサ６６からのブレーキペダルポジションＢＰや車速センサ６８からの車速Ｖ，モータ３２の回転数Ｎｍ，バッテリ入力電力Ｗｂ，バッテリ３６の入力制限Ｗｉｎなどのモータ３２の駆動制御に用いるデータを入力する処理を実行する（ステップＳ３００）。ここで、バッテリ入力電力Ｗｂは、電圧センサ４６ａにより検出された電圧ＶＬと電流センサ４６ｂにより検出された電流Ｉｂとの積を用いるものとした。

【００３７】

こうしてデータを入力すると、入力したブレーキペダルポジションＢＰと車速Ｖとに基づいて駆動軸２２に出力すべき制動トルクとしての要求トルクＴｄ＊を図３の要求トルク設定用マップを用いて設定すると共に（ステップＳ３１０）、入力したバッテリ入力電力Ｗｂがバッテリ３６の適正な使用範囲における入力電力上限値として予め定められている補償電力Ｗｒｅｆを超えているか否かを判定する（ステップＳ３２０）。バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆ以下のときには、バッテリ３６は適正使用範囲で使用されていると判断し、バッテリ３６の入力制限Ｗｉｎを制御用入力制限Ｗｉｎ＊として設定すると共に（ステップＳ３３０）、補正量減少フラグＦに値０をセットし（ステップＳ３４０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定し（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。第２実施例でも、要求トルクＴｄ＊は制動トルクのときには負の値として設定される。また、回生側の定格トルクＴｍｓｅｔもトルク下限Ｔｍｉｎも負の値であるから、要求トルクＴｄ＊と定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをトルク指令Ｔｍ＊として設定する処理は、要求トルクＴｄ＊と定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎのそれぞれの絶対値が最も小さいものをトルク指令Ｔｍ＊として設定するとなる。この処理は、要求トルクＴｄ＊を制御用入力制限Ｗｉｎ＊と定格トルクＴｍｓｅｔにより制限する処理ということもできる。このようにモータ３２を制御することにより、バッテリ３６を適正使用しつつ、駆動軸２２に要求される要求トルクＴｄ＊をバッテリ３６の入力制限Ｗｉｎ（制御用入力制限Ｗ

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ｉｎ＊）とモータ３２の定格トルクＴｍｓｅｔで制限した回生トルクをモータ３２から出力することができる。なお、モータ３２から出力するトルクと要求トルクＴｄ＊との差分については、油圧ブレーキにより補われる。

【００３８】

ステップＳ３２０でバッテリ入力電力Ｗｂが補償電力Ｗｒｅｆを超えていると判定されたときには、バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆになるようにバッテリ入力電力Ｗｂと補償電力Ｗｒｅｆとの差に基づいて次式（２）により制御用入力制限Ｗｉｎ＊を制限する補正量Ｗａｊの設定に用いる目標補正量Ｗａｊ＊を計算する（ステップＳ３５０）。式（２）は、フィードバック制御における補正量を計算する式であり、右辺第１項のＫｐ２は比例項のゲインであり、右辺第２項のＫｉ２は積分項のゲインである。第２実施例では、目標補正量Ｗａｊ＊は正の値となるよう計算するものとした。即ち、バッテリ入力電力Ｗｂと補償電力Ｗｒｅｆとの差が大きいほど大きな正の値となるよう計算するのである。

【００３９】

$$Waj^*=Kp2(Wb-Wref)+Ki2\int(Wb-Wref)dt \quad (2)$$

【００４０】

続いて、補正量減少フラグＦの値を調べ（ステップＳ３６０）、補正量減少フラグＦが値０のときには、前回このルーチンが実行されたときに設定された目標補正量Ｗａｊ＊（以下、前回目標補正量Ｗａｊ＊という）から目標補正量Ｗａｊ＊が減少しているか否かを判定する（ステップＳ３７０）。目標補正量Ｗａｊ＊は、制御用入力制限Ｗｉｎ＊を制限するためのものであるから、大きくなるとより大きな制限を課すことになり、小さくなるとより小さな制限を課すことになる。したがって、目標補正量Ｗａｊ＊の減少の判定は、制限を解除する方向か否かの判定となる。目標補正量Ｗａｊ＊が減少していないとき、即ち、制限を解除する方向ではないときには、目標補正量Ｗａｊ＊を補正量Ｗａｊとして設定し（ステップＳ３８０）、入力制限Ｗｉｎに補正量Ｗａｊを加えた値として制御用入力制限Ｗｉｎ＊を設定し（ステップＳ４６０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定すると共に（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。ここで、制御用入力制限Ｗｉｎ＊は、トルク下限Ｔｍｉｎの設定に用いられるから、補正量Ｗａｊが大きいほど制御用入力制限Ｗｉｎ＊の絶対値は小さくなり、トルク下限Ｔｍｉｎの絶対値も小さくなる。そして、このトルク下限Ｔｍｉｎにより要求トルクＴｄ＊が制限されてモータ３２のトルク指令Ｔｍ＊を設定するから、補正量Ｗａｊが大きくなるほどモータ３２の回生トルクの絶対値は小さくなり、バッテリ３６の充電電力も小さくなり、バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆ以下になるようにすることができる。

【００４１】

ステップＳ３７０で目標補正量Ｗａｊ＊が減少しているとき、即ち、制限を解除する方向であるときには、補正量減少フラグＦに値１をセットすると共に（ステップＳ３９０）、前回このルーチンが実行されたときに設定された補正量Ｗａｊ（以下、前回補正量Ｗａｊという。）を新たな補正量Ｗａｊに設定し（ステップＳ４００）、入力制限Ｗｉｎに補正量Ｗａｊを加えた値として制御用入力制限Ｗｉｎ＊を設定し（ステップＳ４６０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定すると共に（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。即ち、目標補正量Ｗａｊ＊が減少しているときには、制限の解除を遅らせるために、目標補正量Ｗａｊ＊が減少する前の値を保持するのである。このように、目標補正量Ｗａｊ＊が減少したときに補正量減少フラ

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グＦに値１がセットされるから、次回このルーチンが実行されたときには、ステップＳ３６０では、補正量減少フラグＦは値１であると判定される。

【００４２】

ステップＳ３６０で補正量減少フラグＦは値１であると判定されると、補正量減少フラグＦに値１をセットしてから所定時間経過したか否かを判定し（ステップＳ４１０）、補正量減少フラグＦに値１をセットしてから所定時間経過していないときには前回補正量Ｗａｊを新たな補正量Ｗａｊに設定すると共に（ステップＳ４００）、以下、前回補正量Ｗａｊという。）を新たな補正量Ｗａｊに設定し（ステップＳ４００）、入力制限Ｗｉｎに補正量Ｗａｊを加えた値として制御用入力制限Ｗｉｎ＊を設定し（ステップＳ４６０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定すると共に（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。即ち、補正量減少フラグＦに値１をセットしてから所定時間経過するまで、目標補正量Ｗａｊ＊が減少する前の値を補正量Ｗａｊとして保持するのである。ここで、所定時間としては、第１実施例と同様に、モータ３２を含む駆動系の共振周波数の周期とは異なる時間として設定されており、実験などにより、例えば１００ｍｓｅｃや２００ｍｓｅｃ，３００ｍｓｅｃなどを用いることができる。

【００４３】

ステップＳ３６０で補正量減少フラグＦが値１であると判定され、且つ、ステップＳ４１０で補正量減少フラグＦに値１がセットされてから所定時間経過したと判定されると、前回補正量Ｗａｊからレート値Ｗｒｔを減じた値を新たな補正量Ｗａｊとして計算し（ステップＳ４２０）、計算した補正量Ｗａｊが目標補正量Ｗａｊ＊以下であるか否かを判定し（ステップＳ４３０）、補正量Ｗａｊが目標補正量Ｗａｊ＊より大きいときには、入力制限Ｗｉｎに補正量Ｗａｊを加えた値として制御用入力制限Ｗｉｎ＊を設定し（ステップＳ４６０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定すると共に（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。この処理を繰り返し実行することにより、補正量Ｗａｊは、レート値Ｗｒｔずつ目標補正量Ｗａｊ＊の方向に小さくなる。即ち、補正量Ｗａｊは、目標補正量Ｗａｊに一致するかそれより小さくなるまで目標補正量Ｗａｊ＊に向けて単調に変化するものとなる。ここで、レート値Ｗｒｔは、補正量Ｗａｊを単調に変化させると共にモータ３２を十分に制御することができる程度の値として設定されるものである。

【００４４】

一方、ステップＳ４３０で計算した補正量Ｗａｊが目標補正量Ｔａｊ＊以下であると判定されたときには、補正量減少フラグＦに値０をセットすると共に（ステップＳ４４０）、目標補正量Ｗａｊ＊を補正量Ｗａｊに設定し（ステップＳ４５０）、入力制限Ｗｉｎに補正量Ｗａｊを加えた値として制御用入力制限Ｗｉｎ＊を設定し（ステップＳ４６０）、設定した制御用入力制限Ｗｉｎ＊をモータ３２の回転数Ｎｍで除してトルク下限Ｔｍｉｎを設定すると共に（ステップＳ４７０）、要求トルクＴｄ＊とモータ３２の回生側の定格トルクＴｍｓｅｔとトルク下限Ｔｍｉｎとのうち最も大きいものをモータ３２のトルク指令Ｔｍ＊として設定し（ステップＳ４８０）、トルク指令Ｔｍ＊によりモータ３２を駆動制御して（ステップＳ４９０）、本ルーチンを終了する。このように、補正量減少フラグＦに値０がセットされるから、次回本ルーチンが実行されたときには、ステップＳ３６０では補正量減少フラグＦは値０と判定されることになる。

【００４５】

バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆを超えたときの補正量Ｗａｊの時間的変化は

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、図４のバッテリ電圧Ｖｂが補償電圧Ｖｒｅｆを超えたときの補正量Ｔａｊの時間的変化と同様となる。

【００４６】

以上説明した第２実施例の電気自動車２０が搭載する駆動装置によれば、バッテリ入力電力Ｗｂがバッテリ３６の適正な使用範囲における入力電力上限値として予め定められている補償電力Ｗｒｅｆを超えているときには、バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆ以下になるようフィードバック制御における補正量として目標補正量Ｗａｊ＊を計算し、計算した目標補正量Ｗａｊ＊を基本的には補正量Ｗａｊとしてバッテリ３６の入力制限Ｗｉｎに対して制御用入力制限Ｗｉｎ＊を設定する際に用い、目標補正量Ｗａｊ＊が減少したときには、モータ３２を含む駆動系の共振周波数の周期とは異なる時間として予め定められた所定時間に亘って、目標補正量Ｗａｊ＊が減少する前の値を補正量Ｗａｊとして保持して制御用入力制限Ｗｉｎ＊を設定する際に用いるから、バッテリ入力電力Ｗｂが補償電力Ｗｒｅｆを超えたときに制御用入力制限Ｗｉｎ＊が変動することに伴ってトルク下限Ｔｍｉｎおよびモータ３２から出力するトルクが変動し、これに伴ってモータ３２を含む駆動系が共振するのを抑制することができる。しかも、補正量Ｗａｊを保持した後は、補正量Ｗａｊを、目標補正量Ｗａｊ＊に一致するまでレート値Ｔｒｔずつ目標補正量Ｗａｊ＊に向けて単調に変化させるから、補正量Ｗａｊの急変に伴ってモータ３２の出力トルクが急変することによる不都合、例えば、ショックによる乗り心地の悪化などの不都合を抑制することができる。もとより、バッテリ入力電力Ｗｂを補償電力Ｗｒｅｆ以下にすることができる。

【００４７】

第２実施例の電気自動車２０が搭載する駆動装置では、バッテリ入力電力Ｗｂがバッテリ３６の適正な使用範囲における入力電力上限値として予め定められている補償電力Ｗｒｅｆを超えているか否かによって、バッテリ入力電力Ｗｂを補償電力Ｗｒｅｆ以下となるようフィードバック制御における補正量として制御用入力制限Ｗｉｎ＊を設定する際に用いる目標補正量Ｗａｊ＊を計算するものとしたが、バッテリ３６に流れるバッテリ電流Ｉｂがバッテリ３６の適正な使用範囲における電流上限値として予め定められている補償電流Ｉｒｅｆを超えているか否かによって、バッテリ電流Ｉｂを補償電流Ｉｒｅｆ以下となるようフィードバック制御における補正量として制御用入力制限Ｗｉｎ＊を設定する際に用いる目標補正量Ｗａｊ＊を計算するものとしてもよい。また、バッテリ電圧Ｖｂがバッテリ３６の適正な使用範囲における電圧上限値として予め定められている補償電圧Ｖｒｅｆを超えているか否かによって、バッテリ電圧Ｖｂを補償電圧Ｖｒｅｆ以下となるようフィードバック制御における補正量として制御用入力制限Ｗｉｎ＊を設定する際に用いる目標補正量Ｗａｊ＊を計算するものとしてもよい。

【００４８】

第１実施例や第２実施例の電気自動車２０では、昇圧コンバータ４０を備えるものとしたが、昇圧コンバータ４０を備えないものとしてもかまわない。

【００４９】

第１実施例や第２実施例では、本発明を電気自動車に搭載された駆動装置に適用するものとしたが、図６に例示するハイブリッド自動車１２０に示すように、エンジン１２２と、モータ１２４と、エンジン１２２のクランクシャフトとモータ１２４の回転軸と駆動軸２２とに３つの回転要素が接続されたプラネタリギヤ１２６と、駆動軸２２に取り付けられたモータ３２とを備える自動車に搭載された駆動装置に適用するものとしてもよいし、図７に例示するハイブリッド自動車２２０に示すように、駆動軸２２にモータ３２を取り付けると共に、モータ３２の回転軸にクラッチ２２９を介してエンジン１２２を接続する構成の自動車に搭載された駆動装置に適用するものとしてもよい。また、自動車以外の車両に搭載される駆動装置に適用するものとしてもかまわないし、車両以外のシステムに組み込まれる駆動装置に適用するものとしてもよい。

【００５０】

実施例の主要な要素と課題を解決するための手段の欄に記載した発明の主要な要素との

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対応関係について説明する。第１実施例では、モータ３２が「電動機」に相当し、バッテリ３６が「二次電池」に相当し、バッテリ電圧Ｖｂが「電池用パラメータ」に相当し、トルク指令Ｔｍ＊が「制御量」に相当し、図２の回生駆動制御ルーチンを実行する電子制御ユニット５０が「制御手段」に相当する。第２実施例では、モータ３２が「電動機」に相当し、バッテリ３６が「二次電池」に相当し、バッテリ入力電圧Ｗｂが「電池用パラメータ」に相当し、制御用入力制限Ｗｉｎ＊が「制御量」に相当し、図５の回生駆動制御ルーチンを実行する電子制御ユニット５０が「制御手段」に相当する。

【００５１】

なお、実施例の主要な要素と課題を解決するための手段の欄に記載した発明の主要な要素との対応関係は、実施例が課題を解決するための手段の欄に記載した発明を実施するための形態を具体的に説明するための一例であることから、課題を解決するための手段の欄に記載した発明の要素を限定するものではない。即ち、課題を解決するための手段の欄に記載した発明についての解釈はその欄の記載に基づいて行なわれるべきものであり、実施例は課題を解決するための手段の欄に記載した発明の具体的な一例に過ぎないものである。

【００５２】

以上、本発明を実施するための形態について実施例を用いて説明したが、本発明はこうした実施例に何等限定されるものではなく、本発明の要旨を逸脱しない範囲内において、種々なる形態で実施し得ることは勿論である。

【産業上の利用可能性】

【００５３】

本発明は、駆動装置の製造産業などに利用可能である。

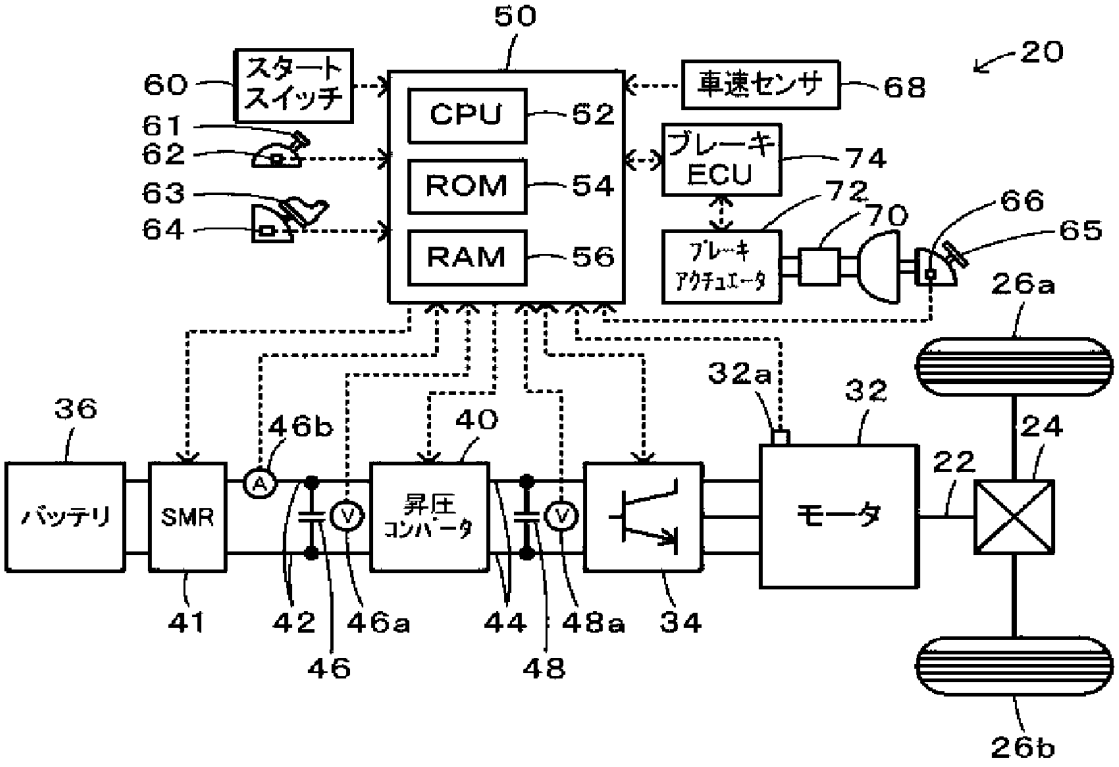
【符号の説明】

【００５４】

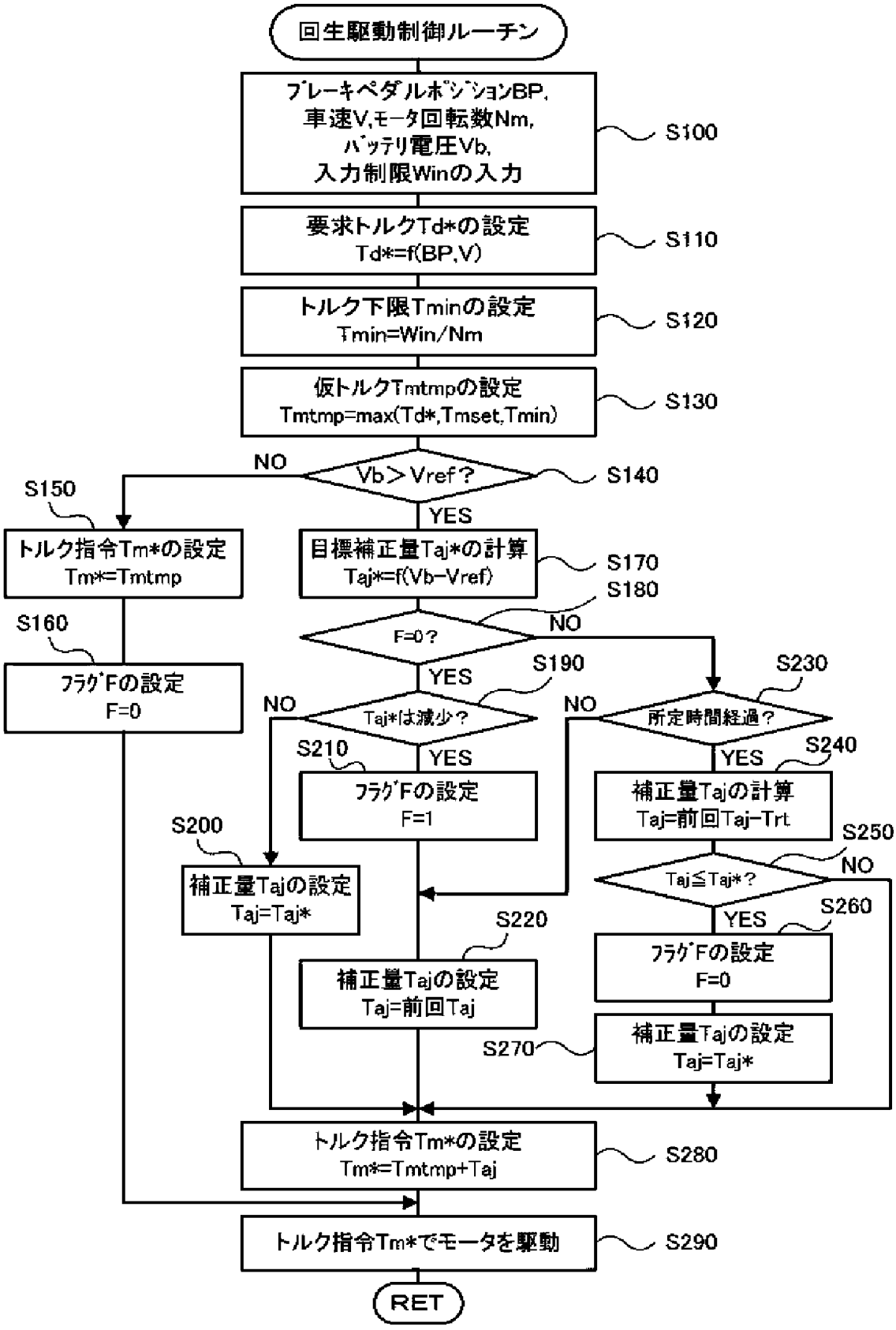
２０　電気自動車、２２　駆動軸、２４　デファレンシャルギヤ、２６　バッテリ、２６ａ，２６ｂ　駆動輪、３２　モータ、３２ａ　回転位置検出センサ、３４　インバータ、３６　バッテリ、４０　昇圧コンバータ、４１　システムメインリレー、４２　電池電圧系電力ライン、４４　高電圧系電力ライン、４６　コンデンサ、４６ａ　電圧センサ、４６ｂ　電流センサ、４８　コンデンサ、４８ａ　電圧センサ、５０　電子制御ユニット、５２　ＣＰＵ、５４　ＲＯＭ、５６　ＲＡＭ、６０　スタートスイッチ、６１　シフトレバー、６２　シフトポジションセンサ、６３　アクセルペダル、６４　アクセルペダルポジションセンサ、６５　ブレーキペダル、６６　ブレーキペダルポジションセンサ、６８　車速センサ、７０　ブレーキマスターシリンダ、７２　ブレーキアクチュエータ、７４　ブレーキ用電子制御ユニット（以下、ブレーキＥＣＵという）、１２０，２２０　ハイブリッド自動車、１２２　エンジン、１２４　モータ、１２６　プラネタリギヤ、２２９　クラッチ。

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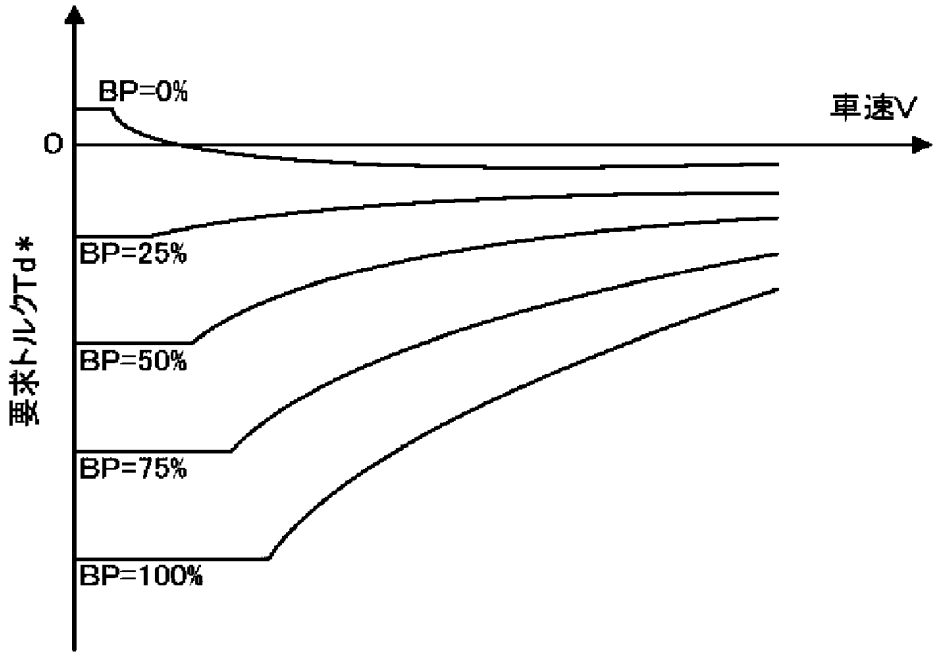
【図１】


50
20
60
スタート
スイッチ
61
62
63
64
CPU
52
ROM
54
RAM
56
車速センサ
68
ブレーキ
ECU
74
72
70
66
65
ブレーキ
アクチュエータ
26a
32a
32
36
46b
40
24
22
バッテリ
SMR
A
V
昇圧
コンバータ
モータ
41
42
46a
44
48a
34
46
48
26b

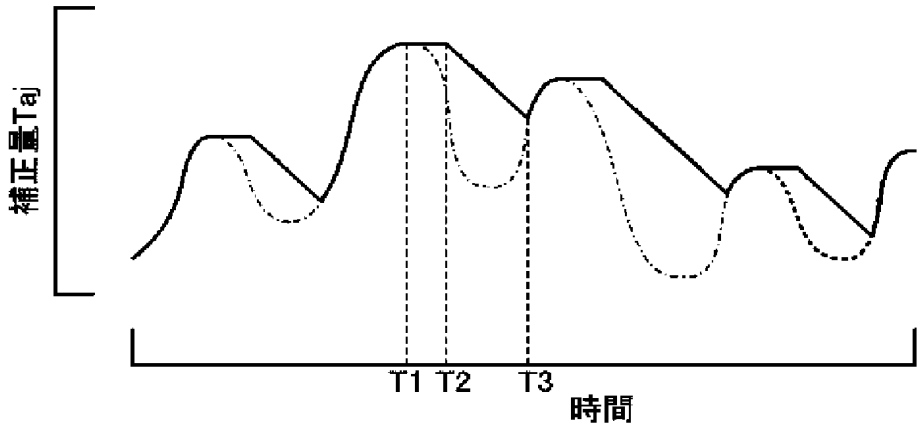
【図２】


回生駆動制御ルーチン
ブレーキペダルポジションBP,
車速V,モータ回転数Nm,
バッテリ電圧Vb,
入力制限Winの入力
S100
要求トルクTd*の設定
Td*=f(BP,V)
S110
トルク下限Tminの設定
Tmin=Win/Nm
S120
仮トルクTmtmpの設定
Tmtmp=max(Td*,Tmset,Tmin)
S130
Vb＞Vref？
S140
NO
YES
S150
トルク指令Tm*の設定
Tm*=Tmtmp
S160
フラグFの設定
F=0
目標補正量Taj*の計算
Taj*=f(Vb-Vref)
S170
S180
F=0？
NO
YES
S190
Taj*は減少？
NO
YES
S210
フラグFの設定
F=1
S200
補正量Tajの設定
Taj=Taj*
S220
補正量Tajの設定
Taj=前回Taj
S230
所定時間経過？
NO
YES
S240
補正量Tajの計算
Taj=前回Taj-Trt
S250
Taj≦Taj*？
NO
YES
S260
フラグFの設定
F=0
S270
補正量Tajの設定
Taj=Taj*
トルク指令Tm*の設定
Tm*=Tmtmp+Taj
S280
トルク指令Tm*でモータを駆動
S290
RET

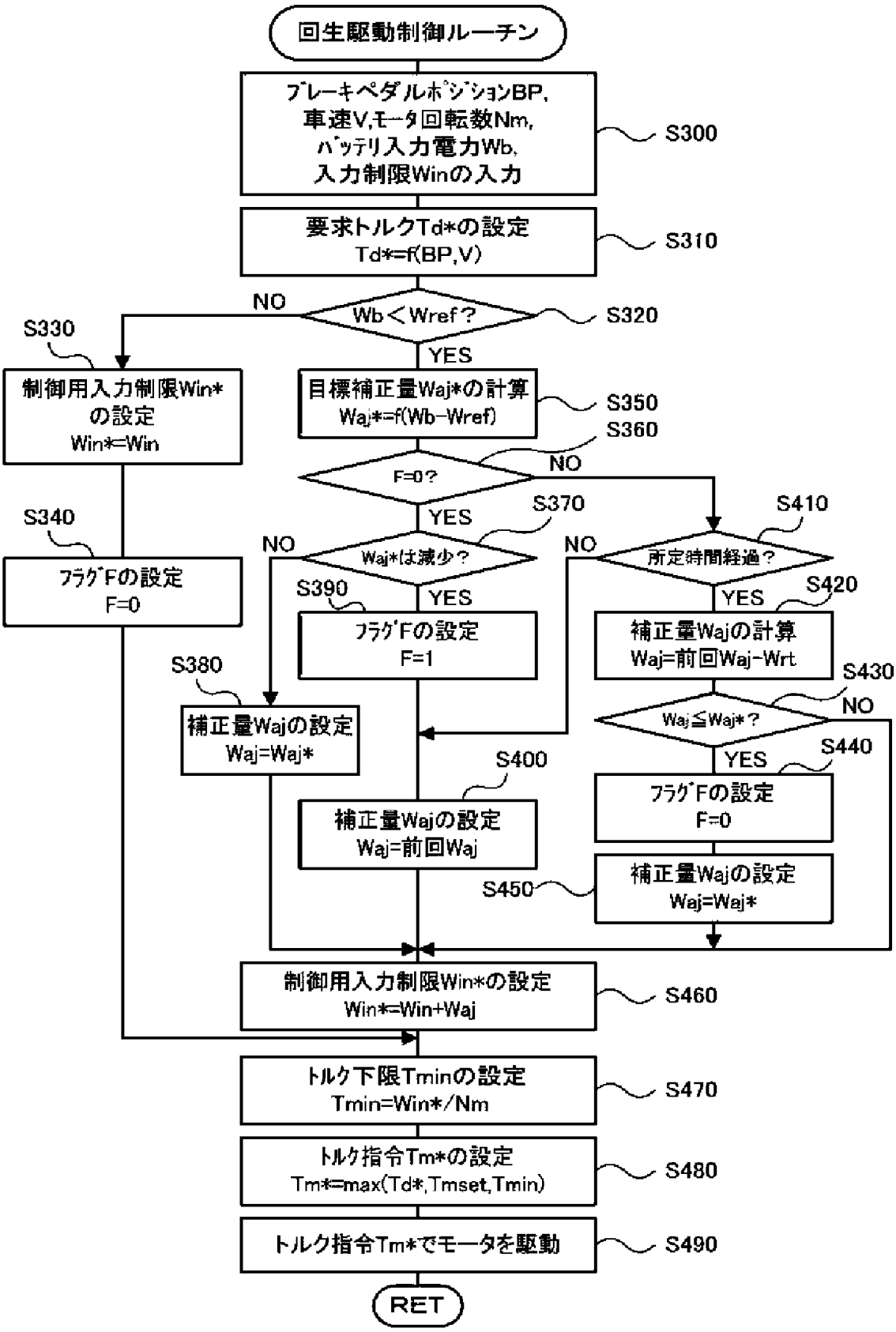
【図３】



【図４】

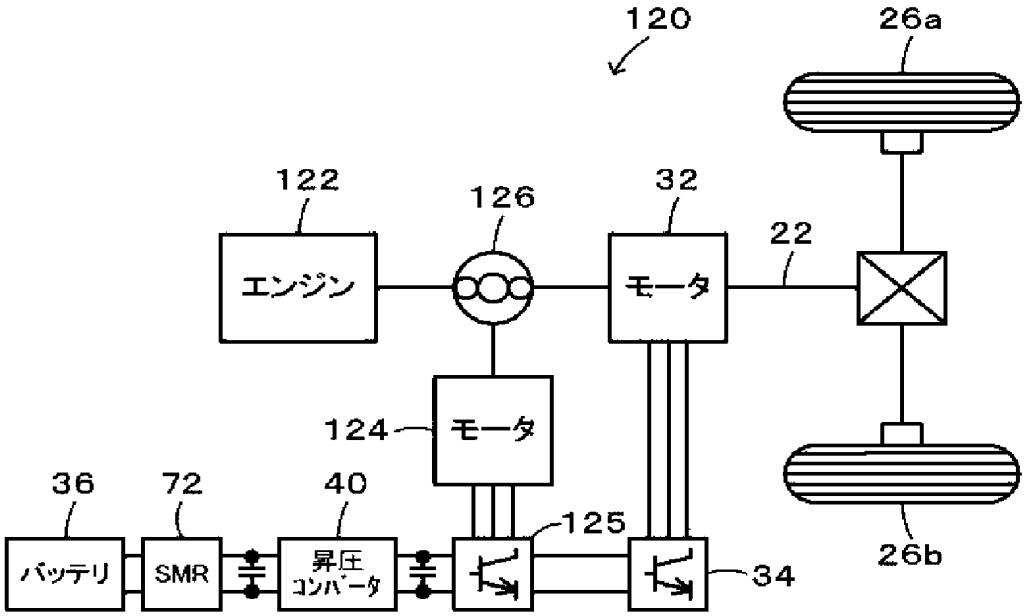


【図５】

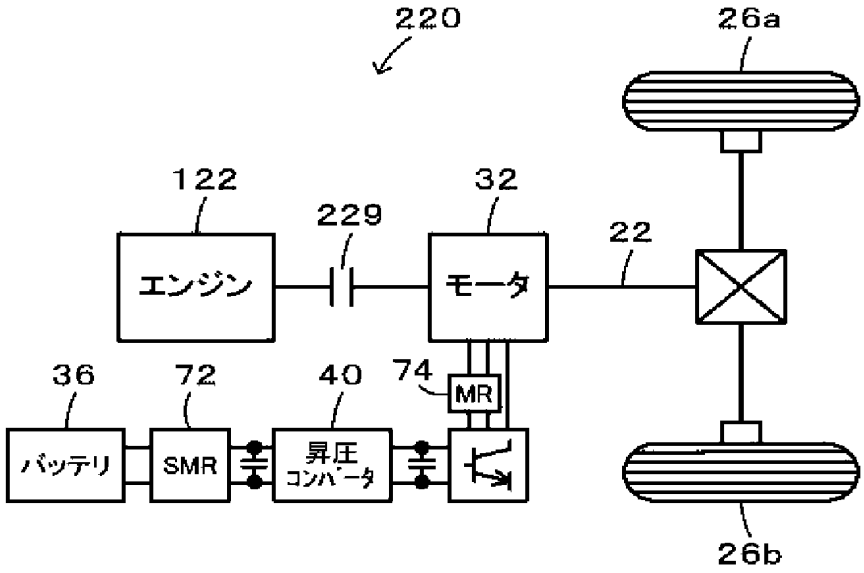


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【図６】


120
26a
122
126
32
22
エンジン
モータ
124
モータ
36
72
40
125
バッテリ
SMR
昇圧
コンバータ
34
26b

【図７】


220
26a
122
229
32
22
エンジン
モータ
36
72
40
74
MR
バッテリ
SMR
昇圧
コンバータ
26b

フロントページの続き

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JJ25 JJ28 LL01 LL22 LL24 LL41 LL43

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Espacenet

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Method for controlling permanent magnet synchronous motor

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Applicant(s): HYUNDAI MOTOR CO LTD; KIA MOTORS CORP ± (HYUNDAI MOTOR CO LTD, ; KIA MOTORS CORP)

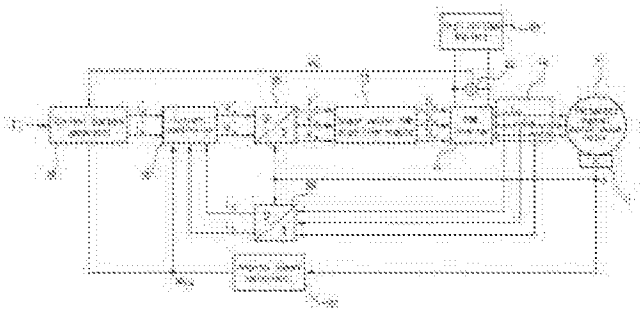
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Abstract of CN102208890 (A)



The present invention provides a method for controlling a permanent magnet synchronous motor. The method for controlling the permanent magnet synchronous motor preferably includes detecting an absolute angular position of a permanent magnet synchronous motor; calculating a rotational speed of the permanent magnet synchronous motor based on the detected absolute angular position; detecting a voltage of a battery as a power source; calculating a compensated speed, for which a battery voltage variation is compensated; generating a d-axis current command and a q-axis current command corresponding to the torque command and the compensated speed using a predetermined current command map; converting three-phase currents flowing into the permanent magnet synchronous motor into a d-axis feedback current and a q-axis feedback current based on the detected absolute angular position; calculating a d-axis voltage command and a q-axis voltage

command based on the d-axis current command, the q-axis current command, the d-axis feedback current, and the q-axis feedback current; converting the d-axis voltage command and the q-axis voltage command into three-phase voltage commands based on the detected absolute angular position; and controlling the operation of the permanent magnet synchronous motor based on the three-phase voltage commands.

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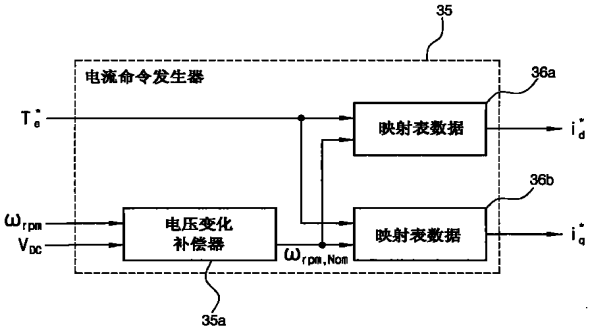
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(54)发明名称

用于控制永磁同步电动机的方法

(57)摘要

本发明提供了一种用于控制永磁同步电动机的方法，其包括：检测永磁同步电动机的绝对角位置；基于检测到的绝对角位置计算永磁同步电动机的旋转速度；检测作为电源的电池的电压；计算使电池电压变化得到补偿的补偿速度；使用预定的电流命令映射表产生与扭矩命令和补偿速度相对应的d轴电流命令和q轴电流命令；基于检测到的绝对角位置，将流入永磁同步电动机的三相电流转换为d轴反馈电流和q轴反馈电流；基于d轴电流命令、q轴电流命令、d轴反馈电流和q轴反馈电流计算d轴电压命令和q轴电压命令；基于检测到的绝对角位置，将d轴电压命令和q轴电压命令转换为三相电压命令；和基于三相电压命令控制永磁同步电动机的运转。



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1. 一种用于控制永磁同步电动机的方法，该方法包括：

检测永磁同步电动机的绝对角位置；

基于检测到的绝对角位置来计算所述永磁同步电动机的旋转速度；

检测作为电源的电池的电压；

基于扭矩命令、所述永磁同步电动机的所述旋转速度和电池电压，从所述永磁同步电动机的所述旋转速度计算使电池电压变化得到补偿的补偿速度；

使用预定的电流命令映射表来产生与所述扭矩命令和所述补偿速度相对应的 d 轴电流命令和 q 轴电流命令；

基于所述检测到的绝对角位置，将流入所述永磁同步电动机的三相电流转换为 d 轴反馈电流和 q 轴反馈电流；

基于所述 d 轴电流命令、所述 q 轴电流命令、所述 d 轴反馈电流和所述 q 轴反馈电流来计算 d 轴电压命令和 q 轴电压命令；

基于所述检测到的绝对角位置，将所述 d 轴电压命令和所述 q 轴电压命令转换为三相电压命令；和

基于所述三相电压命令来控制所述永磁同步电动机的运转。

2. 如权利要求 1 所述的方法，其中所述计算补偿速度的步骤包括：

确定所述永磁同步电动机的所述旋转速度是否大于预定的权重施加速度；

如果所述永磁同步电动机的所述旋转速度大于所述权重施加速度，则通过向所述旋转速度和所述扭矩命令施加权重来计算工作权重；和

基于所述工作权重和在设定所述电流命令映射表时使用的参考电压，从所述永磁同步电动机的所述旋转速度计算使电池电压变化得到补偿的所述补偿速度。

3. 如权利要求 2 所述的方法，其中基于预定的速度权重和扭矩命令权重，通过以下等式 E1 来计算所述工作权重：

E1 : $K_N = K_\omega(\omega_{rpm} - \omega_0) + K_T\left|T_e^*\right|$

其中 K_N 表示所述工作权重，K_ω 表示所述速度权重，ω_{rpm} 表示所述电动机旋转速度，ω_0 表示所述权重施加开始速度，K_T 表示所述扭矩命令权重，并且 T_e^* 表示所述扭矩命令。

4. 如权利要求 2 所述的方法，其中如果所述永磁同步电动机的所述旋转速度小于所述权重施加速度，则所述工作权重为零。

5. 如权利要求 2 所述的方法，其中所述计算补偿速度的步骤还包括确定所述电池电压是否大于预定的补偿开始电压，

其中如果所述电池电压大于所述补偿开始电压，则计算所述补偿速度并将其用作所述电流命令映射表数据的输入，并且如果所述电池电压小于所述补偿开始电压，则所述永磁同步电动机的所述旋转速度代替所述补偿速度被用作所述电流命令映射表数据的输入。

6. 如权利要求 2 所述的方法，其中通过电动机速度归一化公式来计算所述补偿速度，在所述电动机速度归一化公式中，所述工作权重、所述电池电压和所述永磁同步电动机的所述旋转速度被用作输入变量。

7. 如权利要求 6 所述的方法，其中所述补偿速度是通过以下等式 E2 所表示的所述电动机速度归一化公式计算的归一化电动机速度：

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$$E2: \omega_{rpm,Nom} = \left[1 + F\left\{(1+K_N)\frac{V_{DC,MAP}}{V_{DC}} - 1\right\}\right]\omega_{rpm}$$

其中 $\omega_{rpm,Nom}$ 表示所述归一化电动机速度，K_N 表示所述工作权重，$V_{DC,MAP}$ 表示在设定所述映射表时使用的所述参考电压，V_{DC} 表示所述电池电压，并且 F 等于 1($V_{DC} \geq V_0$) 或 0($V_{DC} < V_0$)，其中 V_{DC} 表示所述电池电压并且 V_0 表示所述补偿开始电压。

8. 一种用于控制永磁同步电动机的方法，该方法包括：

检测永磁同步电动机的绝对角位置；

基于检测到的绝对角位置来计算所述永磁同步电动机的旋转速度；

检测作为电源的电池的电压；

计算补偿速度，其中由所述补偿速度补偿电池电压变化；

使用预定的电流命令映射表来产生与所述扭矩命令和所述补偿速度相对应的 d 轴电流命令和 q 轴电流命令；

基于所述检测到的绝对角位置，将流入所述永磁同步电动机的三相电流转换为 d 轴反馈电流和 q 轴反馈电流；

基于所述 d 轴电流命令、所述 q 轴电流命令、所述 d 轴反馈电流和所述 q 轴反馈电流来计算 d 轴电压命令和 q 轴电压命令；

基于所述检测到的绝对角位置，将所述 d 轴电压命令和所述 q 轴电压命令转换为三相电压命令；和

基于所述三相电压命令来控制所述永磁同步电动机的运转。

9. 如权利要求 8 所述的用于控制永磁同步电动机的方法，其中基于扭矩命令、所述永磁同步电动机的所述旋转速度和所述电池电压，从所述永磁同步电动机的所述旋转速度计算所述补偿速度。

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用于控制永磁同步电动机的方法

技术领域

[0001] 本发明一般涉及用于控制电动机的方法。更特别地，本发明涉及用于控制在诸如混合动力车、燃料电池车等的电动车中使用的永磁同步电动机的方法。

背景技术

[0002] 永磁同步电动机 (PMSM) 是高功率和高效率电动机，其广泛地用在包括混合动力车、燃料电池车等的电动车领域以及其它工业领域中。

[0003] 特别地，内置式永磁同步电动机 (IPMSM) 是具有插入转子铁芯中的永磁体的同步电动机。IPMSM 具有极好的高速耐久性和操纵性能，并且因此适合于用作电动车电动机。

[0004] 如图 1 所示，根据用于控制永磁同步电动机的常规方法，电流命令发生器 35 接收扭矩命令 T_e^* 和永磁同步电动机的旋转速度 ω_{rpm}，并基于电流命令映射表数据 36a 和 36b 来产生 d 轴电流命令 i_d^* 和 q 轴电流命令 i_q^*。

[0005] 当电流命令发生器 35 输出所产生的 d 轴和 q 轴电流命令 i_d^* 和 i_q^* 时，电流控制器（未示出）基于 d 轴和 q 轴电流命令 i_d^* 和 i_q^* 来产生 d 轴和 q 轴电压命令 V_d^* 和 V_q^*。此后，通过三相电压命令 V_u^*、V_v^* 和 V_w^* 的产生以及逆变器的脉宽调制 (PWM) 和三相电流控制，来适当地控制永磁同步电动机。

[0006] 然而，传统上，基于预定的参考电压映射表（即，基于在满足电动机的输出规格的最低 DC 链电压处设定的映射表）、根据扭矩命令和电动机旋转速度来产生预定的电流命令并产生相应电动机速度处的扭矩，而不管作为电动机的电源的电池的电压如何。

[0007] 因此，不能实时地反映电池电压变化，这会降低当在运转期间电池电压提高时逆变器的电压利用。

[0008] 特别地，在诸如混合动力车、燃料电池车等的电动车中，由于在车辆驱动电动机运转期间的电池电压高于映射表被设定的参考电压，所以基于在参考电压处设定的映射表来产生电流命令在电压和电流的使用方面是不利的。

[0009] 因此，可以对各电压步长直到在驱动车辆时产生的最大电压使用电流命令映射表来执行线性插值法。然而，这需要大量的数据存储以及相当多的时间和努力。

[0010] 因此，在本领域中需要用于控制在电动车中使用的永磁同步电动机的方法。

[0011] 本背景技术部分中公开的上述信息只是为了增强对本发明的背景的理解，并且因此可能包含不构成在该国对本领域普通技术人员而言已知的现有技术的信息。

发明内容

[0012] 本发明提供了一种用于控制在电动车（诸如混合动力车、燃料电池车等）中使用的永磁同步电动机的方法，其可以实时地反映电池电压变化。

[0013] 在某些优选实施例中，本发明提供了一种用于控制永磁同步电动机的方法，其实时地补偿电池电压变化以改善电动机—逆变器系统的电压利用，并继而改善车辆的燃料效率。

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[0014] 在优选实施例中，本发明提供了一种用于控制永磁同步电动机的方法，该方法优选地包括：检测永磁同步电动机的绝对角位置；基于检测到的绝对角位置来适当地计算永磁同步电动机的旋转速度；适当地检测作为电源的电池的电压；基于扭矩命令、永磁同步电动机的旋转速度和电池电压，从永磁同步电动机的旋转速度中适当地计算使电池电压变化得到补偿的补偿速度；使用预定的电流命令映射表（current command map）来产生与扭矩命令和补偿速度相对应的 d 轴电流命令和 q 轴电流命令；基于检测到的绝对角位置来将流入永磁同步电动机的三相电流转换为 d 轴反馈电流和 q 轴反馈电流；基于 d 轴电流命令、q 轴电流命令、d 轴反馈电流和 q 轴反馈电流来适当地计算 d 轴电压命令和 q 轴电压命令；基于检测到的绝对角位置来将 d 轴电压命令和 q 轴电压命令转换为三相电压命令；以及基于三相电压命令来控制永磁同步电动机的运转。

[0015] 在优选实施例中，计算补偿速度的步骤可以优选地包括确定永磁同步电动机的旋转速度是否大于预定的权重施加速度；如果永磁同步电动机的旋转速度大于权重施加速度，则通过向旋转速度和扭矩命令施加权重来适当地计算工作权重（operating weight）；并且基于工作权重和在设定电流命令映射表时使用的参考电压，从永磁同步电动机的旋转速度计算使电池电压变化得到补偿的补偿速度。

[0016] 在另一优选实施例中，可以基于预定的速度权重和扭矩命令权重，通过下面的等式 E1 来计算工作权重：

[0017] E1：$K_N = K_\omega(\omega_{rpm} - \omega_0) + K_T\left|T_e^*\right|$

[0018] 其中 K_N 表示工作权重，K_ω 表示速度权重，ω_{rpm} 表示电动机旋转速度，ω_0 表示权重施加开始速度，K_T 表示扭矩命令权重，并且 T_e^* 表示扭矩命令。

[0019] 在另一优选实施例中，如果永磁同步电动机的旋转速度小于权重施加速度，则工作权重为零。

[0020] 在又一优选实施例中，计算补偿速度的步骤还可以包括确定电池电压是否大于预定的补偿开始电压，其中如果电池电压大于补偿开始电压，则可以适当地计算补偿速度并将其用作电流命令映射表数据的输入，并且如果电池电压小于补偿开始电压，则永磁同步电动机的旋转速度可以代替补偿速度被用作电流命令映射表数据的输入。

[0021] 在又一优选实施例中，可以通过电动机速度归一化公式来计算补偿速度，在所述电动机速度归一化公式中，工作权重、电池电压和永磁同步电动机的旋转速度被用作输入变量。

[0022] 在另外的优选实施例中，补偿速度可以是通过下面的等式 E2 所表示的电动机速度归一化公式计算的归一化电动机速度：

[0023] E2：$\omega_{rpm,Nom} = \left[1 + F\left\{(1+K_N)\frac{V_{DC,MAP}}{V_{DC}} - 1\right\}\right]\omega_{rpm}$

[0024] 其中 $\omega_{rpm,Nom}$ 表示归一化电动机速度，K_N 表示工作权重，$V_{DC,MAP}$ 表示在设定映射表时使用的参考电压，V_{DC} 表示电池电压，并且 F 等于 1（$V_{DC} \geq V_0$）或 0（$V_{DC} < V_0$），其中 V_{DC} 表示电池电压并且 V_0 表示补偿开始电压。

[0025] 本发明的其它特征及优选实施例在下文中讨论。

[0026] 应该理解的是，本文中使用的术语“车辆”或“车辆的”或其它类似术语包括一般的

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机动车辆（诸如包括运动型多功能车 (SUV)、公共汽车、卡车、各种商用车辆在内的客车）、包括各种艇和船在内的水运工具、飞行器等，并且包括混合动力车、电动车、插电式混合电动车、氢动力车以及其它代用燃料车（例如从除石油以外的资源中取得的燃料）。如本文中所述，混合动力车是具有两个或更多个动力源的车辆，例如既有汽油动力又有电动力的车辆。

[0027] 在结合在本说明书中并形成本说明书的一部分的附图以及与附图一起用于通过举例来解释本发明原理的以下详细说明中，将体现出或更详细地阐述本发明的以上特征和优点。

附图说明

[0028] 现在将参考通过附图示出的本发明的某些示例性实施例来详细描述本发明的上述及其它特征，其中附图将在下文中仅通过例证的方式给出，并且因此并非对本发明进行限制，其中：

[0029] 图 1 是示出用于产生电流命令的常规电流命令发生器的示意图。

[0030] 图 2 是示出根据本发明的示例性实施例的用于控制永磁同步电动机的系统的示意图。

[0031] 图 3 是示出根据本发明的示例性实施例的用于产生电流命令的电流命令发生器的示意图。

[0032] 图 4 是示出根据本发明的示例性实施例的用于控制永磁同步电动机的方法的流程图。

[0033] 附图中陈列的附图标记包括对下面进一步讨论的以下元件的引用：

[0034] 11：永磁同步电动机

[0035] 13：PWM 逆变器

[0036] 15：空间向量脉宽调制算法模块

[0037] 17：位置检测器 19：电流检测器

[0038] 21：电池 23：电压检测器

[0039] 31：角速度计算器

[0040] 33：三相 /d-q 坐标转换器

[0041] 35：电流命令发生器 35a：电压变化补偿器

[0042] 37：电流控制器

[0043] 39：d-q/ 三相坐标转换器

[0044] 应该理解的是，附图不一定要依比例，而是呈现出说明本发明的基本原理的各种优选特征的稍微简化的表示。本文中公开的本发明的特定设计特征，包括例如特定尺寸、方向、位置和形状，将部分地由期望的特定应用和使用环境来确定。

[0045] 在附图中，附图标记在附图的几幅图中始终指代本发明的相同或等效部分。

具体实施方式

[0046] 如本文中所述，本发明的特征在于一种用于控制永磁同步电动机的方法，该方法包括：检测永磁同步电动机的绝对角位置；基于检测到的绝对角位置来计算永磁同步电动

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机的旋转速度；检测作为电源的电池的电压；计算补偿速度，其中由补偿速度来补偿电池电压变化；使用预定的电流命令映射表来产生与扭矩命令和补偿速度相对应的 d 轴电流命令和 q 轴电流命令；基于检测到的绝对角位置将流入永磁同步电动机的三相电流转换为 d 轴反馈电流和 q 轴反馈电流；基于 d 轴电流命令、q 轴电流命令、d 轴反馈电流和 q 轴反馈电流来计算 d 轴电压命令和 q 轴电压命令；基于检测到的绝对角位置将 d 轴电压命令和 q 轴电压命令转换为三相电压命令；以及基于三相电压命令来控制永磁同步电动机的运转。

[0047] 在一个实施例中，基于扭矩命令、永磁同步电动机的旋转速度和电池电压，从永磁同步电动机的旋转速度计算补偿速度。

[0048] 现在将在下文中详细参考本发明的各种实施例，其实例在附图中示出并在下面描述。虽然将结合示例性实施例来描述本发明，但应理解的是，本说明并非旨在将本发明限于那些示例性实施例。相反，本发明旨在不仅涵盖这些示例性实施例，而且涵盖可包括在所附权利要求所限定的本发明的精神和范围内的各种替代形式、改型、等效形式和其它实施例。

[0049] 在说明书和附图中使用的符号定义如下：

[0050] T_e^*：扭矩命令　　V_d^*：d 轴电压命令

[0051] V_q^*：q 轴电压命令　　i_d^*：d 轴电流命令

[0052] i_q^*：q 轴电流命令　　i_d：d 轴反馈电流

[0053] i_q：q 轴反馈电流

[0054] V_u^*，V_v^*，V_w^*：三相电压命令

[0055] D_u，D_v，D_w：逆变器的切换控制信号的占空比

[0056] V_{DC}：电池电压（DC 链电压）

[0057] i_{us}，i_{vs}，i_{ws}：三相电流　　ω_{rpm}：电动机旋转速度

[0058] ω_0：权重施加开始速度　　$\omega_{rpm,Nom}$：归一化电动机速度

[0059] K_ω：速度权重　　K_T：扭矩命令权重

[0060] K_N：工作权重　　V_0：补偿开始电压

[0061] F：电压变化标记

[0062] $V_{DC,MAP}$：映射表设定参考电压（在映射期间的 DC 电压）

[0063] 根据优选实施例，本发明提供了用于控制永磁同步电动机的系统和方法，其在根据电动机旋转速度和要求的扭矩（扭矩命令）产生电流命令时，可以在使用现有的参考电压映射表（即在预定参考电压设定的映射表）的同时实时地反映在运转期间作为电动机的电源的电池的电压变化。

[0064] 根据某些优选实施例并且例如如图 2 所示，附图标记 11 表示永磁同步电动机。在另外的优选实施例中，永磁同步电动机可以是例如内置式永磁同步电动机。

[0065] 在其它另外的优选实施例中，附图标记 21 表示用作永磁同步电动机 11 的电源的电池（高压电池）。优选地，电池 21 在电动车 (EV) 模式或混合电动车 (HEV) 模式中供应电动机的驱动电力，并且在再生制动 (RB) 模式中存储由在发电模式下运转的电动机产生的电能。根据其它另外的优选实施例，在（具有燃料电池—蓄电池混合动力系统的）燃料电池车中，电池 21 与作为主电源的燃料电池堆（未示出）一起被装配，并且充当辅助电源来供应电动机的驱动电力。

[0066] 根据某些示例性实施例，附图标记 13 表示向永磁同步电动机 11 施加三相 AC 电流

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的 PWM 逆变器。优选地，PWM 逆变器 13 通过脉宽调制 (PWM) 来控制电动机施加电压（逆变器输出电压）从而控制施加到电动机 11 的三相电流 i_{us}、i_{vs} 和 i_{ws}。在另外的优选实施例中，PWM 逆变器 13 优选地包括由能够执行高速开关操作的半导体开关（例如，IGBT）和在电力产生期间形成电流回路的二极管组成的电力模块（未示出）。

[0067] 优选地，PWM 控制方法通过适当地改变用于切换逆变器中的半导体开关的切换脉冲的宽度来控制电压（或电流），并且优选地包括三角波比较 PWM 方法和空间向量 PWM 方法。根据某些示例性实施例，图 2 示出空间向量 PWM 方法的实例。逆变器的 PWM 和三相控制对于本领域技术人员来说是熟知的，因此将省略其详细描述。

[0068] 根据其它的优选实施例，根据本发明的控制系统优选地包括用于检测电动机转子的绝对角位置 θ 的位置检测器 17。优选地，绝对角位置 θ 表示电流被施加到永磁同步电动机 11 的各角位置。根据某些优选实施例，位置检测器 17 可以是分解器。

[0069] 根据优选的示例性实施例，附图标记 19 表示电流检测器，其通过 PWM 逆变器 13 的输出电压来检测流入永磁同步电动机 11 的相电流 i_{us}、i_{vs} 和 i_{ws} 中的每个。优选地，由电流检测器检测到的相电流可以用于控制逆变器。

[0070] 根据另外的优选实施例，根据本发明的控制系统在实时地控制电动机以补偿电池电压变化的过程中，监视电池电压变化并适当地反映它。优选地，适当地检测逆变器的 DC 链电压 V_{DC} 并将其用作用于监视电池电压变化的电压值。

[0071] 因此，根据本发明的控制系统优选地包括用于检测 DC 链电压 V_{DC} 作为电池电压的电压检测器 23。优选地，电压检测器 23 可以适当地配置成测量 DC 链接电容器（未示出）两端的电压，所述 DC 链接电容器吸收通过逆变器的操作产生的 DC 电压的高频波纹成分并使 DC 电压平滑。根据其它另外的优选实施例，由于在满足电动机的输出规格的最低 DC 链电压 $V_{DC,MAP}$ 处设定的映射表被用作参考电压映射表 36a 和 36b（如图 3 所示），所以优选地通过电压检测器 23 检测 DC 链电压 V_{DC}，然后使用检测到的 DC 链电压 V_{DC} 来适当地补偿电压变化。

[0072] 根据本发明另外的优选实施例，控制系统还优选地包括：基于位置检测器 17 的信号来计算电动机旋转速度 ω_{rpm} 的角速度计算器 31；基于位置检测器 17 和电流检测器 19 的信号来计算 d 轴反馈电流 i_d 和 q 轴反馈电流 i_q 的三相 /d-q 坐标转换器 33；基于从上级控制器施加的扭矩命令 T_e^*、从角速度计算器 31 输入的电动机旋转速度 ω_{rpm} 和电压检测器 23 的信号来适当地产生使电压变化得到补偿的 d 轴电流命令 i_d^* 和 q 轴电流命令 i_q^* 的电流命令发生器 35；分别适当地计算 d 轴电压命令 V_d^* 和 q 轴电压命令 V_q^* 的电流控制器 37；以及 d-q/ 三相坐标转换器 33，其基于位置检测器 17 的信号以及从电流控制器 37 输入的 d 轴电压命令 V_d^* 和 q 轴电压命令 V_q^* 来计算三相电压命令 V_u^*、V_v^* 和 V_w^*。

[0073] 优选地，角速度计算器 31 接收由位置检测器 17（即分解器）检测到的角位置 θ，并基于检测到的角位置 θ 来计算电动机旋转速度 ω_{rpm}。优选地，角速度计算器 31 可以包括例如微分器。

[0074] 根据其它另外的优选实施例，三相 /d-q 坐标转换器 33 接收由位置检测器 17 检测到的角位置 θ 和由电流检测器 19 检测到的相电流 i_{us}、i_{vs} 和 i_{ws}，并使用角位置 θ 来将三相电流 i_{us}、i_{vs} 和 i_{ws} 转换为 d 轴反馈电流 i_d 和 q 轴反馈电流 i_q。

[0075] 此外，本发明的电流命令发生器 35 接收从上级控制器施加的扭矩命令 T_e^*、由角速

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度计算器 31 计算的电动机旋转速度 ω_{rpm} 和由电压检测器 23 检测到的 DC 链电压 V_{DC}，并使用基于扭矩命令 T_e^*、电动机旋转速度 ω_{rpm} 和 DC 链电压 V_{DC} 的预定电流命令数据来适当地产生使电压变化得到补偿的 d 轴电流命令 i_d^* 和 q 轴电流命令 i_q^*。优选地，上级控制器可以是典型的混合动力控制单元 HCU，其适当地产生并输出扭矩命令。

[0076] 优选地，预定电流命令数据可以是具有作为输入的扭矩命令和旋转速度的现有电流命令数据。优选地，预定电流命令数据包括用于产生 d 轴电流命令 i_d^* 的预定 d 轴电流命令数据和用于产生 q 轴电流命令 i_q^* 的预定 q 轴电流命令数据，其与扭矩命令和旋转速度相对应。

[0077] 优选地，d 轴电流命令数据和 q 轴电流命令数据是用于从扭矩命令适当地计算电流命令的映射表数据，并且在预定参考电压处产生的现有 d 轴电流命令映射表 36a（图 3）和现有 q 轴电流命令映射表 36b（图 3）可以照原样使用。

[0078] 根据本发明另外的优选实施例，预定的 d 轴电流命令映射表 36a 包括分别映射到多个扭矩和多个旋转速度的多个最优 d 轴电流命令值，并且预定的 q 轴电流命令映射表 36b 优选地包括分别映射到多个扭矩和多个旋转速度的多个最优 q 轴电流命令值。

[0079] 根据其它另外的优选实施例，d 轴电流命令映射表和 q 轴电流命令映射表可以使用从先前的试验获得的数据来设定。例如，根据某些示例性实施例，可以使用双向测力计 (bi-directional dynamometer) 经由试验对每个扭矩和旋转速度计算最优 d 轴电流命令和 q 轴电流命令、然后对这些值进行映射，来设定 d 轴电流命令映射表和 q 轴电流命令映射表。

[0080] 优选地，为了以上述方式执行电压变化补偿，本发明的电流命令发生器 35 还包括基于从上级控制器施加的扭矩命令 T_e^*、由角速度计算器 31 计算的电动机旋转速度 ω_{rpm} 和由电压检测器 23 检测到的 DC 链电压（电池电压）V_{DC}，来计算补偿电动机旋转速度 $\omega_{rpm,Nom}$ 的电压变化补偿器 35a（见图 3）。

[0081] 详细地，根据本发明的电流命令发生器 35 使用 d 轴和 q 轴电流命令映射表 36a 和 36d 来适当地产生 d 轴和 q 轴电流命令 i_d^* 和 i_q^*，并且还接收实时地检测到的 DC 链电压 V_{DC}，以补偿电池电压变化。优选地，电压变化补偿器 35a 使用扭矩命令 T_e^*、检测到的电动机旋转速度 ω_{rpm} 和 DC 链电压（电池电压）V_{DC} 来适当地计算补偿电动机旋转速度 $\omega_{rpm,Nom}$。优选地，补偿电动机旋转速度 $\omega_{rpm,Nom}$（下文中称为“补偿速度”）和扭矩命令 T_e^* 被用作 d 轴电流命令映射表 36a 和 q 轴电流命令映射表 36b 的输入以便适当地产生电流命令。

[0082] 因此，根据本发明的优选实施例，由于 d 轴电流命令 i_d^* 和 q 轴电流命令 i_q^* 是基于扭矩命令 T_e^* 和补偿速度 $\omega_{rpm,Nom}$、通过 d 轴电流命令映射表 36a 和 q 轴电流命令映射表 36b 产生的，所以每个产生的电流命令对应于使电压变化得到补偿的电流命令。

[0083] 参考图 3 和 4，在这里描述电流命令发生器 35 的电压变化补偿器 35a 通过使用 DC 链电压 V_{DC} 执行的用于计算补偿速度的处理，即针对电动机旋转速度 ω_{rpm} 来补偿电压变化的处理。

[0084] 根据本发明另外的优选实施例，电流控制器 37 接收从电流命令发生器 35 输出的 d 轴电流命令 i_d^* 和 q 轴电流命令 i_q^*，以及从三相 /d-q 坐标转换器 33 输出的 d 轴反馈电流 i_d 和 q 轴反馈电流 i_q，并基于它们来产生 d 轴电压命令 V_d^* 和 q 轴电压命令 V_q^*。优选地，从角速度计算器 31 输出的电动机旋转速度 ω_{rpm} 还可以被用于计算 d 轴电流命令 i_d^* 和 q 轴

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电流命令 i_q^*。

[0085] 根据其它另外的优选实施例，d-q/ 三相坐标转换器 39 使用从位置检测器 17 输入的绝对角位置 θ，来适当地将从电流控制器 37 输入的 d 轴电压命令 V_d^* 和 q 轴电压命令 V_q^* 转换为三相电压命令 V_u^*、V_v^* 和 V_w^*。

[0086] 结果，从 d-q/ 三相坐标转换器 39 输出的三相电压命令 V_u^*、V_v^* 和 V_w^* 被输入到空间向量 PWM 算法模块以产生切换控制信号的占空比 D_u、D_v 和 D_w，并且 PWM 逆变器 13 基于占空比来控制施加到永磁同步电动机 11 的三相电流。

[0087] 各坐标转换器的坐标转换处理、使用空间向量脉宽调制的占空比生成和三相电流控制以及上述电压命令计算处理在本发明所属的领域中是熟知的，将省略其详细描述。

[0088] 根据另外的优选实施例，参考图 3 和 4 来描述由电流命令发生器 35 的电压变化补偿器 35a 执行的用于计算补偿速度的处理。

[0089] 首先，参考图 3，电流命令发生器 35 优选地包括电压变化补偿器 35a，其接收扭矩命令 T_e^*、电动机旋转速度 ω_{rpm} 和电池电压 V_{DC}，并基于它们来适当地计算使电压变化得到补偿的电动机旋转速度即补偿速度 $\omega_{rpm,Nom}$。

[0090] 根据本发明的优选实施例，为了适当地反映运转期间的电池电压变化，电流命令发生器 35 的电压变化补偿器 35a 使用由电压检测器 23 检测到的电池电压 (DC 链电压) V_{DC}，针对电流命令映射表 36a 和 36b 的输入值来补偿电压变化。优选地，电压变化补偿器 35a 可以配置成针对作为电流映射表数据的输入值的电动机旋转速度 ω_{rpm} 来适当地补偿电压变化。

[0091] 在特别优选的实施例中，在本发明中采用与电压变化相应的电动机速度归一化方法，并且通过电动机速度归一化方法来适当地补偿电池电压变化，在所述电动机速度归一化方法中，对电动机旋转速度、扭矩命令和电池电压中的每一个施加权重。如本文中所述，本发明中的电池电压变化是指基于映射期间的 DC 电压（即电流命令映射表被设定的参考电压）的、在运转期间引起的电池电压的变化。优选地，在设定电流命令映射表的过程中，参考电压（下文中称为“映射表设定参考电压”）通常被确定为满足电动机的输出规格的最低 DC 链电压。

[0092] 根据某些优选实施例并且参考例如图 4，由电压变化补偿器执行的补偿速度计算处理所需的参数值应该预先确定。

[0093] 根据本发明，逻辑所需的参数值包括权重施加开始速度 ω_0、、速度权重 K_ω、扭矩命令权重 K_T、工作权重 K_N 和补偿开始电压 V_0，它们从各种条件下的先前的试验中获得并被存储。

[0094] 因此，在适当地预先确定了参数值的情况下，在永磁同步电动机运转期间检测到的电动机旋转速度 ω_{rpm} 从角速度计算器被输入，当前 DC 电压 V_{DC} 从电压检测器被输入，并且扭矩命令 T_e^* 从上级控制器被输入 (S11)。优选地，确定电动机旋转速度 ω_{rpm} 是否需要权重施加 (S12)。

[0095] 因此，将检测到的电动机旋转速度 ω_{rpm} 与权重施加开始速度 ω_0 进行比较以确定电动机旋转速度 ω_{rpm} 是否对应于权重施加速度。优选地，如果电动机旋转速度 ω_{rpm} 大于权重施加开始速度 ω_0，则确定电动机旋转速度 ω_{rpm} 对应于权重施加速度，并且根据下面的等式 1，对旋转速度和扭矩命令分别施加权重 K_ω 和 K_T 来适当地计算工作权重 K_N(S13)。

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[0096] [等式 1]

[0097] $$K_N = K_\omega(\omega_{rpm} - \omega_0) + K_T\left|T_e^*\right|$$

[0098] 优选地，如果电动机旋转速度 ω_{rpm} 小于权重施加开始速度 ω_0，即，如果确定电动机旋转速度 ω_{rpm} 不符合权重施加条件，则工作权重成为零 ($K_N = 0$) (S13')。

[0099] 优选地，当将权重施加到电动机的每个速度时，这在操作效率方面并不是优选的。因此，考虑操作效率和由电压变化补偿引起的电压利用的改善，用实验获得施加权重的最优阈值。优选地，最优阈值被设定为权重施加开始速度 ω_0，使得只有当符合权重施加条件时才施加权重。

[0100] 此外，一旦以上述方式获得工作权重 K_N，就使用电池电压 V_{DC} 和映射表设定参考电压 $V_{DC,MAP}$ 以及工作权重 K_N，从电动机旋转速度 ω_{rpm} 计算使电池电压变化得到补偿的补偿速度 $\omega_{rpm,Nom}$。

[0101] 在本发明的另一示例性实施例中，基于电池电压（即由电压检测器检测到的 DC 链电压 V_{DC}）来确定是否需要电压变化补偿 (S14)。优选地，如果确定 DC 链电压 V_{DC} 需要电压变化补偿，则根据预定的等式来适当地计算与电压变化相应的补偿速度 $\omega_{rpm,Nom}$ (S15 和 S16)。

[0102] 根据另外的示例性实施例，详细地，将 DC 链电压 V_{DC} 与预定的补偿开始电压 V_0 进行比较以确定是否需要电压变化补偿。优选地，如果 DC 链电压 V_{DC} 大于补偿开始电压 V_0，则确定需要电压变化补偿 (S15)，并且根据预定等式获得与电压变化相应的补偿速度 $\omega_{rpm,Nom}$ (S16)。

[0103] 例如，在示例性实施例中，上述等式可以是与电压变化相应的电动机速度归一化公式，并且电动机速度归一化公式可以由下面的等式 2 表示：

[0104] [等式 2]

[0105] $$\omega_{rpm,Nom} = \left[1 + F\left\{(1 + K_N)\frac{V_{DC,MAP}}{V_{DC}} - 1\right\}\right]\omega_{rpm}$$

[0106] 其中 $V_{DC,MAP}$ 表示映射表设定参考电压。

[0107] 在上面的等式 2 中，F 表示指示是否施加补偿的逻辑标记。如果 DC 链电压 V_{DC} 需要电压变化补偿，则 F 对应于 1 (F = 1) (S15)，然而，如果 DC 链电压 V_{DC} 不需要电压变化补偿，则 F 对应于零 (F = 0) (S15')。

[0108] 等式 2 被用于将根据等式 1 计算的工作权重 K_N、检测到的 DC 链电压 V_{DC} 和电动机旋转速度 ω_{rpm} 用作输入变量，来计算归一化电动机速度 $\omega_{rpm,Nom}$。通过等式 2 计算的归一化电动机速度 $\omega_{rpm,Nom}$ 对应于输入到电流命令映射表的补偿速度。补偿速度与来自从角速度计算器输入的电动机旋转速度 ω_{rpm} 的、使电压变化得到补偿的速度值相对应。

[0109] 然而，如果 DC 链电压 V_{DC} 小于补偿开始电压 V_0，则在等式 2 中 F 对应于零 (F = 0)。因此，当前的电动机旋转速度 ω_{rpm} 代替补偿速度被用作电流命令映射表数据的输入。

[0110] 根据另外的实施例，考虑由电压变化补偿引起的电压利用的改善，通过从先前的试验中获得用于确定是否需要补偿的最优阈值电压，来设定补偿开始电压 V_0。

[0111] 因此，根据本发明的优选实施例，补偿电动机旋转速度 $\omega_{rpm,Nom}$（即补偿速度）与扭矩命令 T_e^* 一起被用作 d 轴电流命令映射表 36a 和 q 轴电流命令映射表 36b 的输入以获得 d 轴和 q 轴命令（参见图 3）。优选地，当获得电压变化得到了反映的 d 轴和 q 轴电流命令

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时，使用它们来控制永磁同步电动机。

[0112] 如本文中所述，根据本发明的用于控制永磁同步电动机的方法，在控制永磁同步电动机的过程中可以实时地反映电池电压变化，这会改善电动机—逆变器系统的电压利用，并继而改善车辆性能（诸如功率效率、燃料效率等）。

[0113] 此外，与对各电压步长直到最大电压使用电流命令映射表执行线性插值法的常规方法相比，可以保证在高压和高速运转范围内电流控制的稳定性，减少用于产生电流命令的数据量和数据存储，并节省用于数据构建和验证所需的人力和时间。

[0114] 已经参考本发明的优选实施例对本发明进行了详细描述。然而，本领域技术人员应该理解的是，可以对这些实施例做出变更而不脱离本发明的原理和精神，其中本发明的范围在所附权利要求及其等价形式中限定。

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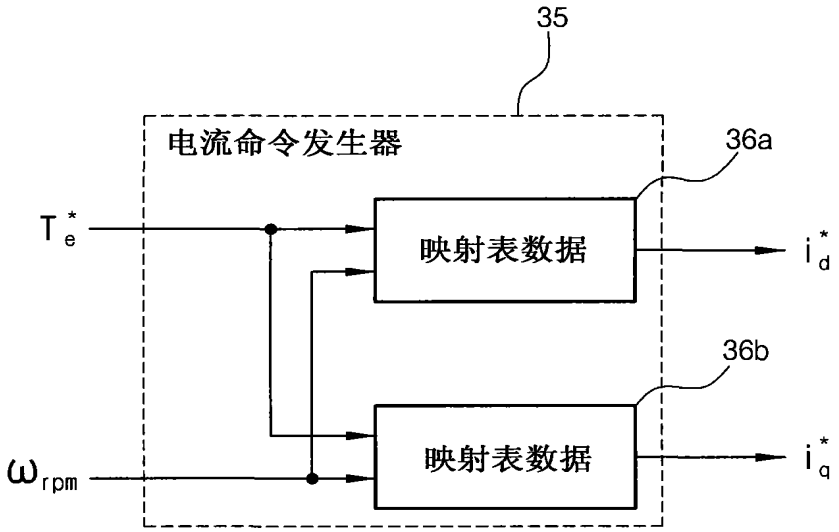


图 1

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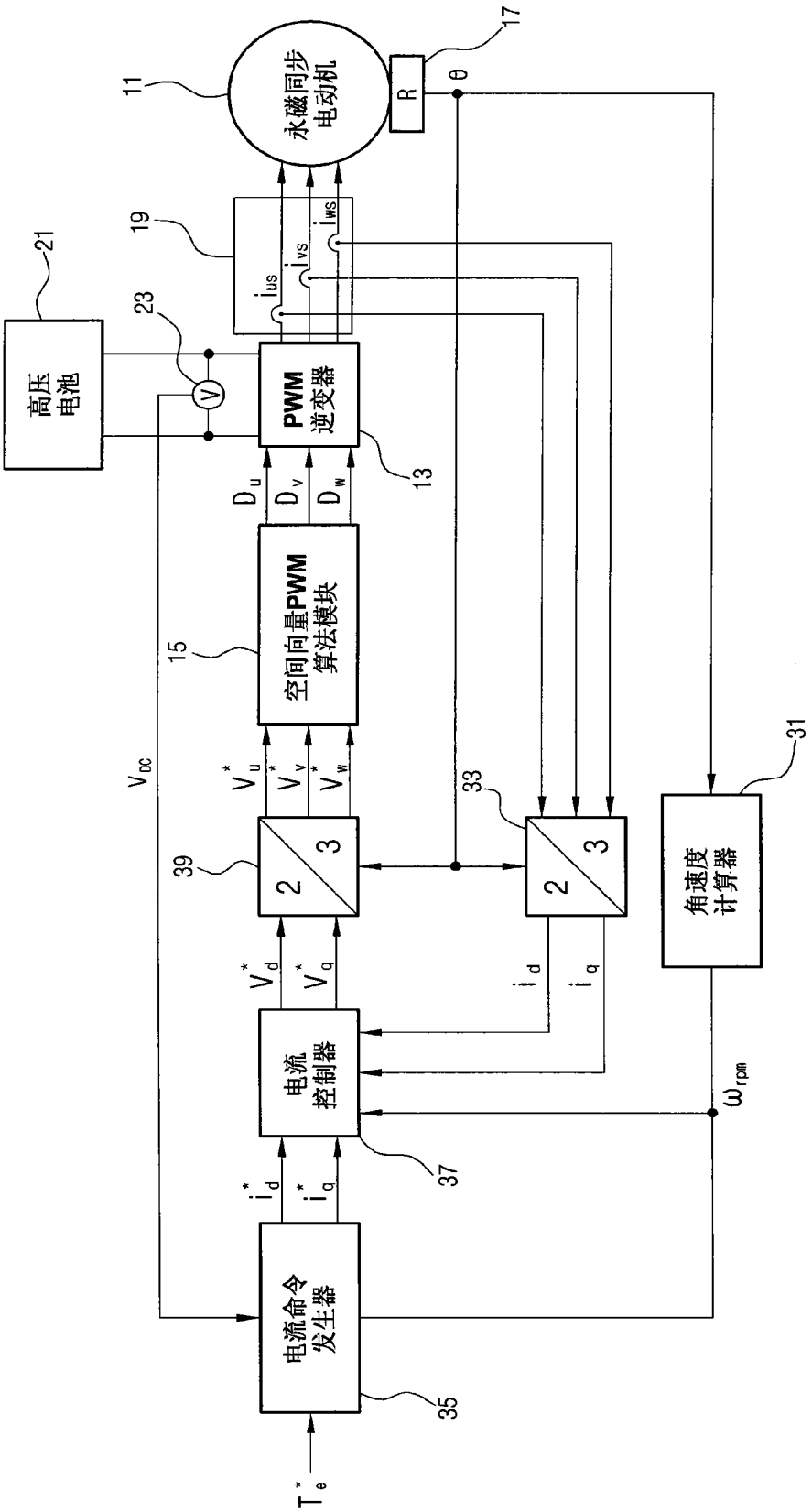


图 2

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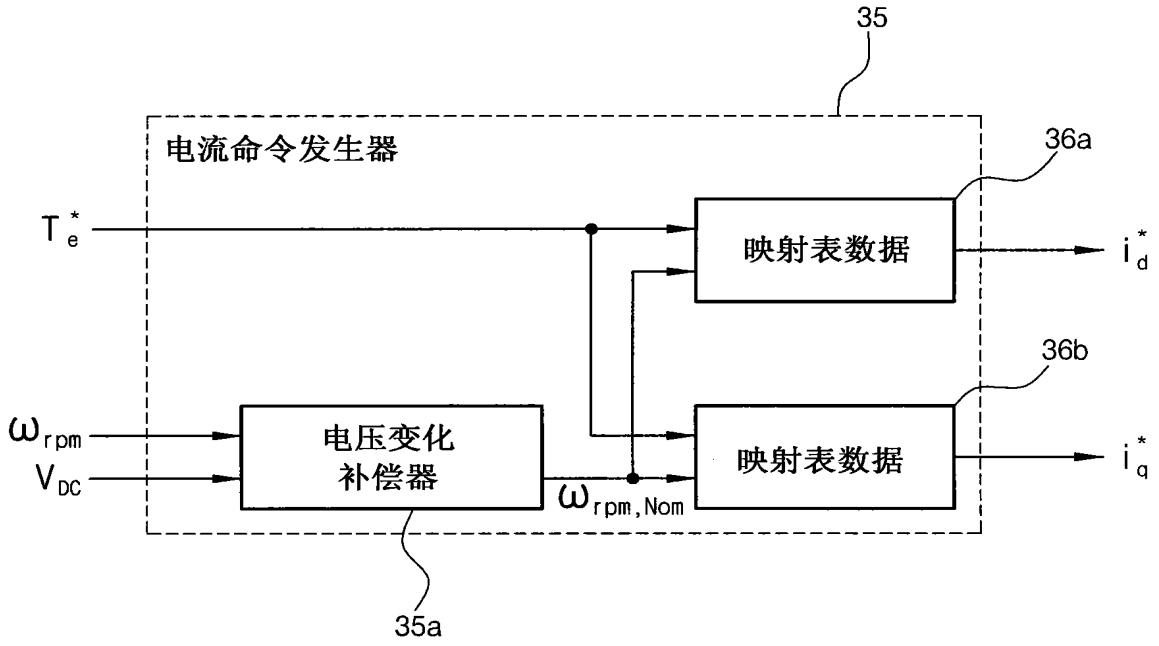


图 3

Textron Specialized Vehicles Inc., Exh. 1003, p. 219

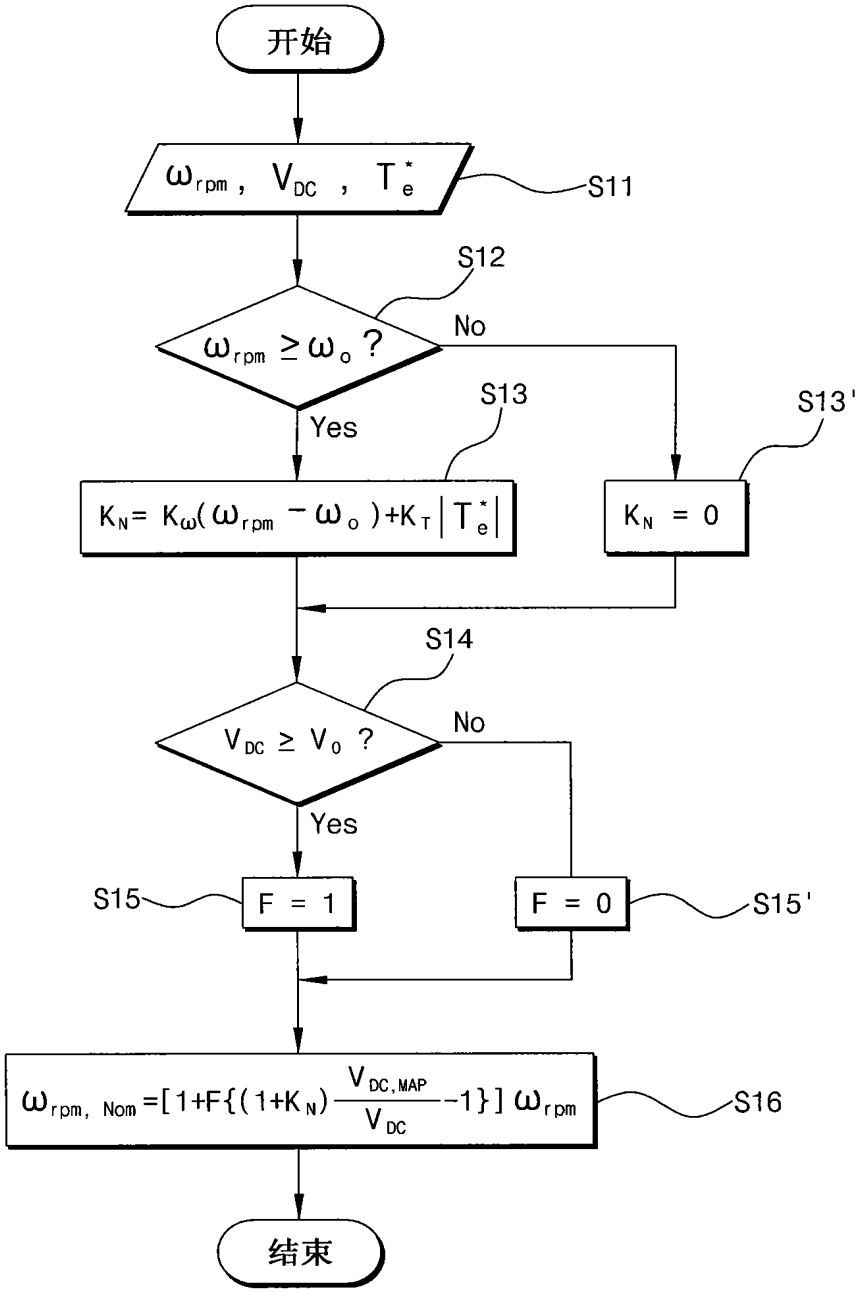


图 4

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Espacenet

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Electric automobile battery pack unit on-off and motor drive system and control method thereof

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Abstract of CN104709102 (A)

The invention provides an electric automobile battery pack unit on-off and motor drive system and a control method thereof. A battery pack unit connection system comprises a motor, a battery pack, a sensor and a controller. A power converter between the battery pack and the motor is omitted, corresponding voltage signals are obtained by controlling a battery pack unit, action is directly conducted on the motor, and the energy loss is reduced; the battery output voltage can be controlled and changed; especially in an alternating-current motor, the voltage regulating function and the frequency regulating function can be achieved by controlling a solid relay according to the conditions, and the control type can be simplified.

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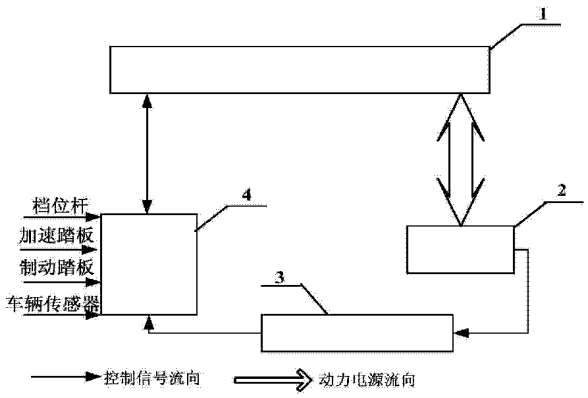
权利要求书3页 说明书10页 附图12页

(54)发明名称

电动汽车电池组单元通断与电动机驱动系统及其控制方法

(57)摘要

本发明提供了电动汽车电池组单元通断与电动机驱动的系统及其控制方法，所述电池组单元连接系统包括电动机、电池组、传感器和控制器。本发明的系统取消了电池组到电动机之间的功率转换器，控制电池组单元，获得相应的电压信号，直接对电动机作用，减小了能量损耗；可以控制和改变电池输出电压，尤其是在交流电机中，可以根据情况，通过控制固态继电器，实现调压和调频的功能，使得控制形式简单化。



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1. 一种电动汽车电池组单元通断与电动机驱动的系统，其特征在于，所述电池组单元连接系统包括电动机（2）、电池组（1）、传感器（3）和控制器（4）；其中：

电池组（1）包括多个电池单元（5）和在连接线路之间的固态继电器（6），固态继电器（6）用于控制电池单元（5）导通与断开、数量和时间、电压的大小、并控制单个或多个电池单元（5）在A、B端输出的极性、以及控制在A、B端输出大小、方向以及频率可变的电压信号；

控制器（4）获得起动、加速、减速及制动信号并结合传感器（3）的信息，控制器（4）控制固态继电器（6）以控制电池组电池单元（5）的导通与断开，并控制器（4）从电池组（1）中获得电源的剩余电量情况，电池组（1）输出的相应电压信号，驱动电动机（2）运转，在制动环节电动机（2）对电源反馈充电。

2. 如权利要求1所述的系统，其特征在于，电池组（1）的连接方式为多个电池单元（5）并列排布，相邻的两个电池单元（5）之间的极性在空间方向上相反；在每个电池单元（5）的两个极性端，分别连接有固态继电器（6）；相邻的两个电池单元（5）在空间方向的同一侧，通过连接导线相互连接，并在连接导线中连入固态继电器（6）；从相邻两个电池单元（5）的空间方向同一侧的连接导线上，分别引出一条引出导线，并在所述引出导线中加入固态继电器（6）；将同一侧两个电池单元（5）的极性端的连接导线中接入的固态继电器（6）放在接入位置的同一侧；通过导线将引出导线的端点连接在一起，并在相邻的两个引出导线的端点之间也加入固态继电器（6）；从引出导线的端点连接线上引出两条导线，从而构成电池组（1）的A、B两个端线。

3. 如权利要求1所述的系统，其特征在于，电池组（1）不经过功率转换器直接与所述电动汽车电动机驱动系统的电动机（2）电连接，以向电动机（2）输出电压信号。

4. 如权利要求1所述的系统，其特征在于，传感器（3）包括电机电压传感器、电机电流传感器、电机速度传感器、电机转矩传感器、电机温度传感器。

5. 如权利要求1所述的系统，其特征在于，电动机（2）为直流电动机或交流电动机。

6. 一种如权利要求1～5任一所述的系统的控制方法，其特征在于，所述控制方法包括如下步骤：

（1）当控制器（4）获得起动信息时，采用他励直流电动机（2），结合传感器（3）接收的信号，通过控制固态继电器（6）的通断，使得电池组（1）的电池单元（5）在保证最低电压所对应的起动转矩大于负载转矩的情况下，逐步增加电池组的电池单元（5）导通的个数，以获得逐级升高的正向电压；起动后，随着转速的上升，控制器（4）控制固态继电器（6）的通断，使得多个电池单元（5）起作用，以提高电动机（2）电枢两端的正向电压，获得所需要的加速转矩；

（2）当控制器（4）获得加速信号时，采用他励直流电机（2），结合传感器（3）接收的信号，控制器（4）控制固态继电器（6）的通断，获得周期的矩形波，在一个周期内，正向电压和反向电压的绝对值大小相等，且所述正向电压和反向电压的绝对值大小对应为电动机（2）的额定电压，通过控制正向时间比反向时间足够长，使得在一个周期内，正向电压的平均值对应的电机转矩大于负载转矩，获得汽车的加速；反之，若在一个周期内，正向电压的平均值对应的电机转矩小于负载转矩，获得汽车的减速；

（3）当控制器（4）获得制动信号时，采用他励直流电机（2），结合传感器（3）接收的信号，控制器（4）控制固态继电器（6）的通断，使得电池组的电池单元（5）的输出电压小于电

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枢电动势，迫使电流从电枢流向电池，形成制动转矩，电动机（2）再生发电；对于电枢电动势因转速下降而减小，控制器（4）相应逐步减少起作用的电池单元（5）；对于最终电动机的反馈电压不足于对单个电池单元充电，则将电动机转向电阻负载，以消耗残余电动机内的电量。

7. 如权利要求 6 所述的控制方法，其特征在于，在起动过程中，控制器（4）控制固态继电器（6）高频通断，使得电池组单元（5）在单位时间内高频交替作用，以使电池均衡放电，当工作一段时间后，电池的输出能力下降，要获得相同的等级的电压，则要增加电池导通的数量。

8. 如权利要求 6 所述的控制方法，其特征在于，在调速过程中，控制器（4）控制固态继电器（6）高频通断，同样使得电池单元（5）在单位时间内高频交替作用，以使电池均衡放电，当工作一段时间后，电池的输出能力下降，为补偿压降获得相同的调速能力，要增加电池导通的数量以获得相同的电压等级。

9. 如权利要求 8 所述的控制方法，其特征在于，在制动过程中，控制器（4）控制固态继电器（6）的高频通断，使得单位交替作用时间内，电池起作用时间相同，以使电池单元（5）再生充电均衡。

10. 一种如权利要求 1 ～ 5 任一所述的系统的控制方法，其特征在于，所述控制方法包括如下步骤：

（1）在电动汽车的起动过程中，采用三相异步交流电动机，电池组提供类正弦电压信号的电压信号，所述系统采用输出电压较小的电池，以降低转矩冲击，并高频控制固态继电器（6），以获得所需要的电压信号的频率和电压大小，因起动转矩的大小与电压有效值平方成正比，与电压频率成反比，采用电压有效值对应起动电流小于额定电流的基础上，减小电压频率的方法，保证电压频率和大小满足起动转矩大于负载转矩；

（2）在电动汽车的调速过程中，采用三相异步交流电机，控制器（4）控制固态继电器（6）的通断，输出电压较小的电池，并高频控制固态继电器（6），以降低在获得类似正弦波时的电压冲击，在单位时间内，控制所有的电池单元（5）的工作时间相同，以保证放电均衡；在加速过程中，结合传感器（3）接受的信号，控制器（4）获加速信号后，控制固态继电器（6）的通断，在满足电机转矩大于负载转矩的基础上，增大类正弦电压信号频率，同时相应调整电池单元（5）的导通个数，使得电压有效值大小为电机的额定电压，对于工作一段时间后，压降的补偿，增加电压信号在峰值时刻的导通的电池单元（5）的个数，使得电压有效值仍为电机的额定电压，这时候，电压和频率对应的转矩不变且仍然大于负载转矩；在减速过程中，结合传感器（3）接受的信号，减小类正弦电压信号频率，同时相应改变电池单元（5）的导通个数，使得电压有效值大小为电机的额定电压，使得对应电机转矩小于负载转矩，，对于压降的补偿，增加电压信号在峰值时刻的导通的电池单元（5）的个数，使得电压有效值大小仍为电机的额定电压，这时候电压和频率对应的电机的转矩不变且仍然小于负载转矩。

（3）在电动汽车的制动过程中，采用三相异步交流电机，当控制器（4）获得制动信号时，结合传感器（3）接收的信号，通过控制固态继电器（6），使得电池组输出的三相电的相序改变，为了保证放电均衡，单位时间内，固态继电器（6）高频交替通断，所有电池单元（5）起作用时间相同。

11. 如权利要求 10 所述的控制方法，其特征在于，在电动汽车的调速过程中，结合传感

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器(3)接受的信号,控制器(4)获加速信号后,控制固态继电器(6)的通断,获得频率增大的类正弦电压信号,对于工作一段时间后,压降的补偿,采用增加电压峰值时刻导通电池单元(5)的个数,以维持电压的有效值;在电动汽车的调速过程的减速过程中,结合传感器(3)接受的信号,同样获得频率减小的类正弦电压信号,对于压降的补偿,采用增加电压峰值时刻导通电池单元(5)的个数,以维持电压的有效值。

12. 如权利要求 10 或 11 所述的控制方法,其特征在于,使用如权利要求 1 或 2 所述的三个电池组(1)以构成三相交流电。

13. 如权利要求 12 所述的控制方法,其特征在于,所述三个电池组(1)对于所述三相异步交流电动机的绕组为 Y 型连接或三角型连接。

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电动汽车电池组单元通断与电动机驱动系统及其控制方法

技术领域

[0001] 本发明涉及一种以电动汽车电池组单元之间通断获得驱动电动机所需电压信号的电机驱动系统及其控制方法，属于电动汽车驱动控制系统。

背景技术

[0002] 目前，对于电动汽车，其电动机驱动系统主要由电动机、功率转换器、控制器、各种检测传感器以及电源（蓄电池）等部分组成。其电动机，按类型可选用直流、交流、永磁无刷或开关磁阻等几种类型。功率转换器器按所选择电动机类型，有 DC/DC 功率转换器，DC/AC 功率转换器等形式，其作用是按所选择电动机驱动电流要求，将蓄电池的直流电转换为相应电压等级的直流、交流或脉冲电源。各种检测传感器主要有电压、电流、速度、转矩以及温度等检测反馈，以及车辆运行状态传感器，其作用是为提高改善电动机的调速特性而设置，对于永磁无刷电动机或开关磁阻电动机还要求有电动机转角位置检测。由于所选电动机类型不同其控制驱动方式也不同。控制器是按驾驶员操纵档位杆、加速踏板和制动踏板等输入的前进、倒退、起步、加速、制动等信号，以及各种电机检测传感器和车辆运行状态传感器反馈的信号，通过运算、逻辑判断、分析比较等适时向功率转换器发出相应的指令，使整个驱动系统有效的运行。

[0003] 在直流调速领域内，他励直流电动机是电动汽车直流驱动电动机中的首选电动机，而他励直流电动机，目前已较多地采用 PWM 调速系统，即脉宽调速。脉宽调速利用脉宽调制器对大功率晶体管开关放大器的开关时间进行控制，将直流电压转换成某一频率的矩形波电压，加到直流电动机的电枢两端，通过对矩形波脉冲宽度的控制，改变电枢两端的平均电压，从而达到调节电动机转速的目的。PWM 控制方式的速度控制单元由脉冲宽度调制器和脉冲功率放大器两部分组成。

[0004] 在交流调速领域内，对于三相异步电动机和同步电动机的调速方式大体一致。对于三相异步电动机的调速，常采用改变定子供电电源的频率的方法。如果频率连续可调，则可平滑地调节转速，实现变频调速。同时为保证电动机的输出转矩，要求调频的同时改变定子电压，因此对交流电动机供电的变频器一般要求同时有调频调压的功能。交流电动机选择直－交变频器，主要由 DC/DC 转换器和逆变器两大部分组成。

[0005] 上述所介绍的直流和交流调速，电能均从电池组输出后经过相应的功率转换器，再输送给电动机，而功率转换器在工作的过程中，损耗了一定的电能，使得能量转换率降低。在直流调速中改变脉冲宽度和交流调速中改变频率和电压的方法环节复杂。

发明内容

[0006] 本发明提出了一种电动车电池组单元通断与电动机驱动系统及其控制方法，可以实现控制电池输出电能，并直接对电动机供电，省去了功率转换器，提高了电池的能源利用率，因驱动控制电压信号从电池组产生，并对电动机直接控制，使得控制形式简单化。

[0007] 为了解决上述现有技术不足之处，本发明目的是提供一种电动汽车用电池组单元

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连接系统，以克服现有技术中的缺陷。

[0008] 为了达到上述目的，本发明提供了电动车电池组单元通断与电动机驱动的系统，所述系统包括电动机、电池组、传感器和控制器。所述电池组包括多个电池单元和在连接线路之间的固态继电器，所述固态继电器用于控制所述电池单元导通与断开、数量和时间、电压的大小、并控制单个或多个电池单元在A、B端输出的极性、以及控制在A、B端输出大小、方向以及频率可变的电压信号；所述控制器获得起动、加速、减速及制动信号并结合所述传感器的信息，所述控制器控制所述固态继电器以控制电池组的电池单元的导通与断开，并所述控制器从所述电池组中获得电源的剩余电量情况，所述电池组输出的相应电压信号，驱动电动机运转，在制动环节电动机对电源反馈充电。

[0009] 优选地，所述电池组的连接方式为多个电池单元并列排布，相邻的两个电池单元之间的极性在空间方向上相反；在每个电池单元的两个极性端，分别连接有固态继电器；相邻的两个电池单元在空间方向的同一侧，通过连接导线相互连接，并在连接导线中连入所述固态继电器；从相邻两个电池单元的空间方向同一侧的连接导线上，分别引出一条引出导线，并在所述引出导线中加入所述固态继电器；将同一侧两个电池单元的极性端的连接导线中接入的所述固态继电器放在接入位置的同一侧；通过导线将引出导线的端点连接在一起，并在相邻的两个引出导线的端点之间也加入所述固态继电器；从引出导线的端点连接线上引出两条导线，从而构成所述电池组的A、B两个端线。

[0010] 优选地，所述电池组不经过功率转换器直接与所述电动汽车电动机驱动系统的所述电动机电连接，以向所述电动机输出电压信号。

[0011] 优选地，所述传感器包括电机电压传感器、电机电流传感器、电机速度传感器、电机转矩传感器、电机温度传感器。

[0012] 优选地，所述电动机为直流电动机或交流电动机。

[0013] 所述控制器根据车辆的运行情况和电机反馈的信息，控制所述固态继电器的通断，可以输出方向，大小可变的电压波形，通过控制固态继电器的通断时间和次序，可以输出矩形电压波形，当电池组单元个体容量小，单个电池组单元输出电压小的情况下，通过控制，可以输出类似正弦波的电压波形。

[0014] 本发明的另一目的在于提供了电动汽车电池组单元通断与电动机驱动系统的控制方法，所述控制方法如下：

[0015] (1) 在电动汽车的起动过程，采用他励直流电动机，当控制器获得起动信息时，结合传感器接受的信号，通过控制固态继电器的通断，使得电池组的电池单元，在保证最低电压所对应的起动转矩大于负载转矩的情况下，逐步增加电池组单元导通的个数，以获得逐级升高的正向电压。起动后，随着转速的上升，控制器控制固态继电器的通断，使得多个电池单元起作用，以提高电动机电枢两端的正向电压，获得所需要的加速转矩。特别优选地，为了使得在起动过程中，电池均衡放电，控制器控制固态继电器高频通断，使得电池组单元在单位时间内高频交替作用。在一个高频交替作用时间内，因电池的放电时间很短，可近似认为电池的输出电压不变，当工作一段时间后，电池的输出能力下降，要获得相同的等级的电压，则要增加电池导通的数量。

[0016] (2) 采用他励直流电机，对于电动汽车的调速过程：当控制器获得加速信号时，结合传感器接受的信号，控制器控制固态继电器的通断，获得周期的矩形波，在一个周期内，

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正向电压和反向电压的绝对值大小相等，且所述正向电压和反向电压的绝对值大小对应为电动机的额定电压，通过控制正向时间比反向时间足够长，使得在一个周期内，正向电压的平均值对应的电机转矩大于负载转矩，获得汽车的加速；反之，若在一个周期内，正向电压的平均值对应的电机转矩小于负载转矩，获得汽车的减速。特别优选地，为了使得在调速过程，电池均衡放电，控制器控制固态继电器高频通断，同样使得电池单元在单位时间内高频交替作用。在一个高频交替作用时间内，因电池的放电时间很短，可近似认为电池的输出电压不变，当工作一段时间后，电池的输出能力下降，为补偿压降要增加电池导通的数量以获得相同的电压等级。

[0017] (3) 采用他励直流电机，对于电动汽车的制动过程：当控制器获得制动信号时，结合传感器接受的信号，控制器控制固态继电器的通断，使得电池组单元的输出电压小于电枢电动势，迫使电流从电枢流向电池，形成制动转矩，电动机再生发电。对于电枢电动势因转速下降而减小，控制器相应逐步减少起作用的电池单元，对于最终电动机的反馈电压不足于对单个电池单元充电，则将电动机转向电阻负载，以消耗残余电动机内的电量。特别优选地，在此过程中，为保证电池单元再生充电均衡，控制器控制固态继电器的高频通断，使得单位交替作用时间内，电池起作用时间相同，对于最终电动机的反馈电压不足于对单个电池单元充电，则将电动机转向电阻负载，以消耗残余电动机内的电量。

[0018] 本发明的再一目的在于提供了电动汽车电池组单元通断与电动机驱动系统的控制方法，所述控制方法如下：

[0019] (1) 在电动汽车的起动过程，采用三相异步交流电动机，为保证有足够大的起动转矩和较小的起动电流，电池组要提供的电压信号为类正弦电压信号，即锯齿形类正弦电压信号。在这里，系统采用输出电压较小的电池，以降低转矩冲击，并高频控制固态继电器，以获得所需要的电压信号的频率和电压大小，因起动转矩的大小与电压有效值平方成正比，与电压频率成反比，可以采用电压有效值对应起动电流小于额定电流的基础上，减小电压频率的方法，保证电压频率和大小满足起动转矩大于负载转矩。

[0020] (2) 在电动汽车的调速过程，采用三相异步交流电机，控制器控制固态继电器的通断，这里系统输出电压较小的电池，并高频控制固态继电器，以降低在获得类似正弦波时的电压冲击，在单位时间内，控制所有的电池工作时间相同，以保证放电均衡。特别优选地，对于加速过程，结合传感器接受的信号，控制器获加速信号后，控制固态继电器的通断，在电机驱动转矩大于负载转矩的基础上，增大类正弦信号的频率，同时调整导通的电池单元的个数，使得电压信号的有效值为电机的额定电压，对于工作一段时间后，压降的补偿，可以采用在增加电压峰值对应导通电池个数，保证电压有效值为电机的额定电压，。对于减速过程，结合传感器接受的信号，调整导通的电池的个数，保证电压有效值为电机的额定转矩的基础上，减小类正弦电压信号的频率，使得对应的电机转矩小于负载转矩，对于压降的补偿，可以采用在不改变电压信号频率的基础上，增加电压信号峰值对应导通电池的个数，使得电压有效值为电机的额定电压，使得电机转矩不变且仍然小于负载转矩。这样可以实现调频兼调压的要求。

[0021] (3) 在电动汽车的制动过程，采用三相异步交流电机，当控制器获得制动信号时，结合传感器接收的信号，通过控制固态继电器，使得电池组输出的三相电的相序改变，即其中任意两相电的相序对调，以改变旋转磁场的方向。同样，为保证放电均衡，单位时间内，固

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态继电器高频交替通断，所有电池单元起作用时间相同。

[0022] 优选地，在电动汽车的调速过程中，结合传感器接受的信号，控制器获加速信号后，控制固态继电器的通断，获得频率增大的类正弦电压信号，对于工作一段时间后，压降的补偿，采用增加电压峰值时刻导通电池单元的个数，以维持电压的有效值；在电动汽车的调速过程的减速过程中，结合传感器接受的信号，同样获得频率减小的类正弦电压信号，对于压降的补偿，采用增加电压峰值时刻导通电池单元的个数，以维持电压的有效值。

[0023] 优选地，使用如上所述的三个电池组以构成三相交流电。更优选地，所述三个电池组对于所述三相异步交流电动机的绕组为 Y 型连接或三角型连接。

[0024] 本发明的电动汽车用电池组单元连接系统的有益效果如下：1、取消了电池组到电动机之间的功率转换器，控制电池组单元，获得相应的电压信号，直接对电动机作用，减小了能量损耗；2、可以控制和改变电池输出电压，尤其是在交流电机中，可以根据情况，通过控制固态继电器，实现调压和调频的功能，使得控制形式简单化。此外，本发明的电动汽车电池组单元通断与电动机驱动系统的控制方法与现有技术相比，其主要优点体现在其通用性，由于本发明的输出电压是可调的，对于直流电机电动车和交流电机电动车，都可以采用本发明，而不用设计不同的系统以满足电机的差异性，其唯一需要改变的只是控制器的控制程序。

附图说明

[0025] 图 1 为电动汽车电池组单元通断与电机驱动的系统的基本框图；

[0026] 图 2 为电池组单元通断的结构图；

[0027] 图 3a 为一个电池单元输出反向电压的结构图；

[0028] 图 3b 为图 3a 输出电压状态示意图；

[0029] 图 4a 为一个电池单元输出正向电压的结构图；

[0030] 图 4b 为图 4a 输出电压状态示意图；

[0031] 图 5a 为两个电池单元输出反向电压的结构图；

[0032] 图 5b 为图 5a 输出电压状态示意图；

[0033] 图 6a 为两个电池单元输出正向电压的结构图；

[0034] 图 6b 为图 6a 输出电压状态示意图；

[0035] 图 7 为两个电池单元输出反向电压的另一结构图；

[0036] 图 8 为两个电池单元输出正向电压的另一结构图；

[0037] 图 9a 为三个电池单元输出反向电压的结构图；

[0038] 图 9b 为图 9a 输出电压状态示意图；

[0039] 图 10a 为三个电池单元输出正向电压的结构图；

[0040] 图 10b 为图 6a 输出电压状态示意图；

[0041] 图 11 为直流电动机起步过程的电压信号状态图；

[0042] 图 12 为直流电动机加速过程的电压信号状态图；

[0043] 图 13 为交流电动机起步过程的电压信号状态图；

[0044] 图 14 为三相交流正弦电压信号状态图；

[0045] 图 15 为交流电动机调速过程的电压信号状态图；

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[0046] 图 16 为电池组 Y 型接法的连接方式示意图；

[0047] 图 17 为电池组 Y 型接法的结构示意图；

[0048] 图 18 为形成 Y 型连接的三个电池组中的一个电池组输出 I-II 端电压信号的电池组单元通断的结构图；

[0049] 图 19 为形成 Y 型连接的三个电池组中的一个电池组输出 I-III 端电压信号的电池组单元通断的结构图；

[0050] 图 20 为形成 Y 型连接的三个电池组中的一个电池组输出 I-IV 端电压信号的电池组单元通断的结构图；

[0051] 图 21 为电池组三角型接法的连接方式示意图；

[0052] 图 22 为电池组三角型接法的结构示意图；

[0053] 图 23 为形成三角型连接的三个电池组中的一个电池组输出 I-II 端电压信号的电池组单元通断的结构图；

[0054] 图 24 为形成三角型连接的三个电池组中的一个电池组输出 I-III 端电压信号的电池组单元通断的结构图；

[0055] 图 25 为形成三角型连接的三个电池组中的一个电池组输出 II-III 端电压信号的电池组单元通断的结构图。

[0056] 附图标记说明如下：

[0057] 电池组 1、电动机 2、传感器 3 包括电机电压传感器、电机电流传感器、电机速度传感器、电机转矩传感器、电机温度传感器传感器，控制器 4、电池单元 5、电池单元 5A、电池单元 5B、电池单元 5C、电池单元 5D、电池单元 5E、电池单元 5N、固态继电器 6、在 7 所示的位置，两根导线跨接，并不直接相连、直流电动机起步过程的起始电压 U_{start}、U_M 为电动机的额定工作电压、电池组两端的电压 U_{AB}^{B}、直流电机 M 两端的反馈电压 U_{12}^{M}、单个单体电池单元的电压 U_{AB}^{cell}、第一周期正向时间 t1、第一周期反向时间 t2、第二周期正向时间 t3、第二周期反向时间 t4、三相交流正弦电压信号 U_A、三相交流正弦电压信号 U_B、三相交流正弦电压信号 U_C、三相类正弦电压信号 U_1、三相类正弦电压信号 U_2、三相类正弦电压信号 U_3、三相交流电压 U1、三相交流电压 U2、三相交流电压 V1、三相交流电压 V2、三相交流电压 W1、三相交流电压 W2。

具体实施方式

[0058] 为了使审查员能够进一步了解本发明的结构、特征及其他目的，现结合所附较佳实施例附以附图详细说明如下，本附图所说明的实施例仅用于说明本发明的技术方案，并非限定本发明。

[0059] 请参见图 1，图 1 为本发明所对应的电动汽车电动机驱动系统的基本组成框图。如图 1 所示，本发明的电池组单元连接系统包括电动机 2、电池组 1、传感器 3 和控制器 4。其中，电池组 1 包括多个电池单元 5 和在连接线路之间的固态继电器 6，固态继电器 6 用于控制电池单元 5 导通与断开、数量和时间、电压的大小、并控制单个或多个电池单元 5 在 A、B 端输出的极性、以及控制在 A、B 端输出大小、方向以及频率可变的电压信号。控制器 4 获得起动、加速、减速及制动信号并结合传感器 3 的信息，控制器 4 控制固态继电器 6 以控制电

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池组电池单元 5 的导通与断开，并控制器 4 从电池组 1 中获得电源的剩余电量情况，电池组 1 输出的相应电压信号，驱动电动机 2 运转，在制动环节电动机 2 对电源反馈充电。

[0060] 对于电池单元 5 和固态继电器 6 的连接方式，请参见图 2，图 2 为本发明的电池组单元通断的结构图。如图 2 所示，在本发明的电池组中，(i) 多个电池单元 5 并列排布，相邻的两个电池单元 5 之间的极性在空间方向上是相反的；(ii) 每个电池单元 5 的两个极性端，分别连接有固态继电器 6；(iii) 对于相邻的两个电池单元 5 的连接，在空间方向的同一侧，通过连接导线相互连接，并在连接导线中连入固态继电器 6；(vi) 从相邻两个电池单元 5 的空间位置同一侧的连接导线上，分别引出一条引出导线，并在所示引出导线中加入固态继电器 6；(v) 将同一侧两个电池极性端的连接导线中接入的固态继电器 6，放在接入位置的同一侧；(vi) 通过导线将引出导线的端点连接在一起，并在相邻两个引出导线的端点之间加入固态继电器 6；(vii) 从引出导线的端点连接线上引出两条导线，从而构成 A、B 两个端线，以在 A、B 端输出可调电压大小、方向、频率的电压信号。其中，图 2 中涂黑的黑点就是最后一个电池 N 的固态继电器 6，固态继电器 6 也可以放在第 N 个电池的正极端下侧，它们在功能上都是一样的。

[0061] 下面，结合附图，详细描述如何在 A、B 端输出电压大小、方向、频率可调的电压信号。

[0062] 首先，请参考图 3a 和图 3b，图 3a 为一个电池单元输出反向电压的结构图，图 3b 为图 3a 输出电压示意图。如图 3a 所示，对于一个电池单元起作用时，即电池单元 5A 起作用，可以在 A、B 端输出如图 3b 所示的电压为 -u。并且可以认为，在放电时间比较短的确情况下，-u 没有衰减；而且这个放电的时间长短还可以任意控制。

[0063] 同样的，对于电池单元 5A，其也可以在 A、B 端输出电压为 +u。请参考图 4a 和图 4b，图 4a 为一个电池单元输出正向电压的结构图，图 4b 为图 4a 输出电压示意图。如图 4a 所示，电池单元 5A 起作用，可以在 A、B 端输出如图 4b 所示的电压为 +u。并且可以认为，在放电时间比较短的确情况下，+u 没有衰减。

[0064] 需要说明的是，这里面，因为电池单元排布结构没有特殊性，可以控制如图 3a 和图 4a 所示的电池单元 5A、5B、5C……5N 中的任意一个电池单元独自放电，使得在 A、B 端的电压极性可变。

[0065] 接着，请参考图 5a、图 5b、图 6a 和图 6b，其中，图 5a 为两个电池单元输出反向电压的结构图；图 5b 为图 5a 输出电压状态示意图；图 6a 为两个电池单元输出正向电压的结构图；图 6b 为图 6a 输出电压状态示意图。本发明对于两个电池单元的控制，也具有随意性，如图 5a 和图 6a 所示，固态继电器 6 控制电池单元 5A 和 5B 放电，从而在 A、B 端可以输出如图 5b 和图 6b 所示的 -2u 和 +2u 的电压信号。

[0066] 此外，请参考图 7 和图 8，其中图 7 为两个电池单元输出反向电压的另一结构图；图 8 为两个电池单元输出正向电压的另一结构图。本发明同样可以对任意两个电池单元进行控制，如图 7 和图 8 所示，固态继电器 6 还可以控制电池单元 5A 和电池单元 5C 放电，也就是说，本发明在这里可以控制任意两个电池单元放电，从而形成如图 5b 和图 6b 所示的 -2u 和 +2u 的电压信号。

[0067] 同样的，对于 3 个电池单元的控制，如图 9a 和图 10a 所示，这里控制电池单元 5A、5C 和 5D 同时起作用，从而形成如图 9b 和图 10b 所示的 -3u 和 +3u 的电压信号。当然，本发

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明可以任意切换到其他 3 个电池单元起作用，比如，电池单元 5B、5C 和 5D ；电池单元 5B、5C 和 5E ；电池单元 5C、5E 和 5F 等等，并且这个切换时间可以忽略不计。

[0068] 由此，通过上述的连接，本发明通过控制导通固态继电器 6 控制起作用的电池单元 5 的数量，其中可以使得任何一个电池单元 5 处于导通和断开状态，这样可以控制电压的大小。同样，当一个或者多个电池单元 5 起作用时，控制固态继电器 6 的导通和截止，可以使得在 A、B 端的输出电压极性改变。就同一个电池单元 5 和多个电池单元 5，通过控制固态继电器 6，可以在 A、B 端输出极性相反的电压信号。

[0069] 更进一步地，由于本发明是通过控制器 4 控制固态继电器 6，进而以控制电池组电池单元 5 的导通与断开，因此，本发明的电池组 1 不需要经过功率转换器便直接与电动汽车电动机驱动系统的电动机 2 电连接，从而向电动机 2 输出电压信号，在本发明中，电动机 2 可以为直流电动机，也可以为交流电动机。由此可见，本发明通过直接对电动机 2 供电，省去了功率转换器，从而提高了电池的能源利用率，而且由于驱动控制电压信号从电池组 1 产生，并对电动机 2 直接进行控制，从而使得本发明的控制形式更加简单化。

[0070] 在本发明中，控制器 4 需要获得起动、加速、减速及制动信号，同时结合传感器 3 的信息，以控制固态继电器 6。其中，传感器 3 包括电机电压传感器、电机电流传感器、电机速度传感器、电机转矩传感器、电机温度传感器。

[0071] 下面，以电动机分别为他励直流电动机和三相异步交流电动机两种情况，详述本发明的电动汽车电池组单元通断与电动机驱动系统的控制方法。

[0072] （一）采用他励直流电动机时，控制方法包括如下步骤 ：

[0073] （1）当控制器 4 获得起动信息时，结合传感器 3 接收的信号，通过控制固态继电器 6 的通断，使得电池组 1 的电池单元 5 在保证最低电压所对应的起动转矩大于负载转矩的情况下，逐步增加电池组的电池单元 5 导通的个数，以获得逐级升高的正向电压 ；起动后，随着转速的上升，控制器 4 控制固态继电器 6 的通断，使得多个电池单元 5 起作用，以提高电动机 2 电枢两端的正向电压，获得所需要的加速转矩 ；

[0074] （2）当控制器 4 获得加速信号时，结合传感器 3 接收的信号，控制器 4 控制固态继电器 6 的通断，获得周期的矩形波，在一个周期内，正向电压和反向电压的绝对值大小相等，且该正向电压和反向电压的绝对值大小对应为电动机 2 的额定电压，通过控制正向时间比反向时间足够长，使得在一个周期内，正向电压的平均值对应的电机转矩大于负载转矩，获得汽车的加速 ；反之，若在一个周期内，正向电压的平均值对应的电机转矩小于负载转矩，则获得汽车的减速 ；

[0075] （3）当控制器 4 获得制动信号时，结合传感器 3 接收的信号，控制器 4 控制固态继电器 6 的通断，使得电池组的电池单元 5 的输出电压小于电枢电动势，迫使电流从电枢流向电池，形成制动转矩，电动机 2 再生发电 ；对于电枢电动势因转速下降而减小，控制器 4 相应逐步减少起作用的电池单元 5 ；对于最终电动机的反馈电压不足于对单个电池单元 5 充电，则将电动机 2 转向电阻负载，以消耗残余电动机 2 内的电量。

[0076] 其中，对于当控制器 4 获得起动信息时，请参阅图 11，图 11 为直流电机起步过程的电压信号状态图。如图 11 所示，在他励直流电动机的起步过程中，要使得起始电压 U_{start} 对应于他励直流电动机的转矩，且大于汽车的负载转矩，以满足汽车的起步要求，然后逐级增加导通电池单元 5 的个数，提高他励直流电动机 2 电枢两端的正向电压，以获得需要的加速

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转矩。

[0077] 特别的是，在起动过程中，控制器 4 控制固态继电器 6 高频通断，使得电池组单元 5 在单位时间内高频交替作用，以使电池均衡放电，当工作一段时间后，电池的输出能力下降，要获得相同的等级的电压，则要增加电池导通的数量。

[0078] 而对于当控制器 4 获得加速信号时，请参阅图 12，图 12 为直流电动机加速过程的电压信号状态图。在调速阶段，U_M 为他励直流电动机的额定工作电压，若要加速，如图 12 所示，只要在一个周期 T 内，控制正向时间 t1、t3 比相应的反向时间 t2、t4 足够大，使得正向平均电压对应的电机转矩大于负载转矩。反之，若要减速，则使得正向平均电压对应的电机转矩小于负载转矩，并且这个周期 T 是不变的。

[0079] 特别的是，在调速过程中，控制器 4 控制固态继电器 6 高频通断，同样使得电池单元 5 在单位时间内高频交替作用，以使电池均衡放电，当工作一段时间后，电池的输出能力下降，为补偿压降获得相同的调速能力，要增加电池导通的数量以获得相同的电压等级。

[0080] 在直流电动机的条件下，控制器 4 获得制动信号时，其电压的改变状态如下：

[0081] (1)由于电池组 1 的通断个数，是可以随意控制的，因此，通过控制电池组 1 的单体电池单元 5 的通断的个数，由此可以控制电池组 1 的 A、B 的端电压 U_{AB}^{B}；

[0082] (2) 在制动环节，直流电机 M 两端 1、2 的反馈电压 U_{12}^{M} 可以大于电池组 A、B 的端电压 U_{AB}^{B}，这样，直流电机就对电池组 1 充电；

[0083] (3) 这里的 U_{12}^{M} 是衰减的，那么就控制直流电机，使得 $U_{AB}^{B} > U_{12}^{B}$，这样直流电机 M 一直对电池组 1 充电；

[0084] (4) 这里的 U_{AB}^{B} 不是无限小的，其最小值是单个单体电池单元 5 的电压 U_{AB}^{cell}；

[0085] (5) 当 U_{AB}^{B} 衰减到 $U_{AB}^{B} \leq U_{AB}^{cell}$ 的时候，这时候，将直流电机转向负载电阻，消耗掉电机 M 的电量。

[0086] 特别的是，在制动过程中，控制器 4 控制固态继电器 6 的高频通断，使得单位交替作用时间内，电池单元 5 起作用时间相同，以使电池单元 5 再生充电均衡。

[0087] (二)采用三相异步交流电动机时，需要使用如图 2 所示的三个电池组结构，以构成三相交流电，其控制方法包括如下步骤：

[0088] (1) 在电动汽车的起动过程中，电池组 1 提供类正弦电压信号的电压信号，系统采用输出电压较小的电池，以降低转矩冲击，并高频控制固态继电器 6，以获得所需要的电压信号的频率和电压大小，因起动转矩的大小与电压有效值平方成正比，与电压频率成反比，可以采用电压有效值对应起动电流小于额定电流的基础上，减小电压频率的方法，保证电压频率和大小满足起动转矩大于负载转矩；

[0089] (2) 在电动汽车的调速过程中，控制器 4 控制固态继电器 6 的通断，输出电压较小的电池，并高频控制固态继电器 6，以降低在获得类似正弦波时的电压冲击，在单位时间内，控制所有的电池单元 5 的工作时间相同，以保证放电均衡；在加速过程中，结合传感器 3 接受的信号，控制器 4 获加速信号后，控制固态继电器 6 的通断，在满足电机转矩大于负载转

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矩的基础上，增大类正弦电压信号频率，同时相应调整电池单元 5 的导通个数，使得电压有效值大小为电机的额定电压，对于工作一段时间后，压降的补偿，增加电压信号在峰值时刻的导通的电池单元 5 的个数，使得电压有效值仍为电机的额定电压，这时候，电压和频率对应的转矩不变且仍然大于负载转矩；在减速过程中，结合传感器 3 接受的信号，减小类正弦电压信号频率，同时相应改变电池单元 5 的导通个数，使得电压有效值大小为电机的额定电压，使得对应电机转矩小于负载转矩，对于压降的补偿，增加电压信号在峰值时刻的导通的电池单元 5 的个数，使得电压有效值大小仍为电机的额定电压，这时候电压和频率对应的电机的转矩不变且仍然小于负载转矩；

[0090] （3）在电动汽车的制动过程中，当控制器 4 获得制动信号时，结合传感器 3 接收的信号，通过控制固态继电器 6，使得电池组输出的三相电的相序改变，为了保证放电均衡，单位时间内，固态继电器 6 高频交替通断，所有电池单元 5 起作用时间相同。

[0091] 其中，在电动汽车的起动过程中，请参考图 13，图 13 为交流电动机起步过程的电压信号状态图。如图 13 所示，对于交流电机的起步，一般要求起动电流小于额定电流，起动转矩大于负载转矩。起动转矩与电压的平方成正比，与电压频率成反比，而起动电流只与电压有关，那么可以在保证有效电压对应起动电流小于额定电流的基础上，减小电压频率，输入如图 14 所示的类正弦电压信号。

[0092] 而在电动汽车的调速过程中，在电压有效值对应为电机额定电压的基础上，改变电压的频率，以实现调速。具体说，请参考图 14 和图 15，图 14 为三相交流正弦电压信号状态图，图 15 为交流电动机调速过程的电压信号状态图。如图 15 所示，对于交流电机的调速过程，本发明输出三相类正弦电压信号 U1、U2 和 U3，其中他们的相位差是 120 度，并且这里的频率 W 是可变的；本发明的交流电动机在调速过程中，只是调整频率，而不调整电压有效值。其中：(a)在加速的过程中，增大频率 W，保证电压的有效值不变，电压衰减的话，就增加导通的电池单元 5 的个数；(b) 在减速过程中，减小频率 W，保证电压的有效值不变，电压衰减的话，就增加导通的电池单元 5 的个数。

[0093] 特别的是，在电动汽车的调速过程中，结合传感器 3 接受的信号，控制器 4 获加速信号后，控制固态继电器 6 的通断，获得频率增大的类正弦电压信号，对于工作一段时间后，压降的补偿，采用增加电压峰值时刻导通电池单元 5 的个数，以维持电压的有效值；在电动汽车的调速过程的减速过程中，结合传感器 3 接受的信号，同样获得频率减小的类正弦电压信号，对于压降的补偿，采用增加电压峰值时刻导通电池单元 5 的个数，以维持电压的有效值。

[0094] 对于在电动汽车的制动过程中，请继续参考图 15，只要 U1、U2 和 U3 中，改变其中任意两个电压信号的相序，就可以在三相异步交流电动机中形成制动转矩。所以这部分制动，只是改了相序而已，没有其他的东西。在这个过程中电动机不反馈充电，其仅是为了使得汽车尽快制动。

[0095] 此外，本发明当采用三相异步交流电动机时，需要使用三个如图 2 所示的电池组结构，以构成三相交流电，而这三个电池组 1 对于三相异步交流电动机，其绕组为 Y 型连接或三角型连接。

[0096] 对于 Y 型连接，请参考图 16 至图 20，图 16 为电池组 Y 型接法的连接方式示意图，图 17 为电池组 Y 型接法的结构示意图，图 18 为形成 Y 型连接的三个电池组中的一个电池

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组输出 I-II 端电压信号的电池组单元通断的结构图，图 19 为形成 Y 型连接的三个电池组中的一个电池组输出 I-III 端电压信号的电池组单元通断的结构图，图 20 为形成 Y 型连接的三个电池组中的一个电池组输出 I-IV 端电压信号的电池组单元通断的结构图。如图 16 至图 20 所示，三个电池组形成 Y 型连接时，三个电池组共同连接于 I 点位，三个电池组分别输入 I-II 端电压信号、I-III 端电压信号和 I-IV 端电压信号，从而构成三相交流电。

[0097] 对于三角型连接，请参考图 21 至图 25，图 21 为电池组三角型接法的连接方式示意图，图 22 为电池组三角型接法的结构示意图，图 23 为形成三角型连接的三个电池组中的一个电池组输出 I-II 端电压信号的电池组单元通断的结构图，图 24 为形成三角型连接的三个电池组中的一个电池组输出 I-III 端电压信号的电池组单元通断的结构图，图 25 为形成三角型连接的三个电池组中的一个电池组输出 II-III 端电压信号的电池组单元通断的结构图。如图 21 至图 25 所示，电池组形成三角型连接时，三个电池组首尾相接，三个电池组分别输入 I-II 端电压信号、I-III 端电压信号和 II-III 端电压信号，从而构成三相交流电。

[0098] 因此，本发明不仅取消了电池组到电动机之间的功率转换器，控制电池组单元，获得相应的电压信号，直接对电动机作用，减小了能量损耗；而且还可以控制和改变电池输出电压，尤其是在交流电机中，可以根据情况，通过控制固态继电器，实现调压和调频的功能，使得控制形式简单化。

[0099] 需要声明的是，上述发明内容及具体实施方式意在证明本发明所提供技术方案的实际应用，不应解释为对本发明保护范围的限定。本领域技术人员在本发明的精神和原理内，当可作各种修改、等同替换或改进。本发明的保护范围以所附权利要求书为准。

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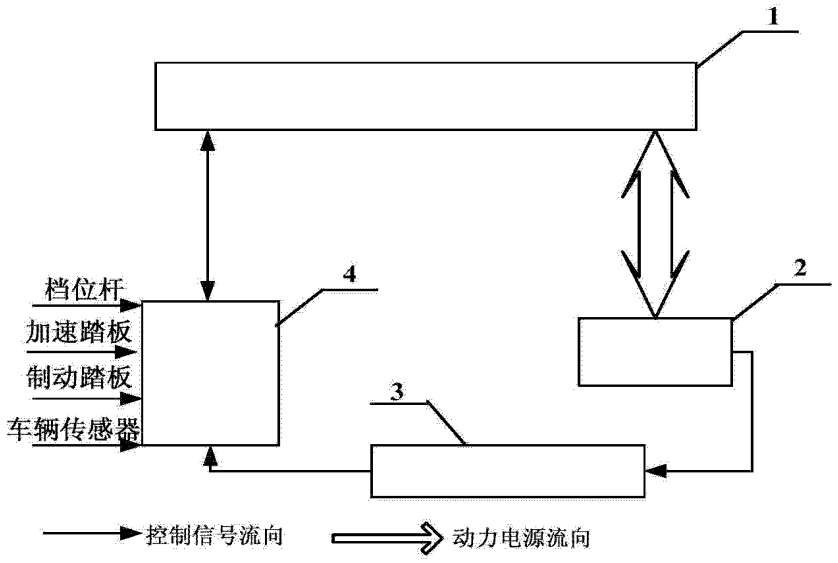


图 1

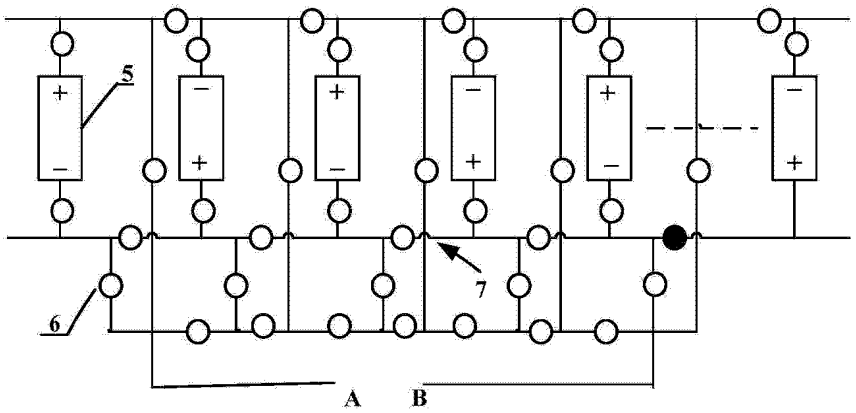


图 2

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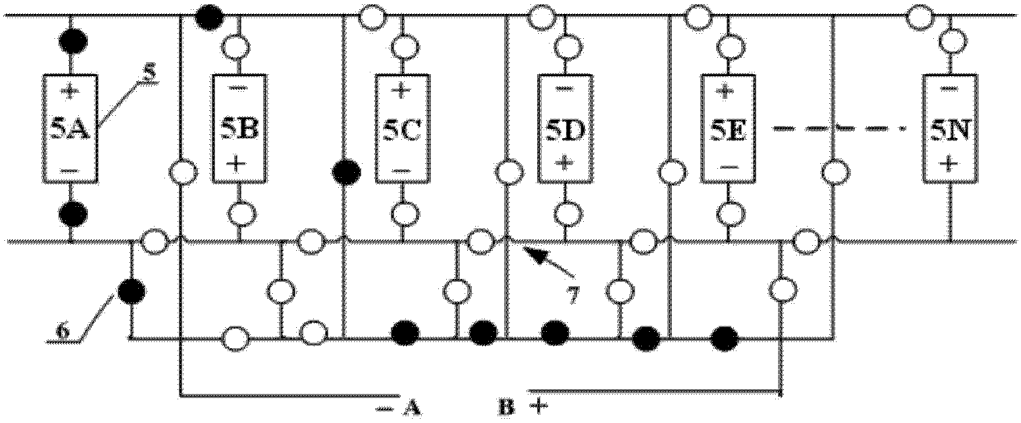


图 3a

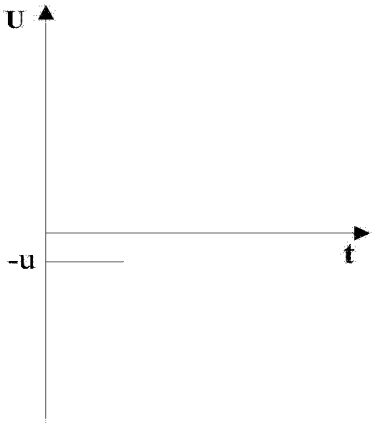


图 3b

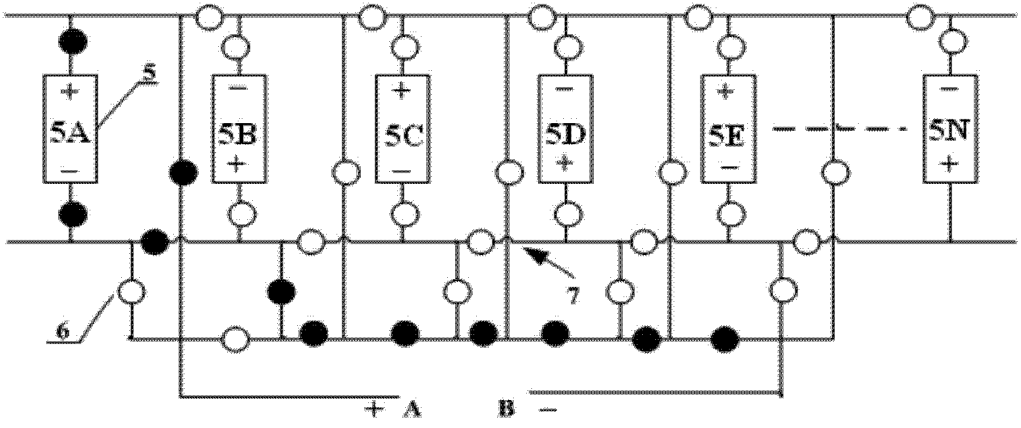


图 4a

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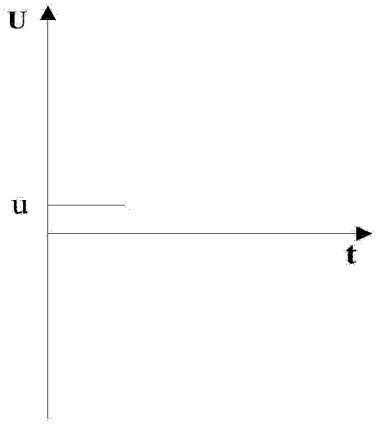


图 4b

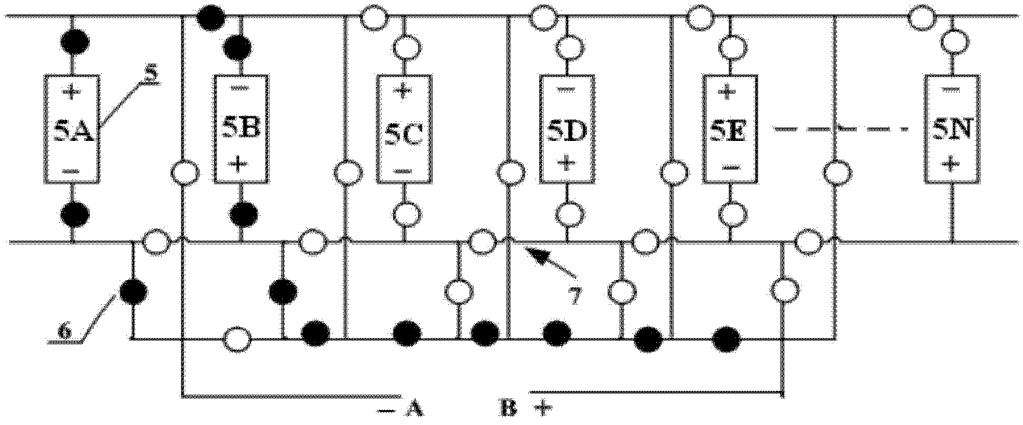


图 5a

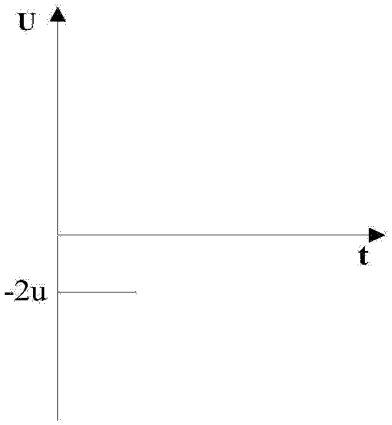


图 5b

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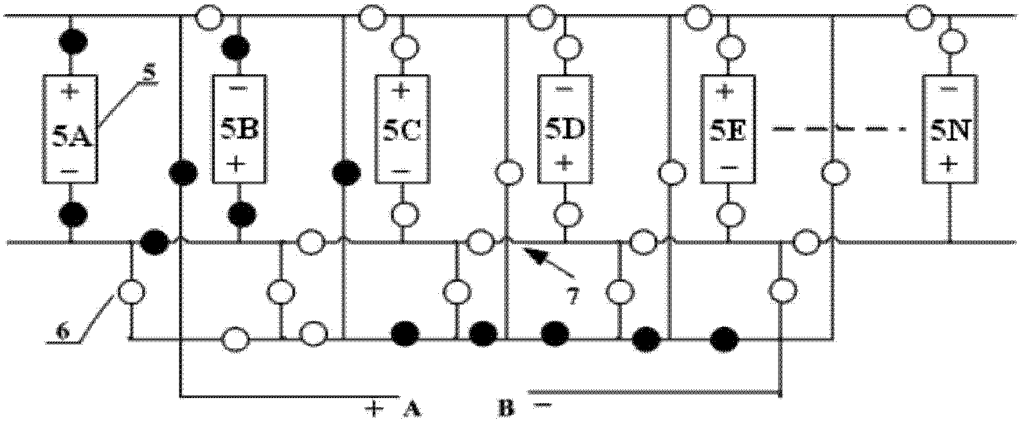


图 6a

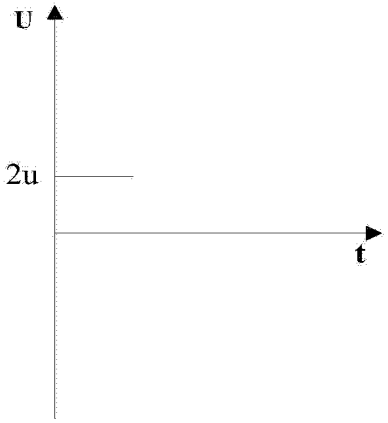


图 6b

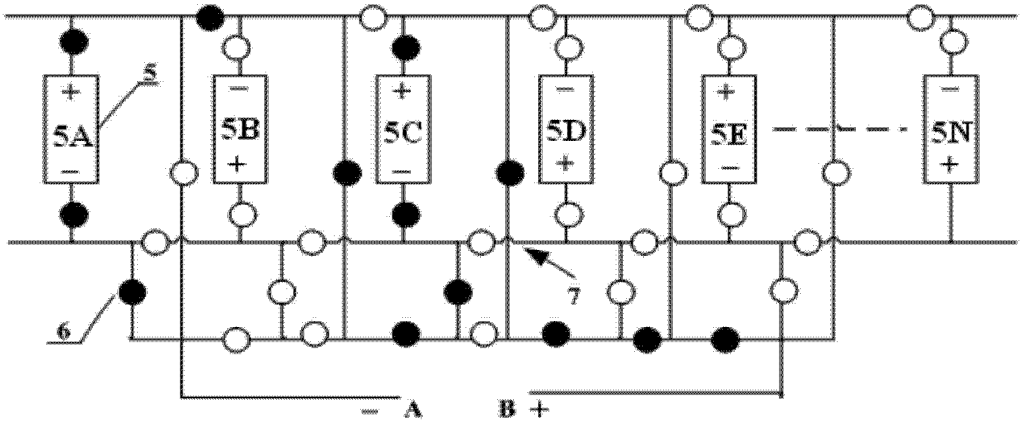


图 7

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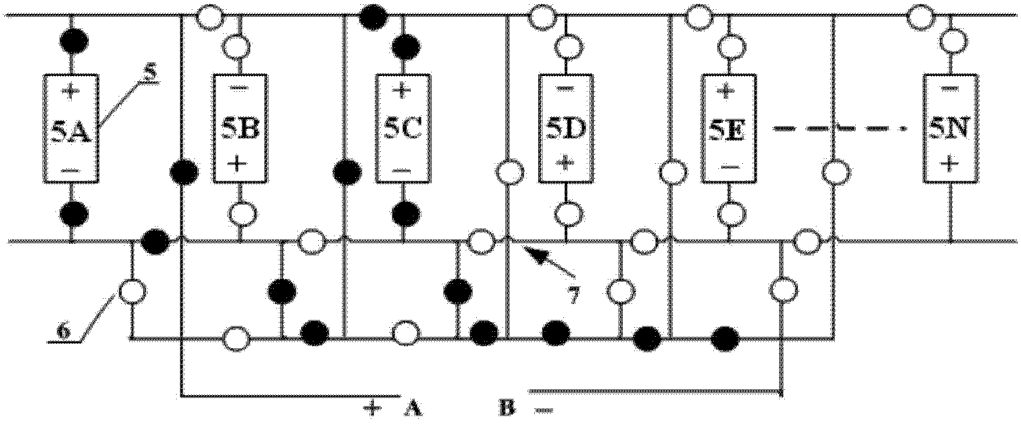


图 8

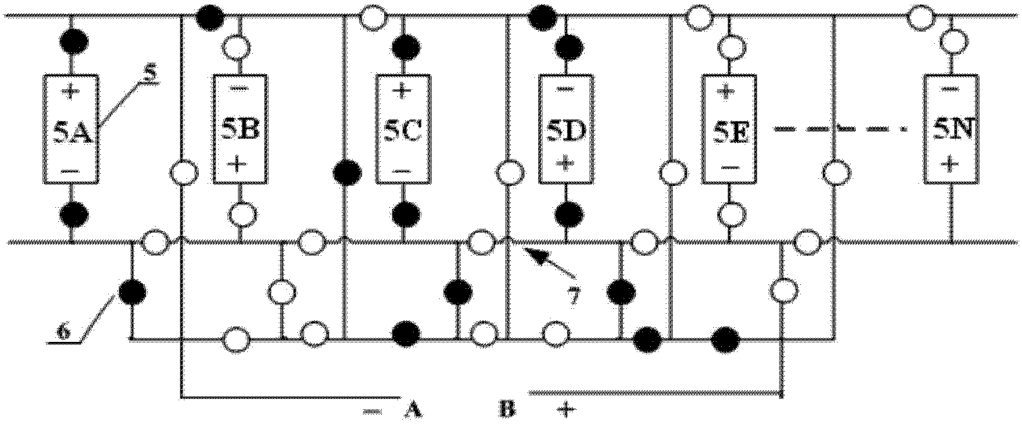


图 9a

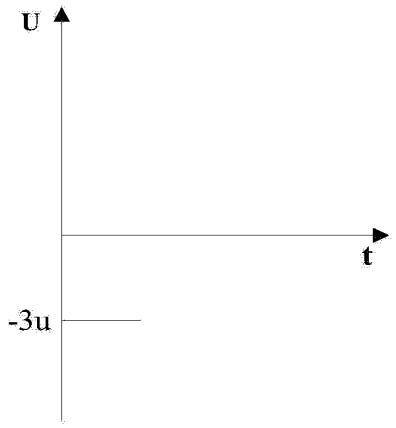


图 9b

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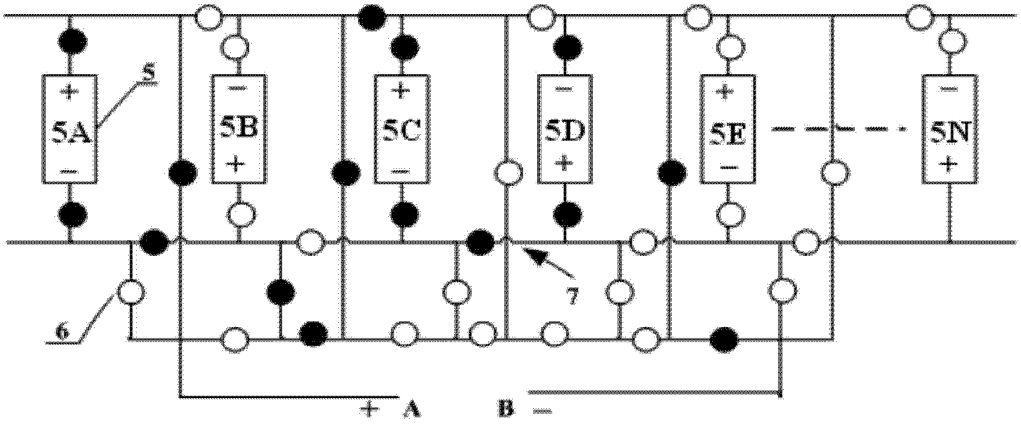


图 10a

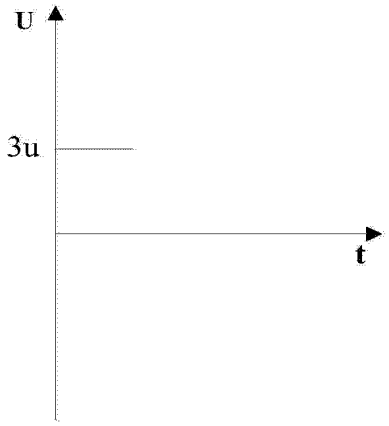


图 10b

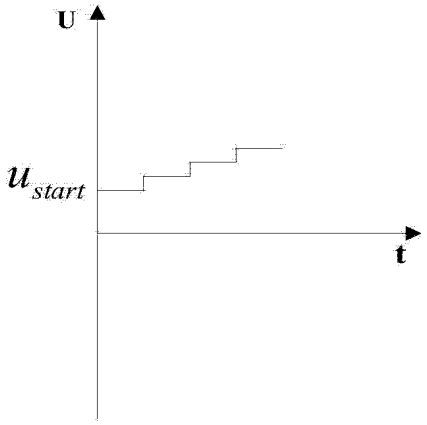


图 11

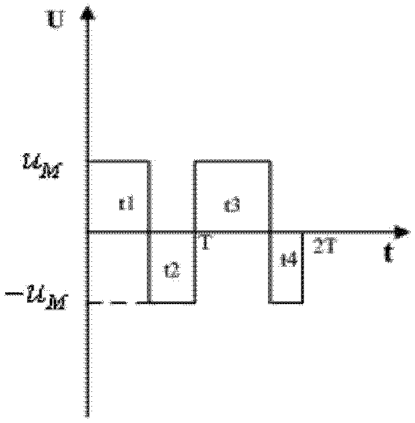


图 12

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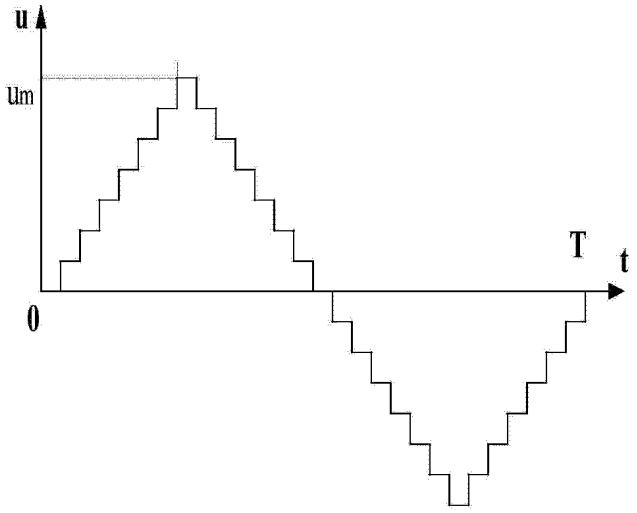


图 13

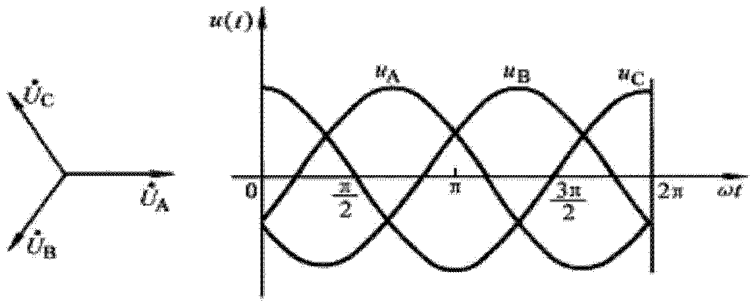


图 14

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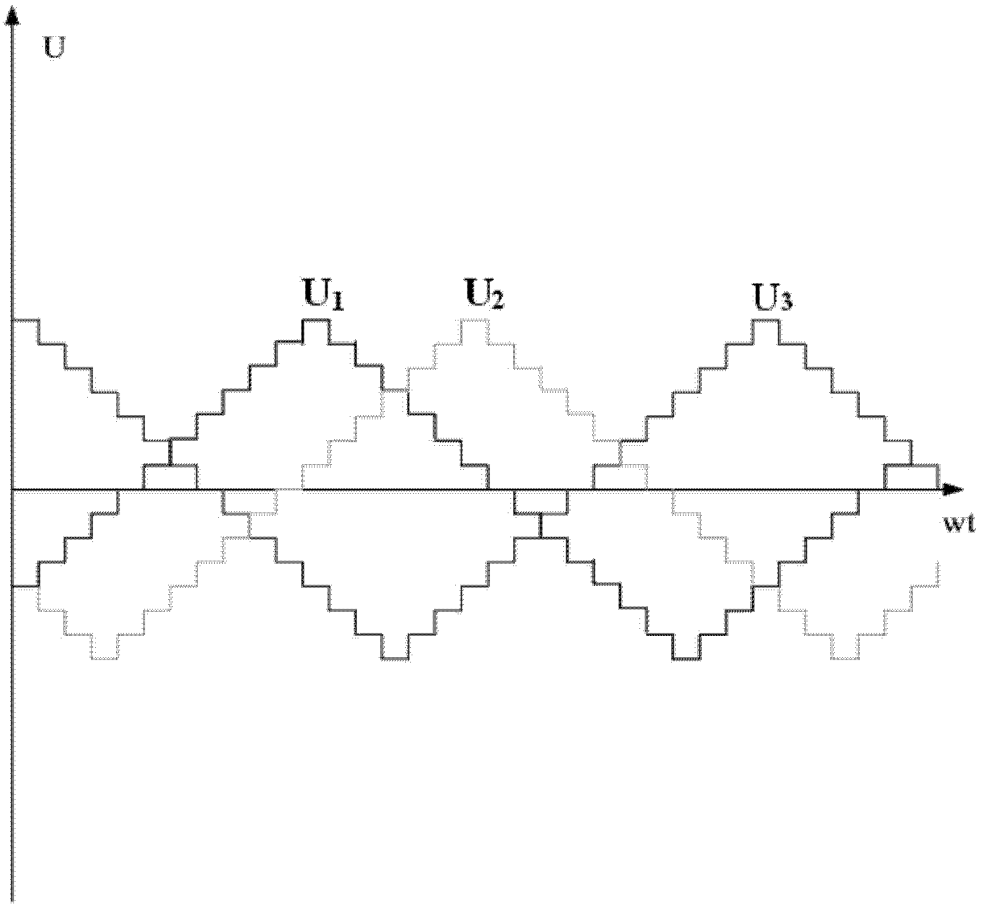
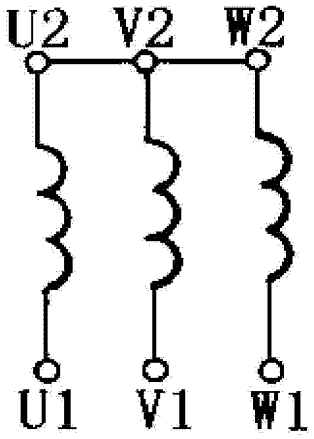


图 15

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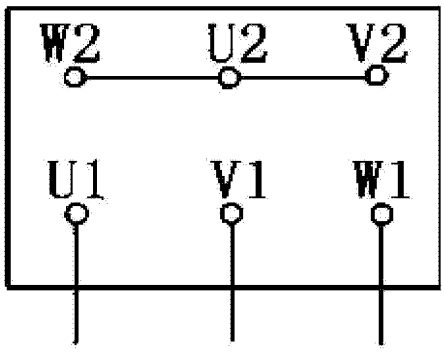


图 16

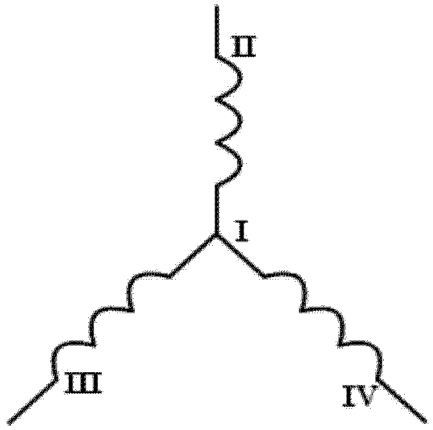


图 17

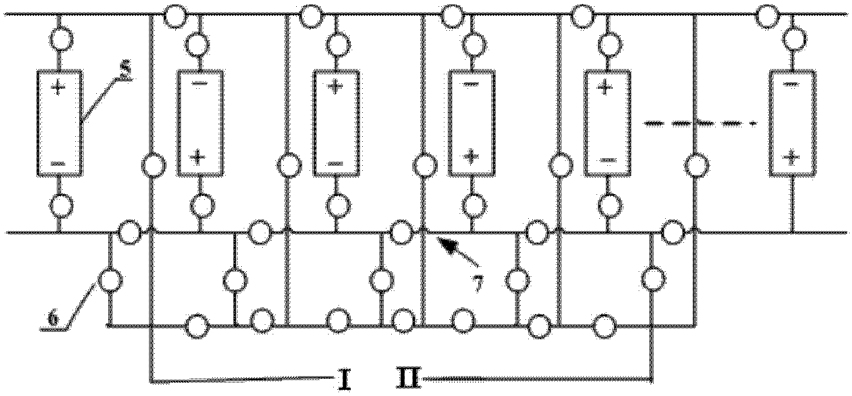


图 18

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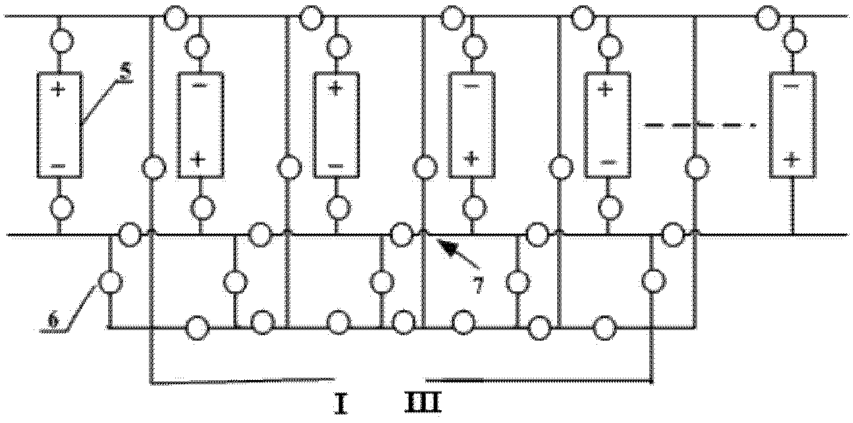


图 19

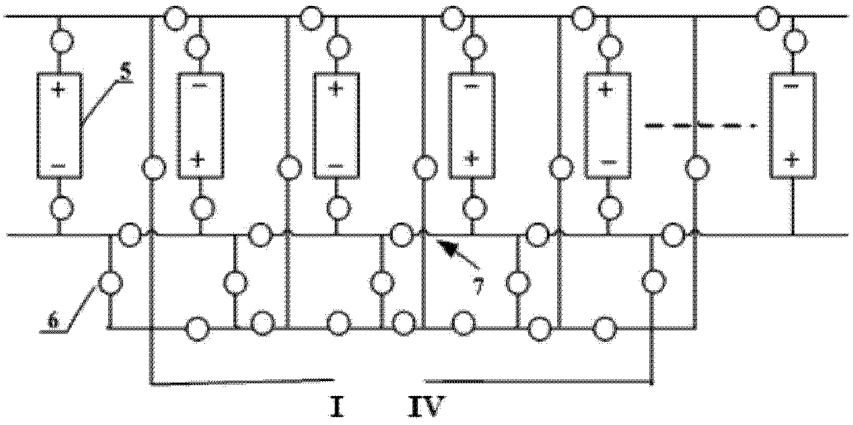


图 20

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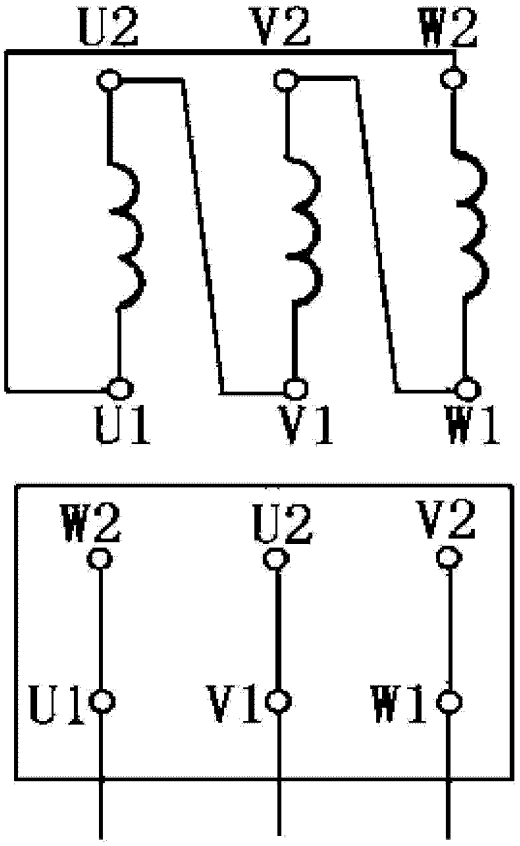


图 21

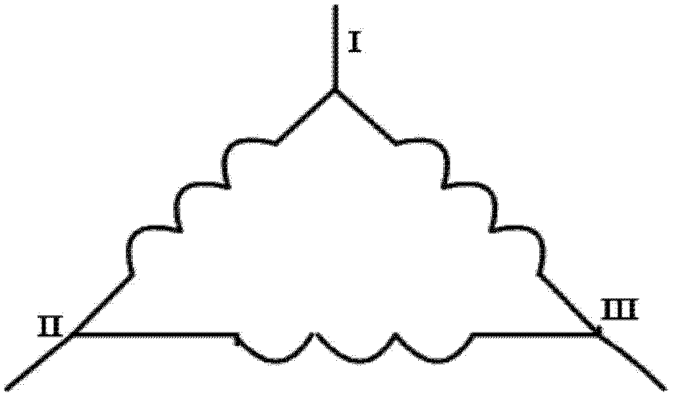


图 22

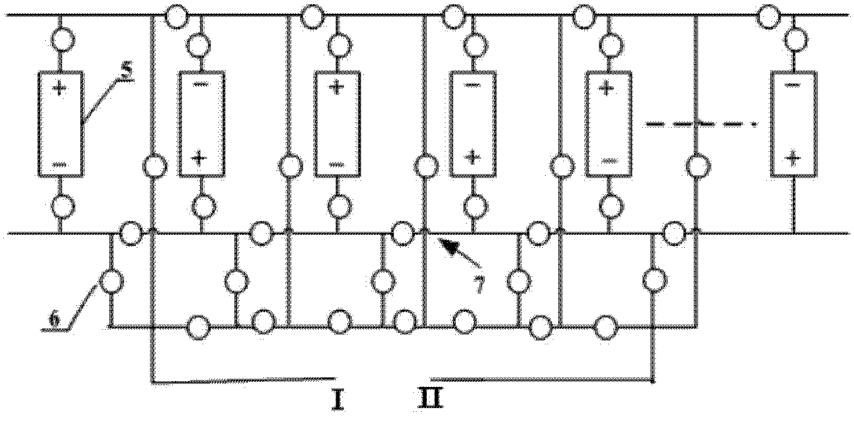


图 23

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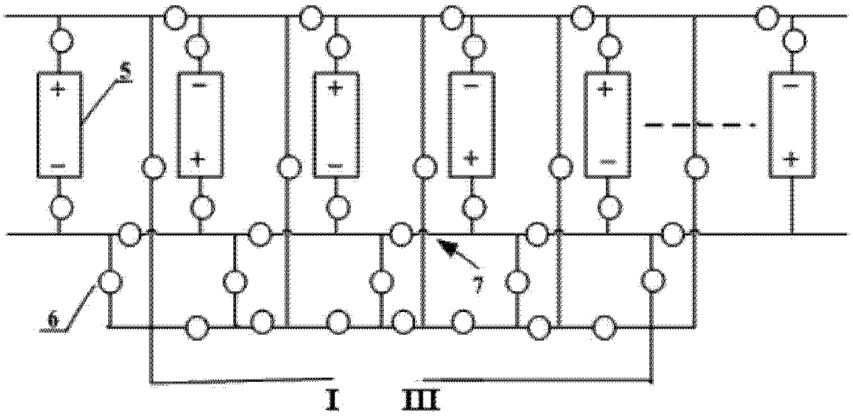


图 24

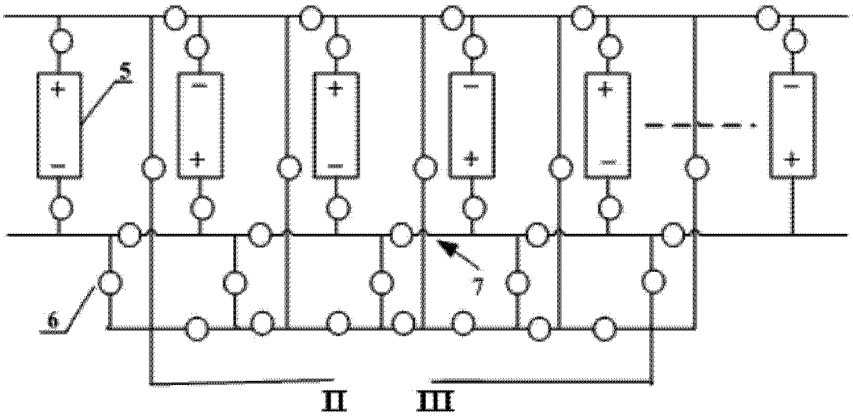


图 25

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Bibliographic data: CN105324930 (A) — 2016-02-10

Automatic suppression device for cyclic disturbance

Inventor(s): YAMAGUCHI TAKASHI; TADANO YUGO ± (YAMAGUCHI TAKASHI, ; TADANO YUGO, ; 山口崇, ; 只野裕吾)

Applicant(s): MEIDENSHA ELECTRIC MFG CO LTD ± (MEIDENSHA CORPORATION, ; 株式会社明电舍)

Classification: - international: ***H02P21/05***
- cooperative: **B60L15/025**; **H02P21/05**; **H02P21/20**; **H02P7/28**; Y02T10/643

Application number: CN2014833035 20140610 Global Dossier

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Abstract of CN105324930 (A)

When a feed forward table is used to suppress a torque pulsation of a device which has a battery as a main power source, the internal resistance of the battery causes a voltage fluctuation in accordance with a load power, thereby generating an error in the compensation table. An automatic suppression device for cyclic disturbance preliminarily stores a compensation value for suppressing a torque pulsation in a compensation table. When suppressing the torque pulsation for each frequency component using a torque compensation value based on the torque setting value inputted and the rotation speed detected, the suppression device detects the voltage of the main power source to be controlled to input the detected voltage into a compensation table corresponding to the voltage, and outputs a torque compensation value dependent on the voltage referring to the compensation table to perform compensation. A compensation value correction unit refers to a specific table or a proportional expression, which depend only on the voltage to correct a torque compensation value (Tcn) obtained by adding the output (Ta) from a real part compensation table and an imaginary part compensation table (jTb).

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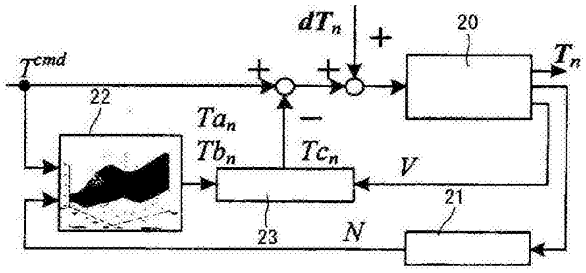
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(54)发明名称

周期性干扰自动抑制装置

(57)摘要

如果针对以电池为主电源的装置使用前馈表格来进行转矩脉动的抑制控制，则根据负载电力，由于电池的内部电阻，电压会变动，从而产生补偿表格误差。将用于抑制转矩脉动的补偿值预先表格化为补偿表格，在根据所输入的转矩设定值和检测出的转速而利用转矩补偿值抑制每个频率分量的转矩脉动时，检测控制对象的主电源电压并输入到与电压对应的补偿表格，针对补偿表格输出取决于电压的转矩补偿值来进行补偿。另外，在补偿值校正部中，针对基于实部补偿表格的输出Ta与虚部补偿表格jTb之和的转矩补偿值Tc_n，通过仅取决于电压的特定的表格或者比例式来进行校正。



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1. 一种周期性干扰自动抑制装置，其特征在于，

在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

构成为：使所述补偿表格成为多个补偿表格，检测所述控制对象的主电源电压并输入到与电压对应的补偿表格，针对补偿表格输出与主电源电压的变动值连动的转矩补偿值。

2. 一种周期性干扰自动抑制装置，其特征在于，

在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的控制对象的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

构成为：所述补偿表格具备校正实数部的实部补偿表格和校正虚数部的虚部补偿表格，并且设置输入所述控制对象的主电源电压的检测值 V 的补偿值校正部，在该补偿值校正部中，针对基于所述实部补偿表格的输出 Ta 与虚部补偿表格 jTb 之和的转矩补偿值 Tc_n，通过与主电源电压的变动值连动的特定的表格或者比例式来进行校正。

3. 根据权利要求 2 所述的周期性干扰自动抑制装置，其特征在于，

用于校正所述转矩补偿值 Tc_n 的比例式是利用基于下式的一次多项式来校正的，

$Tc_n = Ta_n/(a/V+b)+jTb_n/(c/V+d)$，

其中，下标 n 表示 n 次分量。

4. 根据权利要求 2 所述的周期性干扰自动抑制装置，其特征在于，

构成为：设置输入转矩设定值和控制对象的转速检测值并输出取决于转矩 / 转速的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转矩 / 转速的表格或者比例式，进行转矩补偿值 Tc_n 的校正。

5. 根据权利要求 4 所述的周期性干扰自动抑制装置，其特征在于，

用于校正所述转矩补偿值 Tc_n 的比例式是利用基于下式的一次多项式来校正的，

$Tc_n = Ta_n/\{fa(T^{cmd},N)/V+fb(T^{cmd},N)\}+jTb_n/\{fc(T^{cmd},N)/V+fd(T^{cmd},N)\}$，

其中，fa ～ fd 是系数，T^{cmd} 是转矩设定值，N 是转速，V 是电压检测值，n 是 n 次分量。

6. 根据权利要求 2 所述的周期性干扰自动抑制装置，其特征在于，

构成为：设置输入转矩设定值并输出取决于转矩的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转矩的表格或者比例式，进行转矩补偿值 Tc_n 的校正。

7. 根据权利要求 6 所述的周期性干扰自动抑制装置，其特征在于，

用于校正所述转矩补偿值 Tc_n 的比例式是利用基于下式的一次多项式来校正的，

$Tc_n = Ta_n/\{fa(T^{cmd})/V+fb(T^{cmd})\}+jTb_n/\{fc(T^{cmd})/V+fd(T^{cmd})\}$，

其中，fa ～ fd 是系数，T^{cmd} 是转矩设定值，V 是电压检测值，n 是 n 次分量。

8. 根据权利要求 2 所述的周期性干扰自动抑制装置，其特征在于，

构成为：设置输入所述控制对象的转速检测值并输出取决于转速的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转速的表格或者比例式，进行转矩补偿值 Tc_n 的校正。

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9. 根据权利要求 8 所述的周期性干扰自动抑制装置，其特征在于，

用于校正所述转矩补偿值 Tc_n 的比例式是通过基于下式的一次多项式来校正的，

$Tc_n = Ta_n / \{fa(N)/V+fb(N)\} + jTb_n / \{fc(N)/V+fd(N)\}$，

其中，fa ～ fd 是系数，N 是转速，V 是电压检测值，n 是 n 次分量。

10. 一种周期性干扰自动抑制装置，其特征在于，

在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的控制对象的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

所述控制对象将主电源作为电池，具备能够对电压进行可变控制的电压控制单元，所述补偿表格是根据基于预先由电压控制单元针对每个工作点而调整的施加电压的校正值而生成的补偿表格。

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周期性干扰自动抑制装置

技术领域

[0001] 本发明涉及自动地抑制例如马达等旋转电机等那样的旋转电机的转矩波纹的周期性干扰自动抑制装置，特别是涉及预先针对每个转矩脉动频率分量学习补偿电流、对所学习的补偿值进行表格化的补偿表格。

背景技术

[0002] 作为周期性干扰的产生抑制控制，存在利用机器人的定位控制、测力计系统的轴转矩共振抑制、马达框体的振动抑制等，期望高精度地抑制这些各个产品中的周期性干扰。例如，马达在原理上产生转矩波纹，引起振动、噪音、对乘坐感觉的不利影响、电气 / 机械共振等各种问题。特别是，嵌入磁铁形的 PM(永磁) 马达复合地产生齿槽转矩波纹和磁阻转矩波纹。作为抑制该转矩波纹的控制方式，专利文献 1 等成为公知。

[0003] 图 13 是专利文献 1 中记载的马达的转矩脉动抑制系统的结构图，是示出通过电流矢量控制方式的逆变器对电动机进行转矩 / 速度控制的情况的图。在逆变器 1 的电流矢量控制部 11 中，通过坐标变换部 13，从由电流传感器 12 检测出的马达驱动电流 i_u、i_v、i_w和马达 2 的转子旋转角度 θ，变换为与马达旋转坐标同步的 dq 轴正交旋转坐标系的电流，通过变换而得的 d、q 轴电流检测值与指令值的比较，进行马达电流的控制。通过速度 / 相位检测部 14，根据由旋转位置传感器 3 得到的编码器波形 abz，与速度 ω 一起求出转子旋转角度 θ 。

[0004] 转矩 /id、iq 变换部 15 从来自控制器 5 的转矩指令值 T_{ref}和马达旋转速度 ω，变换为矢量控制中的旋转 dq 坐标系的 d 轴以及 q 轴电流指令值 i_d^*、i_{q0}^*，对这些电流指令值中的 q 轴电流指令值 i_{q0}^*重叠转矩脉动补偿电流 i_{qc*}而作为电流矢量控制指令值。控制器 5 搭载转矩波纹抑制控制单元 5A 和学习单元 5B，将转矩脉动抑制中所需的补偿电流作为傅立叶系数表格保存到存储器。

[0005] 之后，构成图 14 所示的装载了补偿表格 16 的转矩脉动抑制系统，进行以前馈方式抑制转矩脉动的转矩脉动抑制控制。图 14 的系统与图 13 不同的部分在于，省略控制器 5 以及转矩计 4，在逆变器 1 中搭载抑制转矩脉动的补偿电流生成单元，并且直接提供转矩指令值 T_{ref}^*。作为该补偿电流生成单元，具备振幅 / 相位补偿电流表格 16 和补偿电流生成部 17。

[0006] 在专利文献 1 中，在上位具有产生控制指令值的控制器，针对产生周期性干扰的控制对象，通过使用周期性干扰观察器而获取的振动抑制用补偿表格来抑制振动。即，设置了转矩脉动抑制单元，该转矩脉动抑制单元为了针对控制对象进行前馈控制，提取马达的转矩脉动分量，求出为了抑制提取出的转矩脉动分量而所需的补偿电流并反馈给控制对象的控制装置来抑制转矩脉动。学习该转矩脉动抑制单元所得出的转矩抑制运转时的转矩脉动补偿电流，对补偿电流进行表格化并装载到控制装置。然后，在马达的控制运转时通过从表格所读出的补偿电流以前馈方式补偿转矩脉动。

[0007] 专利文献 1 :作为日本的公开专利的日本特开 2011-50118 号公报

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发明内容

[0008] 在为了前馈控制而利用补偿表格的情况下，在转速获取部中获取控制对象的转速，将该转速N(ω)和可变地设定的转矩设定值T_{ref}^*作为输入变量而输入到补偿表格，通过各点处的转矩补偿值Tc_n的输出与转矩设定值T_{ref}^*的偏差来进行补偿，所以能够使抑制响应性提高、控制装置的结构简化。然而，在控制对象由于某种原因而发生了变动的情况下，基本上会产生与前馈表格的偏差而以补偿误差的方式出现，根据情况会产生振动比控制前还放大的担忧。

[0009] 如果作为应用前馈表格的控制对象之一，考虑电动车的马达等以电池为主电源的装置，则在该情况下，根据负载电力，由于电池的内部电阻，输入到控制装置的电压会变动。另外，在电池自身的充电的状况、并联地连接了负载的情况等，马达控制装置自身产生的转矩波纹、电流控制响应会发生变动。由此，如果在应用在特定的电池电压时获取的前馈表格来进行抑制控制的状态下发生电池电压变动，则会产生上述担忧的补偿表格误差。

[0010] 因此，本发明的目的在于，通过考虑在对控制装置应用前馈表格时的电压变动，补偿电压变动所致的误差，从而提供更高性能的周期性干扰自动抑制装置。

[0011] 根据本发明的一个观点，其特征在于，在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

[0012] 构成为：针对每个电压设置多个所述补偿表格，检测所述控制对象的主电源电压并输入到与电压对应的补偿表格，针对补偿表格输出与主电源电压的变动值连动的转矩补偿值。

[0013] 根据本发明的另一观点，其特征在于，在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的控制对象的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

[0014] 构成为：所述补偿表格具备校正实数部的实部补偿表格和校正虚数部的虚部补偿表格，并且设置输入所述控制对象的主电源电压的检测值V的补偿值校正部，在该补偿值校正部中，针对基于所述实部补偿表格的输出Ta与虚部补偿表格jTb之和的转矩补偿值Tc_n，通过与主电源电压的变动值连动的特定的表格或者比例式来进行校正。

[0015] 根据本发明的其它观点，其特征在于，用于校正所述转矩补偿值Tc_n的比例式是利用基于下式的一次多项式来校正的，

[0016] $Tc_n = Ta_n/(a/V+b)+jTb_n/(c/V+d)$，

[0017] 其中，下标n表示n次分量。

[0018] 根据本发明的又一其它观点，其特征在于，构成为：设置输入转矩设定值和控制对象的转速检测值并输出取决于转矩/转速的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转矩/转速的表格或者比例式，进行转矩补偿值Tc_n的校正。

[0019] 根据本发明的其它观点，其特征在于，用于校正所述转矩补偿值Tc_n的比例式是利

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用基于下式的一次多项式来校正的，

[0020] $Tc_n = Ta_n/\{fa(T^{cmd}, N)/V+fb(T^{cmd}, N)\}+jTb_n/\{fc(T^{cmd}, N)/V+fd(T^{cmd}, N)\}$，

[0021] 其中，fa ～ fd 是系数，T^{cmd}是转矩设定值，N 是转速，V 是电压检测值，n 是 n 次分量。

[0022] 根据本发明的其它观点，其特征在于，构成为：设置输入转矩设定值并输出取决于转矩的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转矩的表格或者比例式，进行转矩补偿值 Tc_n的校正。

[0023] 根据本发明的又一其它观点，其特征在于，用于校正所述转矩补偿值 Tc_n的比例式是利用基于下式的一次多项式来校正的，

[0024] $Tc_n = Ta_n/\{fa(T^{cmd})/V+fb(T^{cmd})\}+jTb_n/\{fc(T^{cmd})/V+fd(T^{cmd})\}$，

[0025] 其中，fa ～ fd 是系数，T^{cmd}是转矩设定值、V 是电压检测值、n 是 n 次分量。

[0026] 根据本发明的其它观点，其特征在于，构成为：设置输入所述控制对象的转速检测值并输出取决于转速的多项式用的系数的系数表格，将该系数表格的输出输入到所述补偿值校正部，在该补偿值校正部中，通过取决于转速的表格或者比例式，进行转矩补偿值 Tc_n的校正。

[0027] 根据本发明的其它观点，其特征在于，用于校正所述转矩补偿值 Tc_n的比例式是利用基于下式的一次多项式来校正的，

[0028] $Tc_n = Ta_n/\{fa(N)/V+fb(N)\}+jTb_n/\{fc(N)/V+fd(N)\}$，

[0029] 其中，fa ～ fd 是系数，N 是转速，V 是电压检测值，n 是 n 次分量。

[0030] 根据本发明的又一观点，其特征在于，在将用于提取控制对象的转矩脉动频率分量而抑制转矩脉动的补偿值预先表格化为补偿表格、通过所输入的转矩设定值和检测出的控制对象的转速来求出转矩补偿值、将求出的转矩补偿值与转矩设定值的偏差量输入到控制对象来抑制每个频率分量的转矩脉动的结构中，

[0031] 所述控制对象将主电源作为电池，具备能够对电压进行可变控制的电压控制单元，所述补偿表格是根据基于预先由电压控制单元针对每个工作点而调整的施加电压的校正值而生成的补偿表格。

附图说明

[0032] 图 1 是示出本发明的实施例的周期性干扰自动抑制装置的主要部分概略结构图。

[0033] 图 2 是补偿表格数据生成说明图。

[0034] 图 3 是补偿表格的结构图。

[0035] 图 4 是示出其它实施例的周期性干扰自动抑制装置的主要部分概略结构图。

[0036] 图 5 是补偿表格数据生成说明图。

[0037] 图 6 是示出其它实施例的周期性干扰自动抑制装置的主要部分概略结构图。

[0038] 图 7 是补偿表格数据生成说明图。

[0039] 图 8 是其它周期性干扰自动抑制装置的主要部分概略结构图。

[0040] 图 9 是其它周期性干扰自动抑制装置的主要部分概略结构图。

[0041] 图 10 是控制对象中的控制设备结构图。

[0042] 图 11 是示出其它实施例的周期性干扰自动抑制装置的主要部分概略结构图。

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[0043] 图 12 是示出其它实施例的周期性干扰自动抑制装置的学习系统的结构图。

[0044] 图 13 是以往的周期性干扰自动抑制装置的学习系统的结构图。

[0045] 图 14 是以往的周期性干扰自动抑制装置的结构图。

具体实施方式

[0046] 在本发明中，将用于抑制转矩脉动的补偿值预先表格化为补偿表格，在通过所输入的转矩设定值和检测出的转速、利用转矩补偿值来抑制每个频率分量的转矩脉动时，检测控制对象的主电源电压并输入到与电压对应的补偿表格，针对补偿表格输出取决于电压的转矩补偿值来进行补偿，以下根据附图进行详细描述。

[0047] 图 1 是示出本发明的第 1 实施例的概略结构图。基本上如图 14 那样地构成，但控制对象 20 在此包括逆变器的主电路、马达等，通过转速检测部 21 检测马达的转速 N。另外，从逆变器的直流电路检测电压 V 并与转速 N 一起输入到补偿表格 22。补偿表格 22 具有 1 ～ n 个这样的多个补偿表格，还被输入与图 14 所示的 Tref* 相当的转矩设定值 T^{cmd}。

[0048] 作为补偿表格 22 中的数据获取方法，使用图 13 所示的系统来变更转矩设定值 T^{cmd} 和转速 N，获取该点处的振动抑制的补偿值。在设想工作范围的全部点处重复进行该操作来获取实验数据。最终，根据全部实验数据，原样地或者部分性地进行插值处理来生成补偿表格。

[0049] 在本发明中，还考虑电压所致的变动值，将逆变器主电源的直流电压 V 也加入到变动要素，通过补偿表格 22 生成转矩补偿值 Tc_n。由此，生成图 2 所示那样的（转矩 i 点 × 转速 j 点）× 主电压 k 点的补偿表格数据，将其装载到周期性干扰自动抑制装置来进行前馈控制。即，根据检测出的电压 V，按照线 11 或者 12 那样的特性，求出转矩补偿值 Tc_n。

[0050] 图 3 示出补偿表格的详细图。n 个补偿表格分别具有实数部的补偿表格 22A 和虚数部的补偿表格 22B，分别被输入转矩设定值 T^{cmd} 和转速 N 而被选择与输入值对应的转矩 Ta、Tb，在补偿值校正部（加法部）23 中实数值 Ta_n 与虚数值 jTb_n 之和成为转矩补偿值 Tc_n。

[0051] 在参照表格时，针对补偿表格 22 的数据，根据针对转矩设定值 T^{cmd} 检测出的当前的转速 N 和主电源电压 V，参照补偿值，将振动抑制的转矩补偿值 Tc_n 输出到减法部，求出与转矩设定值 T^{cmd} 的偏差，将该偏差与周期性干扰 dTn 的加法值输入到控制对象 20 而进行振动抑制。

[0052] 根据本实施例，在上位具有产生控制指令值的控制器，针对产生周期性干扰的控制对象，通过使用周期性干扰观察器而获取的振动抑制用补偿表格来抑制振动的结构中，通过将负载变化所致的主电源电压变动作为以转矩 / 转速 / 主电源电压为参数的补偿表格，特别是在主电源为电池的情况下，能够实现马达控制装置自身产生的转矩波纹的抑制、高精度的电流控制响应。

[0053] 图 4 是示出第 2 实施例的图，是补偿值变动量仅取决于控制对象主电源的电压变动的情况的例子。在补偿值变动量仅取决于电压的情况下，补偿表格 22 如图 3 所示仅为 1 组实数部的补偿表格 22A 和虚数部的补偿表格 22B 即可，并且无需如实施例 1 那样包括转矩 / 转速来获取数据。

[0054] 在该实施例中，针对按标称的主电压来获取主电压 V 而得的补偿表格，将主电压 V 直接输入到补偿值校正部 23，通过仅取决于电压的特定表格或者比例式来进行运算，从而

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省略补偿表格保存用的存储器，根据检测出的电压 V，按照图 5 那样的补偿特性，求出转矩补偿值 Tc_n。

[0055] 另外，在补偿值校正部 23 中，通过 (1) 式，计算用一次多项式进行校正时的转矩补偿值 Tc_n。

[0056] $Tc_n = Ta_n/(a/V+b)+jTb_n/(c/V+d)$ …… (1)

[0057] 在参照表格时，从补偿表格 22 中选择与转矩设定值 T^{cmd} 和检测出的当前的转速 N 对应的转矩 Ta_n、Tb_n，在补偿值校正部 23 中，进行 (1) 式的运算，计算转矩补偿值 Tc_n。关于转矩补偿值 Tc_n，在减法部中进行与转矩设定值 T^{cmd} 的差运算来求出偏差，将该偏差与周期性干扰 dTn 的加法值输入到控制对象 20 来进行振动抑制。

[0058] 根据该实施例，在控制对象的主电源是电池那样的系统中，针对负载变化所致的主电源电压变动，使用以主电源电压为参数的式子或者表格来进行振动抑制，从而得到能够省略补偿表格保存用的存储器的效果。其它方面具有与实施例 1 同样的效果。

[0059] 图 6 是示出第 3 实施例的图，与图 4 的区别点在于设置了系数校正表格 24。构成为对系数校正表格 24 输入转矩设定值 T^{cmd} 和检测出的转速 N，将与输入值对应的系数 fa、fb、fc、fd 输出到补偿值校正部 23，在补偿值校正部 23 中，通过 n 次多项式，校正标称的补偿表格的补偿值。针对此时的多项式系数，通过取决于转矩 / 转速的表格或者式子进行校正，关于校正式的参数，通过实验或者解析进行计算。

[0060] 图 7 是示出所生成的补偿表格数据的样式的图，与电压对应地按照线 11 或者 12 那样的特性求出转矩补偿值 Tc_n。另外，根据 (2) 式，进行在补偿值校正部 23 中利用一次多项式实施校正时的转矩补偿值 Tc_n 的计算。

[0061] $Tc_n = Ta_n/\{fa(T^{cmd},N)/V+fb(T^{cmd},N)\}+jTb_n/\{fc(T^{cmd},N)/V+fd(T^{cmd},N)\}$ …… (2)

[0062] 图 8 是示出对系数校正表格 24 仅输入转矩设定值 T^{cmd} 时的例子的图，根据 (3) 式，进行此时的补偿值校正部 23 中利用一次多项式的转矩补偿值 Tc_n 的计算。

[0063] $Tc_n = Ta_n/\{fa(T^{cmd})/V+fb(T^{cmd})\}+jTb_n/\{fc(T^{cmd})/V+fd(T^{cmd})\}$ …… (3)

[0064] 另外，图 9 是示出对系数校正表格 24 仅输入检测出的转速 N 时的例子的图，根据 (4) 式，进行此时的补偿值校正部 23 中利用一次多项式的转矩补偿值 Tc_n 的计算。

[0065] $Tc_n = Ta_n/\{fa(N)/V+fb(N)\}+jTb_n/\{fc(N)/V+fd(N)\}$ …… (4)

[0066] 因此，根据该实施例 3，通过利用 n 次多项式来校正补偿表格的补偿值，能够实现比实施例 2 的补偿进一步扩展的用于振动抑制的补偿。

[0067] 在控制对象的主电源是电池的系统中，关于主电源的变动，能够以指令值为基准而估计与负载相伴的内部电阻所致的降低 (或者增加) 量。该实施例适合于这样的情况，如图 10 所示，在控制对象 20 中具有能够进行电压控制的电压控制单元 CE，根据 (5) 式的关系，根据 (6) 式，控制施加电压 Vin。

[0068] $Vin = Vbas-Iin/Rin$

[0069] $Iin = Pout/Vin$

[0070] $Pout = \omega/T^{cmd}$ …… (5)

[0071] [公式 1]

[0072] $$Vin = \frac{Vbas \pm \sqrt{Vbas^2 - 4Rin \cdot \omega \cdot T^{cmd}}}{2} \quad \cdots (6)$$

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[0073] 此处，Rin：主电源内部电阻、Vbas：主电源内部电压、Iin：主电源流通电流、Vin：设备施加电压、Pout：设备输出电压、ω：马达转速

[0074] 作为补偿表格 22 处的数据获取方法，使用图 12 所示的系统，将转矩 / 速度指令值输入到电压运算部 6，根据 (5) 式的关系，根据 (6) 式，对电压 Vin 进行运算，可变电压控制部 7 根据电压 Vin 来控制逆变器 1 的直流电压 Vdc。将此时的转速和转矩检测值与图 13 同样地保存到控制器 5 的转矩脉动抑制单元。在包括瞬间的负载电流变动的设想工作范围的全部点处重复进行该操作来获取实验数据。最终，根据全部实验数据，原样地或者部分性地进行插值处理来生成补偿表格。

[0075] 作为利用了该实施例中的补偿表格的振动抑制控制装置，使用图 11，对补偿表格 22 仅输入转矩设定值 T^{cmd} 和转速 N。在标称的补偿表格的生成中，将主电源的电压控制单元 CE 的电压指令设为 Vin，针对每个工作点，利用此时的转矩 / 旋转指令值，电压控制单元 CE 进行电压调整，生成基于补偿表格 22 的转矩补偿值。因此，所得到的补偿表格 22 成为预先考虑了电压变动量的表格，通过将其装载到周期性干扰自动抑制装置，从而在运转时，对于电压变动也能够无误差地实现振动抑制。

[0076] 根据该实施例，相比于实施例 1 ～ 3，即使考虑到主电源电压变动，也能够不会对控制设备的存储器量造成变动而高精度地进行振动抑制。

[0077] 如以上那样，根据本发明，使为了进行前馈控制而使用的补偿表格也对负载变化所致的主电源电压变动进行补偿，由此，即使在控制对象产生了变动的情况下，也能够进行高精度的振动抑制控制。

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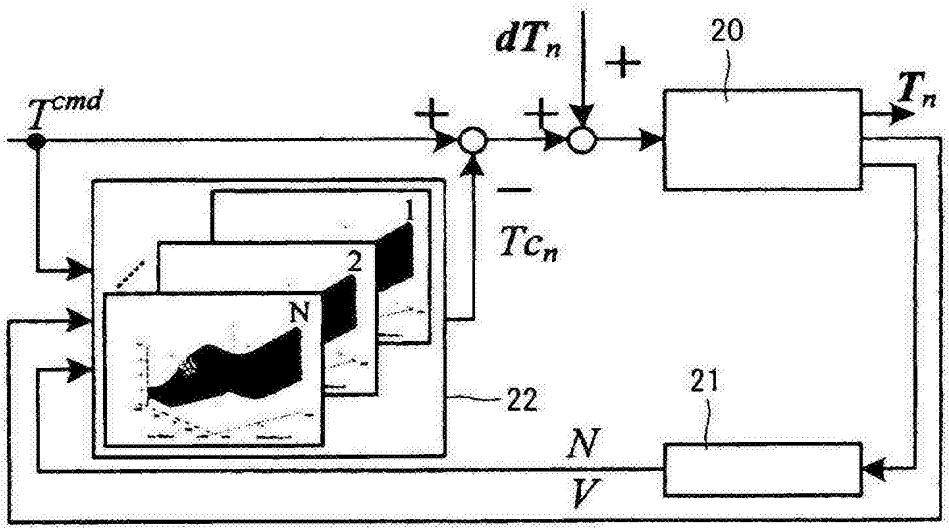


图 1

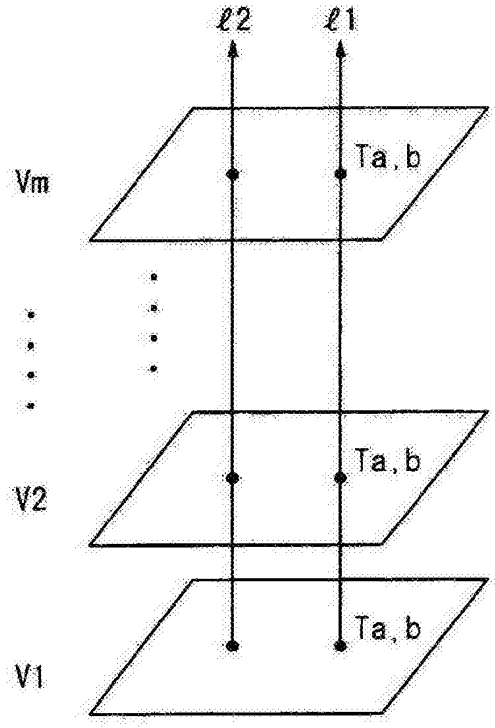


图 2

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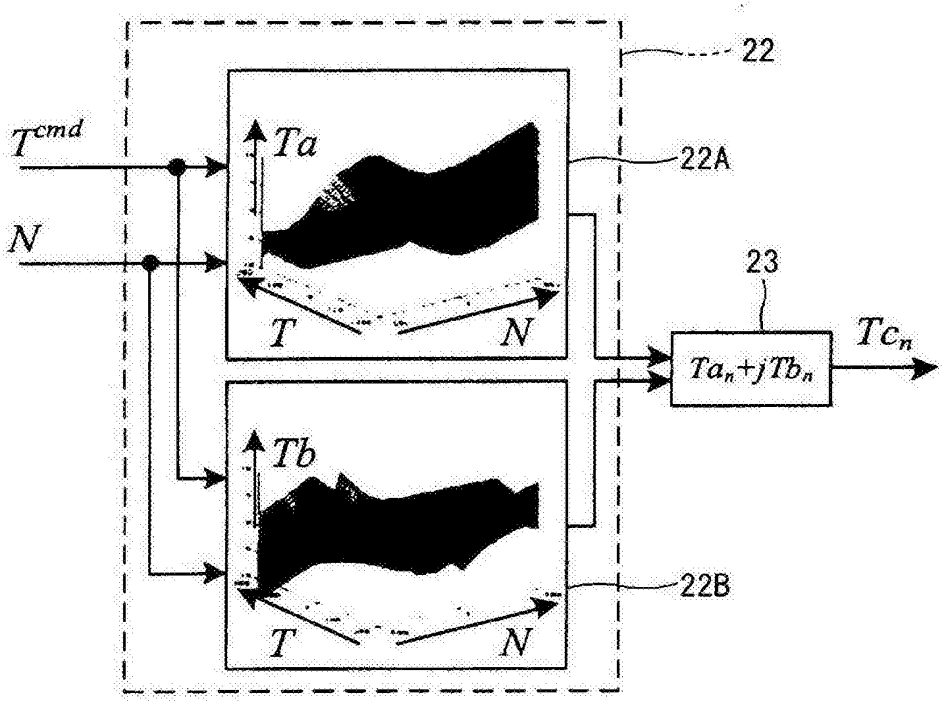


图 3

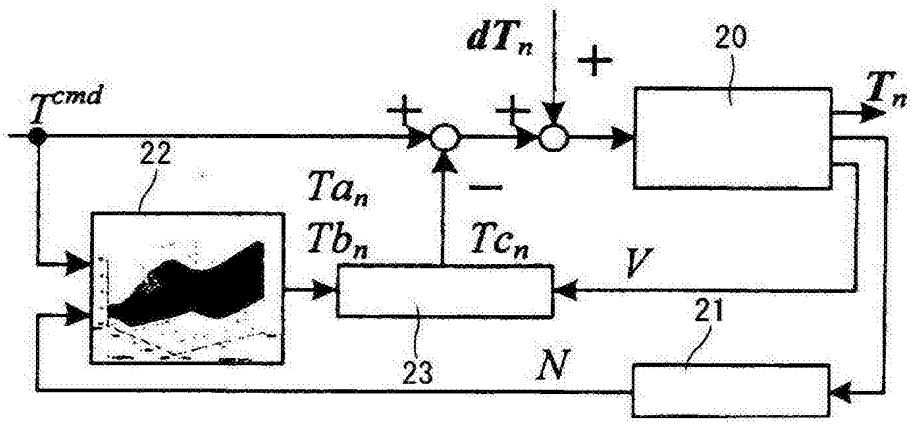


图 4

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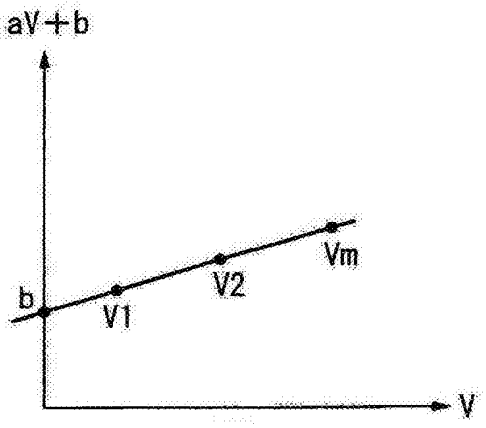


图 5

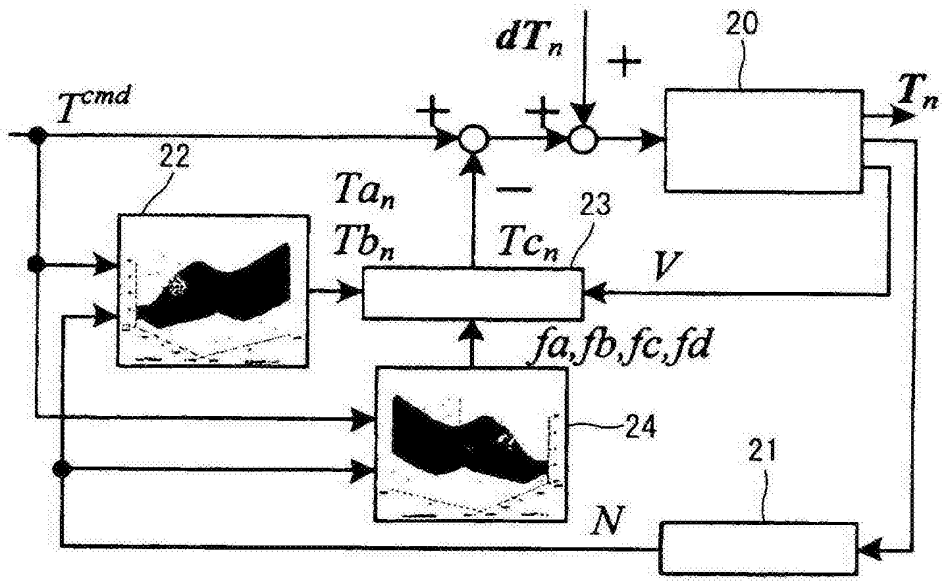


图 6

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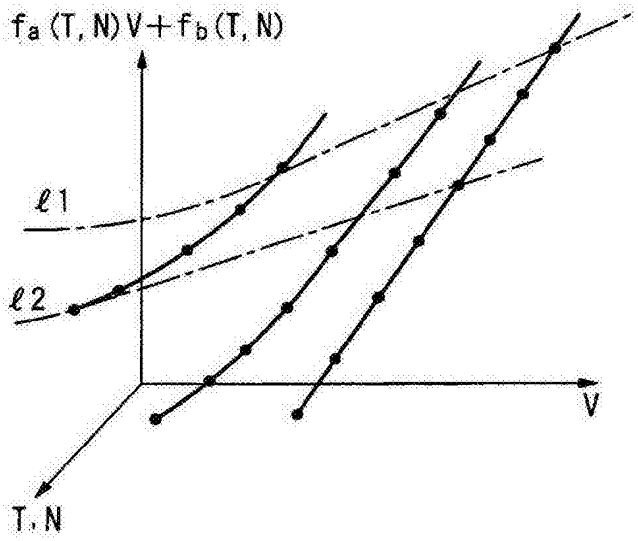


图 7

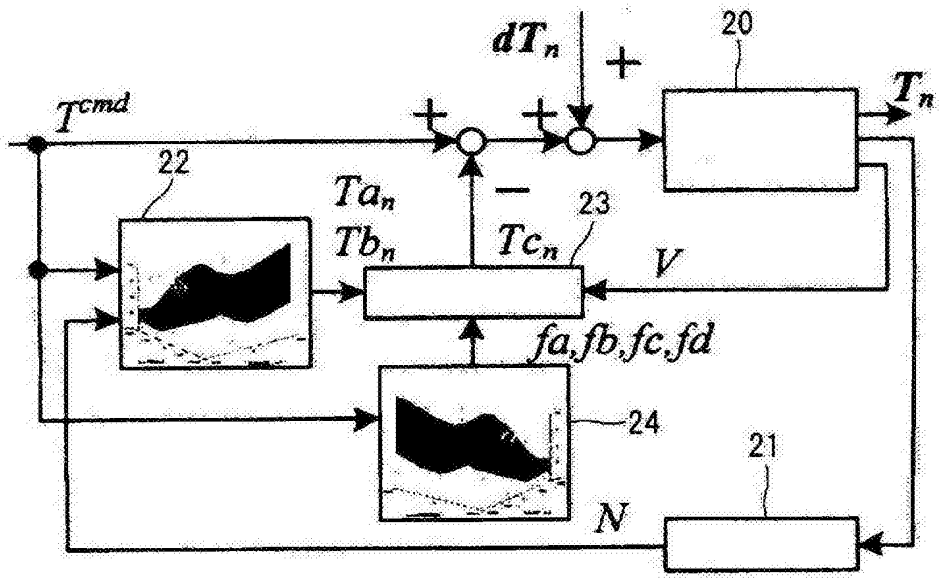


图 8

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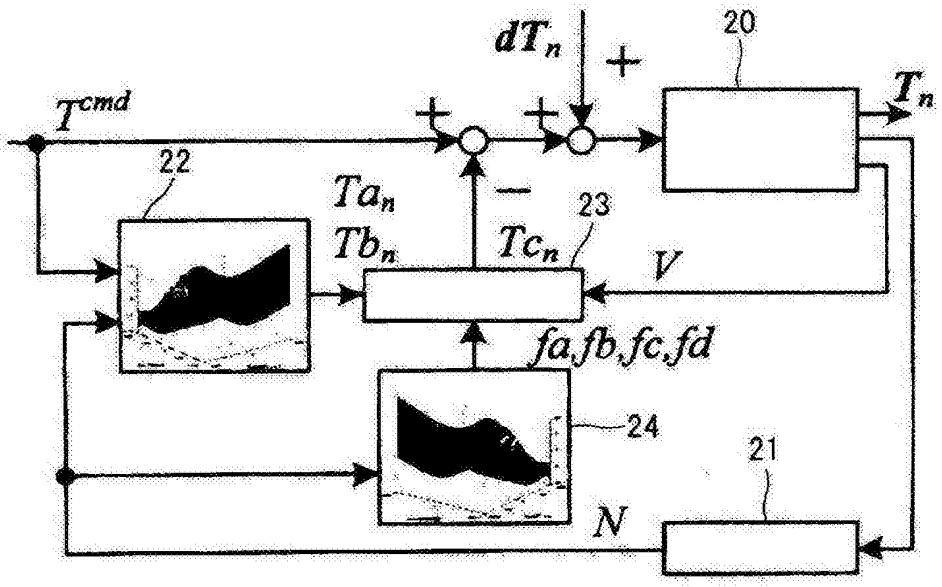


图 9

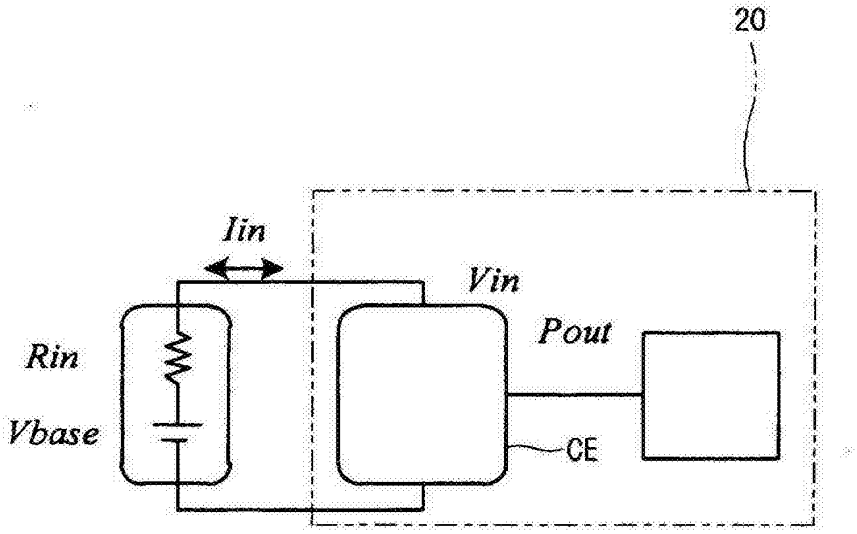


图 10

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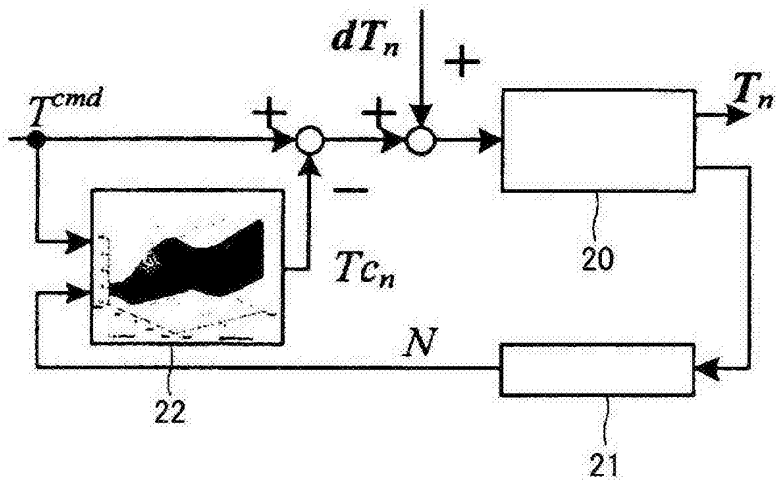


图 11

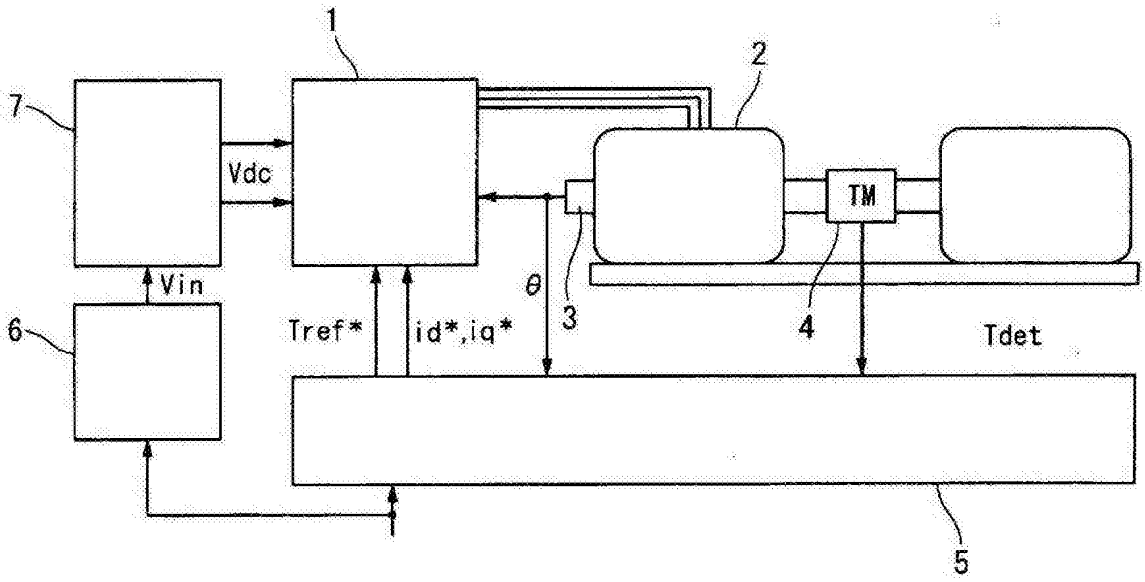


图 12

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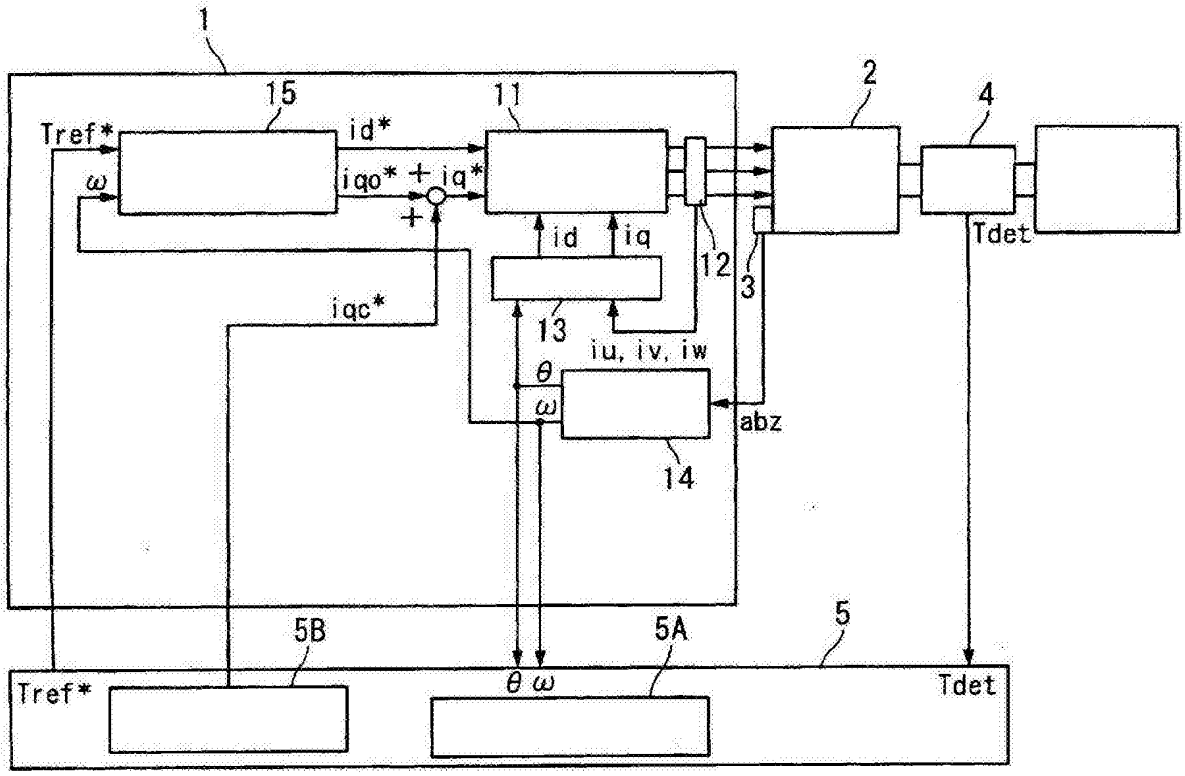


图 13

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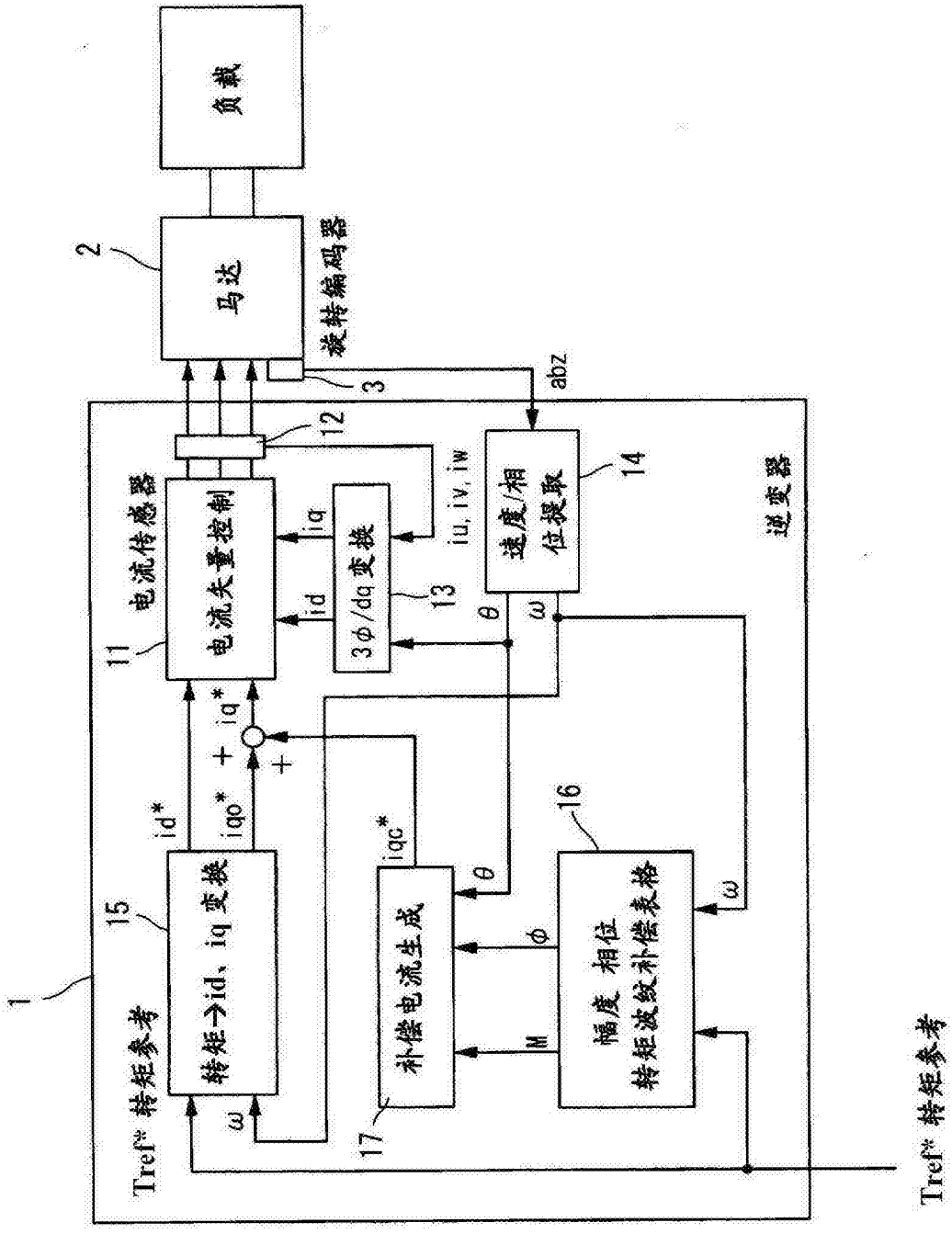


图 14

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/116,279

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			N/A	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	17 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 460 =	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			TOTAL	1720

APPLICATION AS AMENDED - PART II

		(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($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	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	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	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.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/116,279	08/29/2018	2852	1720	00203.3030.00US	17	3

CONFIRMATION NO. 6124

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Date Mailed: 10/05/2018

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Inventor(s)

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Applicant(s)

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Power of Attorney: The patent practitioners associated with Customer Number 136725

Domestic Priority data as claimed by applicant

This application is a CON of PCT/CN2016/075097 03/01/2016

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 Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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If Required, Foreign Filing License Granted: 10/03/2018

Textron Specialized Vehicles Inc., Exh. 1003, p. 267

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/116,279**

Projected Publication Date: 01/10/2019

Non-Publication Request: No

Early Publication Request: Yes

Title

MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

Preliminary Class

396

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Filer:	Wenye Tan/Ting Xue
Attorney Docket Number:	00203.3030.00US

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1720**

PTO/AIA/15 (03-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	00203.3030.00US
First Named Inventor	Changxing ZHOU
Title	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☐ **Fee Transmittal Form** (PTO/SB/17 or equivalent)
2. ☐ **Applicant asserts small entity status.** See 37 CFR 1.27
3. ☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
4. ☑ **Specification** [*Total Pages* 31] Both the claims and abstract must start on a new page. *(See MPEP § 608.01(a) for information on the preferred arrangement)*
5. ☑ **Drawing(s)** (35 U.S.C. 113) [*Total Sheets* 7]
6. **Inventor's Oath or Declaration** [*Total Pages* 3] *(including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))*
   a. ☑ Newly executed (original or copy)
   b. ☐ A copy from a prior application (37 CFR 1.63(d))
7. ☑ **Application Data Sheet** ** See note below.* See 37 CFR 1.76 (PTO/AIA/14 or equivalent)
8. **CD-ROM or CD-R** in duplicate, large table, or Computer Program (*Appendix*)
   ☐ Landscape Table on CD
9. **Nucleotide and/or Amino Acid Sequence Submission** (*if applicable, items a. – c. are required*)
   a. ☐ Computer Readable Form (CRF)
   b. ☐ Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper
   c. ☐ Statements verifying identity of above copies

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Commissioner for Patents
P.O. Box 1450
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ACCOMPANYING APPLICATION PAPERS

10. ☐ **Assignment Papers** (cover sheet & document(s))
    Name of Assignee _____
11. ☐ **37 CFR 3.73(c) Statement** (*when there is an assignee*) ☑ **Power of Attorney**
12. ☐ **English Translation Document** (*if applicable*)
13. ☑ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☑ Copies of citations attached
14. ☐ **Preliminary Amendment**
15. ☐ **Return Receipt Postcard** (*MPEP § 503*) (*Should be specifically itemized*)
16. ☐ **Certified Copy of Priority Document(s)** (*if foreign priority is claimed*)
17. ☐ **Nonpublication Request** Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
18. ☐ **Other:** _____

Note*: (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 136725 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Li JIANG/	Date	2018-08-29
Name (Print/Type)	Li JIANG	Registration No. (Attorney/Agent)	74191

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MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of International Application No. PCT/CN2016/075097, filed on March 1, 2016, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of unmanned aerial vehicle and, more particularly, to a method, a device, and a system for controlling a motor.

BACKGROUND

[0003] In conventional technologies, a battery supplies power to an electronic speed controller (ESC), such that the ESC outputs a voltage to a motor and thus control a speed of the motor. The ESC receives a throttle signal sent from a flight controller. An increased high-level pulse width, i.e., an increased high-level pulse time duration, of the throttle signal may indicate that a higher rotation speed of the motor may be needed by the flight controller.

[0004] However, a voltage of the battery continuously decreases during the discharging process. Compared with an original full voltage of the battery, the voltage outputted from the ESC to the motor decreases as the battery voltage decreases, when the ESC receives a same throttle signal. Thus, the rotation speed of the motor decreases. When an unmanned aerial vehicle performs actions that need high mobility, issues of slow response often occur, and the unmanned aerial vehicle has decreasing power during a flight.

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SUMMARY

[0005] In accordance with the disclosure, there is provided a method for controlling a motor. The method includes obtaining a present electrical parameter of a battery, calculating a compensation amount of a control signal of the motor according to the present electrical parameter, and modifying the control signal according to the compensation amount.

[0006] Also in accordance with the disclosure, there is provided another method for controlling a motor. The method includes obtaining a present electrical parameter of a battery, calculating a voltage compensation amount of the battery according to the present electrical parameter, and compensating an output voltage of the battery according to the voltage compensation amount to maintain the output voltage of the battery stable.

[0007] Also in accordance with the disclosure, there is provided an apparatus for controlling a motor. The apparatus includes one or more processors. The one or more processors are configured to obtain a present electrical parameter of a battery, calculate a compensation amount of a control signal of the motor according to the present electrical parameter, and modify the control signal according to the compensation amount.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a flowchart of an exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0009] FIG. 2 is a topological diagram for an exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0010] FIG. 3 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

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[0011] FIG. 4 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0012] FIG. 5 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0013] FIG. 6 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0014] FIG. 7 is another topological diagram for an exemplary motor control method consistent with various disclosed embodiments of the present disclosure.

[0015] FIG. 8 is a block diagram of an exemplary motor control apparatus consistent with various disclosed embodiments of the present disclosure.

[0016] FIG. 9 is a block diagram of an exemplary power system consistent with various disclosed embodiments of the present disclosure.

[0017] FIG. 10 is a block diagram of an exemplary motor control apparatus consistent with various disclosed embodiments of the present disclosure.

[0018] FIG. 11 is a block diagram of another exemplary power system consistent with various disclosed embodiments of the present disclosure.

[0019] FIG. 12 is a schematic structural diagram of an exemplary unmanned aerial vehicle (UAV) consistent with various disclosed embodiments of the present disclosure.

[0020] Reference numerals used in the drawings include: 20, battery; 21, electronic speed controller (ESC); 22, motor; 23, flight controller; 24, voltage sensor; 25, switch controller; 26, switch; 27, external power supply; 1001, power system; 1002, propeller; and 1003, electronic speed controller (ESC).

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DETAILED DESCRIPTION OF THE EMBODIMENTS

[0021] Technical solutions of the present disclosure will be described with reference to the drawings. It will be appreciated that the described embodiments are some rather than all of the embodiments of the present disclosure. Other embodiments conceived by those having ordinary skills in the art on the basis of the described embodiments without inventive efforts should fall within the scope of the present disclosure.

[0022] As used herein, when a first component is referred to as "fixed to" a second component, it is intended that the first component may be directly attached to the second component or may be indirectly attached to the second component via another component. When a first component is referred to as "connecting" to a second component, it is intended that the first component may be directly connected to the second component or may be indirectly connected to the second component via a third component between them. The terms "perpendicular," "horizontal," "left," "right," and similar expressions used herein are merely intended for description.

[0023] Unless otherwise defined, all the technical and scientific terms used herein have the same or similar meanings as generally understood by one of ordinary skill in the art. As described herein, the terms used in the specification of the present disclosure are intended to describe exemplary embodiments, instead of limiting the present disclosure. The term "and/or" used herein includes any suitable combination of one or more related items listed.

[0024] Further, in the present disclosure, the disclosed embodiments and the features of the disclosed embodiments may be combined when there are no conflicts.

[0025] The present disclosure provides a method for controlling a motor. FIG. 1 is a flowchart of an exemplary motor control method consistent with various disclosed embodiments of the present disclosure. FIG. 2 is a topological diagram for an exemplary motor control method

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consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 2, a battery 20 provides power to an electronic speed controller (ESC) 21. The ESC 21 outputs a voltage to a motor 22 to cause the motor to rotate, and controls an operating status of the motor 22, such as a rotation speed, steering, or the like. A flight controller 23 sends a throttle signal to the ESC 21 through a wireless transmission. The ESC 21 controls a magnitude of the voltage outputted to the motor 22 according to a magnitude of the throttle signal, and thus controls a magnitude of the rotation speed of the motor 22. In some embodiments, the throttle signal may include a rectangular wave. Further, an increased high-level pulse width, i.e., an increased high-level pulse time duration, of the rectangular wave may indicate that the flight controller 23 may need the motor to rotate at a higher rotation speed. As the battery voltage continuously decreases during the discharging process, the rotation speed of the motor may decrease. Thus, when the UAV performs actions that need high mobility, issues of slow response may occur, and the power of the UAV may decrease during a flight. The present disclosure provides a motor control method that solves this problem. The control method can be implemented, e.g., by a control apparatus of the motor. The control apparatus may be coupled to the motor, and may obtain the present electrical parameter of the battery. With reference to FIG. 1, the method is described below.

[0026] At S101, a present electrical parameter of the battery is obtained.

[0027] In some embodiments, the battery may be coupled to an electrical parameter sensor, and the electrical parameter sensor may be used for detecting an electrical parameter of the battery. In some embodiments, the control apparatus may obtain a present electrical parameter of the battery from the electrical parameter sensor. In some other embodiments, the control apparatus may include an electrical parameter detection circuit. The electrical parameter detection circuit

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may be used for detecting the present electrical parameter of the battery. The present electrical parameter may include at least one of a present electrical charge quantity of the battery, a present voltage of the battery, a present output electrical current of the battery, or a present internal resistance of the battery.

[0028] At S102, a compensation amount of a control signal of the motor is calculated according to the present electrical parameter.

[0029] The electrical parameter of the battery may continuously change during discharge. For example, an electrical charge quantity of the battery may continuously decrease, an output voltage of the battery may continuously decrease, and an output power of the battery may continuously decrease. For a same throttle signal, in order to prevent the control signal for the motor from fluctuating with a variation of the battery electrical parameter, i.e., the electrical parameter of the battery, in some embodiments, a compensation amount of the control signal for the motor that needs to be compensated due to the change of the electrical parameter of the battery may be calculated according to the present electrical parameter of the battery.

[0030] In some embodiments, the control signal of the motor may include at least one of a control signal configured to control a rotation speed of the motor or a control signal configured to control an output power of the motor.

[0031] At S103, the control signal of the motor is modified according to the compensation amount of the control signal.

[0032] According to the compensation amount calculated in the above processes, the control signal of the motor may be modified. Since the control signal of the motor decreases with the drop of the battery electrical parameter, in some embodiments, a modification method may include adding the compensation amount to an original control signal of the motor.

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[0033] In some embodiments, the present electrical parameter of the battery may include a characteristic parameter associated with the battery itself, and the control signal for the motor may include a parameter associated with a motor characteristic, which are not restricted in the present disclosure.

[0034] In some embodiments, a compensation amount of the control signal of the motor may be calculated according to the present electrical parameter of the battery, and the control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0035] The present disclosure provides another motor control method. In addition to the above-described examples, a compensation amount of the control signal of the motor may be calculated through a feedforward control approach, and a control signal of the motor may be modified according to the compensation amount of the control signal. FIG. 3 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure. With reference to FIG. 3, the method is described below.

[0036] At S301, a present voltage of the battery is obtained.

[0037] In some embodiments, the present electrical parameter of the battery may include a present battery voltage, i.e., the present voltage of the battery. The approach to obtain the present battery voltage may include coupling a voltage sensor to two terminals of the battery, i.e., the power supply, in parallel. The voltage sensor may detect the battery voltage in real time,

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or periodically detect the battery voltage. The voltage sensor may be coupled to the control apparatus and controlled by the control apparatus to detect the battery voltage. In some embodiments, the control apparatus may send a collection control signal to the voltage sensor, such that the voltage sensor may obtain the present battery voltage according to the collection control signal.

[0038] At S302, a compensation amount of the control signal of the motor corresponding to a subsequent time point is calculated according to the present battery voltage, also referred to as a "present voltage of the battery," and a preset voltage model. In some embodiments, in the preset voltage model, battery voltages correspond to preset compensation amounts in a one-to-one manner.

[0039] In some embodiments, a voltage model may be preset according to a discharge curve of the battery. The voltage model, e.g., the preset voltage model, may indicate a correspondence between the battery voltages and the compensation amounts of the control signal for the motor. In some embodiments, in the voltage model, the battery voltages may correspond to the compensation amounts of the control signal of the motor in one-to-one manner. A subsequent time point at which the battery voltage drops and an amount of the voltage drop may be predicted at a present time point according to the voltage model, and a compensation amount of the control signal of the motor corresponding to the subsequent time point may be determined according to the amount of the voltage drop, i.e., the predicted amount of the voltage drop, corresponding to the subsequent time point.

[0040] At S303, the control signal of the motor is modified at the present time point according to the compensation amount of the control signal.

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[0041] According to the compensation amount of the control signal of the motor corresponding to the subsequent time point, the control signal of the motor is modified at the present time point. In some embodiments, at the present time point, the compensation amount may be added to the control signal of the motor to prevent a drop of the motor rotation speed caused by a drop of the battery voltage at the subsequent time point.

[0042] In some embodiments, through a preset voltage model, a one-to-one correspondence between battery voltages and preset compensation amounts may be determined. A compensation amount of the control signal of the motor corresponding to the subsequent time point may be calculated according to a present battery voltage and the preset voltage model. The control signal of the motor may be modified at the present time point to prevent a drop of the motor rotation speed caused by a drop of the battery voltage at the subsequent time point, thereby improving timeliness of modifying the control signal of the motor.

[0043] The present disclosure provides another motor control method. In some embodiments, in addition to the above-described example, a compensation amount of the control signal of the motor may be calculated through a feedback control approach, and the control signal of the motor may be modified according to the compensation amount of the control signal. FIG. 4 is a flowchart of an exemplary motor control method consistent with various disclosed embodiments of the present disclosure. With reference to FIG. 4, the method is described below.

[0044] At S401, a present battery voltage is obtained.

[0045] Process S401 is same as or similar to process S301, descriptions of which are omitted here.

[0046] At S402, a compensation amount of the control signal of the motor is calculated in real time according to the present battery voltage.

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[0047] In some embodiments, the control signal of the motor may control a rotation speed of the motor. After the control apparatus obtains the present battery voltage, if the present battery voltage is lower than a full battery voltage, and under the condition that the throttle signal is fixed, the rotation speed of the motor may have decreased. A needed compensation amount of the rotation speed of the motor may be calculated in real time at the present time point.

[0048] At S403, the control signal of the motor is modified according to the compensation amount of the control signal.

[0049] After the control apparatus calculates the compensation amount of the rotation speed of the motor that needs to be compensated, the control apparatus may actively increase the rotation speed of the motor. In some embodiments, the compensation amount may be added to the decreased rotation speed of the motor to prevent the rotation speed of the motor from being changed by the fluctuation of the battery voltage.

[0050] In some embodiments, a compensation amount of the control signal of the motor may be calculated in real time, and thus the control signal of the motor may be calculated according to the compensation amount of the control signal, thereby improving real time performance of modifying the control signal of the motor.

[0051] The present disclosure provides another motor control method. In some embodiments, in addition to the above-described examples, a compensation amount of the voltage of the motor may be calculated through a feedback control approach, and an original voltage outputted by the ESC to the motor may be modified according to the compensation amount of the voltage of the motor. FIG. 5 is a flowchart of another exemplary motor control method consistent with various disclosed embodiments of the present disclosure. With reference to FIG. 5, the method is described below.

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[0052] At S501, a present battery voltage is obtained.

[0053] Process S501 is same as or similar to process S301, descriptions of which are omitted here.

[0054] At S502, a compensation amount of the voltage outputted to the motor is calculated in real time according to the present battery voltage.

[0055] The compensation amount of the voltage of the motor may be determined according to a difference between the full battery voltage and the present battery voltage. A formula for calculating the compensation amount of the voltage may be $P = (V_0 - V_t) * \frac{S_t}{V_0}$, where P denotes the compensation amount of the voltage outputted to the motor, V_0 denotes the full battery voltage, t denotes the present time point, V_t denotes the present battery voltage, S_t denotes a voltage value corresponding to a throttle signal at the present time point.

[0056] For example, the full battery voltage may be 5V, the ESC may output a voltage to the motor at one of five levels. A first level may correspond to an output voltage of approximately 1 V. A second level may correspond to an output voltage of approximately 2 V. A third level may correspond to an output voltage of approximately 3 V. A fourth level may correspond to an output voltage of approximately 4 V. A fifth level may correspond to an output voltage of approximately 5 V. The output voltage of approximately 1 V may correspond to a motor rotation speed of approximately 100 revolutions per second (RPS). The output voltage of approximately 2 V may correspond to a motor rotation speed of approximately 200 RPS. The output voltage of approximately 3 V may correspond to a motor rotation speed of approximately 300 RPS. The output voltage of approximately 4 V may correspond to a motor rotation speed of approximately 400 RPS. The output voltage of approximately 5 V may correspond to a motor

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rotation speed of approximately 500 RPS. Assuming that the throttle signal is approximately 2, the output voltage of the ESC outputted to the motor may be controlled to be approximately 2V. Thus, the motor rotation speed may be controlled to be approximately 200 RPS. As the battery discharges, the battery voltage may continuously drop. If a present battery voltage is approximately 3V and the throttle signal received by the ESC does not change, then for a full battery voltage of approximately 5V, an actual output voltage outputted by the ESC to the motor may be $\frac{3}{5}*2=1.2V$. According to the formula $P=(V_0-V_t)*\frac{S_t}{V_0}$, the voltage compensation amount may be $(5-3)*\frac{2}{5}=0.8V$.

[0057] At S503, the original voltage outputted to the motor is modified according to the compensation amount of the voltage of the motor.

[0058] Approximately 0.8 V may be added to the voltage of the approximately 1.2 V outputted by the ESC to the motor, to ensure that under the control of a same throttle signal, the motor rotation speed does not change with the variation of the battery voltage.

[0059] In some embodiments, a compensation amount of the voltage outputted to the motor may be calculated in real time, and the original voltage outputted to the motor may be modified according to the compensation amount of the voltage of the motor, thereby improving an accuracy of modifying the control signal of the motor.

[0060] The present disclosure provides another motor control method. In some embodiments, the battery voltage may be controlled in using hardware, such that the output voltage of the battery may be held stable, and a rotation speed of the motor may be prevented from fluctuating along with the fluctuation of the battery voltage. FIG. 6 is a flowchart of another exemplary

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motor control method consistent with various disclosed embodiments of the present disclosure. With reference to FIG. 6, the method is described below.

[0061] At S601, a present electrical parameter of the battery is obtained.

[0062] The present electrical parameter of the battery includes at least one of a present charge quantity of the battery, a present voltage of the battery, a present output electrical current of the battery, or a present internal resistance of the battery.

[0063] FIG. 7 is a topological diagram of an exemplary motor control method consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 7, a voltage sensor 24 is coupled to the power supply, i.e., the battery, in parallel. Through the voltage sensor 24, the output voltage of the battery may be detected in real time or periodically.

[0064] At S602, a voltage compensation amount of the battery is calculated according to the present electrical parameter.

[0065] In some embodiments, the voltage compensation amount of the battery may be calculated according to a present battery voltage and a full battery voltage. The voltage compensation amount may be equal to a difference between the full battery voltage and the present battery voltage.

[0066] When the voltage sensor 24 detects the present battery voltage, a magnitude of the present battery voltage may be transmitted to a switch controller 25, and the switch controller 25 may calculate an amplitude drop of the battery voltage. For example, the full battery voltage may be approximately 5V, the present battery voltage may be approximately 4.5V, and thus the voltage compensation amount of the battery may be approximately 0.5V.

[0067] At S603, the output voltage of the battery is compensated according to the voltage compensation amount to maintain a stable output voltage of the battery.

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[0068] As shown in FIG. 7, the battery 20 is coupled to an external power supply 27 through a switch 26. As the battery voltage drops, the switch controller 25 turns on the switch 26 to electrically couple the battery 20 to the external power supply 27. The external power supply 27 compensates the battery 20 by a voltage of approximately 0.5 V, to ensure that the output voltage of the battery is held at approximately 5V.

[0069] In some embodiments, in response to the voltage sensor 24 detecting that the present battery voltage is lower than the full battery voltage, the switch controller 25 may directly turn on the switch 26 to electrically couple the battery 20 to the external power supply 27, and the external power supply 27 may add a voltage to the battery. In response to the voltage sensor 24 detecting that the present battery voltage recovers to the full battery voltage, the switch controller 25 may directly cut, i.e., turn off, the switch 26. In response to the voltage sensor 24 detecting that the present battery voltage decreases again, the switch controller 25 may repeat the operation of turning on the switch 26 and subsequent operations.

[0070] In some embodiments, a present electrical parameter of the battery may be detected, and a voltage compensation amount of the battery may be calculated according to the present electrical parameter. An output voltage of the battery may be compensated according to the voltage compensation amount, such that the output voltage of the battery is held stable. Accordingly, the control signal of the motor may be prevented from fluctuating with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

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[0071] The present disclosure provides another motor control apparatus. FIG. 8 is a block diagram of an exemplary control apparatus consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 8, the motor control apparatus 80 includes one or more processors 81. The one or more processors 81 are configured to obtain a present electrical parameter, calculate a compensation amount of the control signal of the motor according to the present electrical parameter, and modify a control signal of the motor according to the compensation amount of the control signal.

[0072] The control apparatus of the present disclosure may be configured to execute one of the methods consistent with the disclosure, such as the example method described above in connection with FIG. 1. Detailed descriptions of functions of the control apparatus are omitted here.

[0073] In some embodiments, a compensation amount of the control signal of the motor may be calculated according to the present electrical parameter of the battery, and the control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0074] Further, as shown in FIG. 8, the motor control apparatus 80, i.e., the control apparatus of the motor, also includes an electrical parameter detection circuit 82. The electrical parameter detection circuit 82 is electrically coupled to the one or more processors 81 and configured to detect the present electrical parameter of the battery.

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[0075] In some embodiments, the electrical parameter detection circuit 82 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0076] In some embodiments, the one or more processors 81 may be configured to calculate a compensation amount of the control signal of the motor corresponding to a subsequent time point according to the present battery voltage and a preset voltage model. In some embodiments, in the preset voltage model, battery voltages may correspond to preset compensation amounts in a one-to-one manner. The one or more processors 81 may be further configured to modify, at a present time point, a control signal of the motor according to the compensation amount of the control signal.

[0077] In some embodiments, the one or more processors 81 may be configured to calculate in real time a compensation amount of the control signal of the motor according to the present battery voltage.

[0078] Further, the one or more processors 81 may be configured to calculate in real time a compensation amount of the voltage outputted to the motor according to the present battery voltage, and modify an original voltage outputted to the motor according to the compensation amount of the voltage of the motor.

[0079] The control apparatus of the present disclosure may be configured to execute one of the methods consistent with the disclosure, such as one of the example methods described above in connection with FIGs. 3-5. Detailed descriptions of functions of the control apparatus are omitted here.

[0080] In some embodiments, through a preset model, a one-to-one correspondence between battery voltages and preset compensation amounts may be determined. A compensation amount

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of the control signal of the motor corresponding to a subsequent time point may be calculated according to a present battery voltage and the preset voltage model. Further, the control signal of the motor may be modified at the present time point to prevent a drop of the motor rotation speed caused by a drop of the battery voltage at the subsequent time point, thereby improving timeliness of modifying the control signal of the motor. Further, a compensation amount of the control signal of the motor may be calculated in real time, and the control signal of the motor may be calculated according to the compensation amount of the control signal, thereby improving real time performance of modifying the control signal of the motor. The compensation amount of the voltage outputted to the motor may be calculated in real time, and an original voltage outputted to the motor may be modified according to the compensation amount of the voltage of the motor, thereby improving an accuracy of modifying the control signal of the motor.

[0081] The present disclosure provides a power system. FIG. 9 is a block diagram of an exemplary power system 90 consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 9, the power system 90 includes a motor 91 and the control apparatus 80. The control apparatus 80 is electrically coupled to the motor 91 and configured to control the motor 91. The control apparatus 80, i.e., the motor control apparatus, includes the one or more processors 81. The one or more processors 81 are configured to obtain a present electrical parameter of a battery, calculate a compensation amount of the control signal of the motor according to the present electrical parameter, and modify a control signal of the motor according to the compensation amount of the control signal.

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[0082] In some embodiments, the control apparatus 80 further includes the electrical parameter detection circuit 82. The electrical parameter detection circuit 82 is electrically coupled to the processor 81 for detecting the present electrical parameter of the battery.

[0083] The electrical parameter detection circuit 82 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0084] In some embodiments, a compensation amount of the control signal of the motor may be calculated according to the present electrical parameter of the battery, and the control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0085] The present disclosure provides another motor control apparatus. FIG. 10 is a block diagram of an exemplary motor control apparatus 100 consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 10, the control apparatus 100 includes one or more processors 101. The one or more processors 101 are configured to obtain a present electrical parameter of a battery, calculate a voltage compensation amount of the battery according to the present electrical parameter, and compensate an output voltage of the battery according to the voltage compensation amount, such that the output voltage of the battery is held stable.

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[0086] The control apparatus of the present disclosure may be configured to execute one of the methods consistent with the disclosure, such as the method described above in connection with FIG. 6. Detailed descriptions of functions of the control apparatus are omitted here.

[0087] In some embodiments, a present electrical parameter of the battery may be detected, and a voltage compensation amount of the battery may be calculated according to the present electrical parameter. An output voltage of the battery may be compensated according to the voltage compensation amount, such that the output voltage of the battery is held stable. Accordingly, the control signal of the motor may be prevented from fluctuating with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0088] Further, the motor control apparatus 100 also includes an electrical parameter detection circuit 102. The electrical parameter detection circuit 102 is electrically coupled to the processor 101 for detecting the present electrical parameter of the battery.

[0089] The electrical parameter detection circuit 102 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0090] The present disclosure provides another power system. FIG. 11 is a block diagram of another exemplary power system 110 consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 11, the power system 110 includes a motor 111 and the control apparatus 100. The control apparatus 100 is electrically coupled to the motor 111 and configured to control the motor 111. The control apparatus 100 includes the one or more processors 101. The one or more processors 101 are configured to obtain a present electrical

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parameter of a battery, calculate a voltage compensation amount of the battery according to the present electrical parameter, and to compensate an output voltage of the battery according to the voltage compensation amount to maintain the output voltage of the battery stable.

[0091] Further, the control apparatus 100 also includes the electrical parameter detection circuit 102. The electrical parameter detection circuit 102 is electrically coupled to the processor 101 for detecting the present electrical parameter of the battery.

[0092] The electrical parameter detection circuit 102 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0093] In some embodiments, a present electrical parameter of the battery may be detected, and a voltage compensation amount of the battery may be calculated according to the present electrical parameter. An output voltage of the battery may be compensated according to the voltage compensation amount, such that the output voltage of the battery is held stable. Accordingly, the control signal of the motor may be prevented from fluctuating with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0094] The present disclosure provides an unmanned aerial vehicle (UAV). FIG. 12 is a schematic structural diagram of an exemplary UAV consistent with various disclosed embodiments of the present disclosure. As shown in FIG. 12, the UAV includes a fuselage, a power system 1001, a propeller 1002, a flight controller, and an electronic speed controller (ESC) 1003. In some embodiments, the power system 1001 includes the power system 90 shown in FIG. 9. The power system 90 may be mounted at the fuselage for providing flight

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power. As shown in FIG. 9, the power system 90 includes the motor 91 and the control apparatus 80. The control apparatus 80 is electrically coupled to the motor 91 and configured to control the motor 91. The control apparatus 80 includes the one or more processors 81. The one or more processors 81 are configured to obtain a present electrical parameter, calculate a compensation amount of the control signal of the motor according to the present electrical parameter, and modify a control signal of the motor according to the compensation amount of the control signal.

[0095] Further, the control apparatus 80 includes the electrical parameter detection circuit 82. The electrical parameter detection circuit 82 is electrically coupled to the processor 81 and configured to detect the present electrical parameter of the battery.

[0096] Further, the electrical parameter detection circuit 82 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0097] In some embodiments, a compensation amount of the control signal of the motor may be calculated according to the present electrical parameter of the battery, and the control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0098] The present disclosure provides another UAV. As shown in FIG. 12, in some embodiments, the UAV includes the fuselage, the power system 1001, the propeller 1002, the

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flight controller, and the ESC1003. In some embodiments, the power system 1001 includes the power system 110 shown in FIG. 11. The power system 110 is mounted at the fuselage and configured to provide flight power. The power system 110 includes the motor 111 and the control apparatus 100. The control apparatus 100 is electrically coupled to the motor 111 and configured to control the motor 111. The control apparatus 100 includes the one or more processors 101. The processors 101 are configured to obtain a present electrical parameter of the battery, calculate a voltage compensation amount of the battery according to the present electrical parameter, and compensate an output voltage of the battery according to the voltage compensation amount to maintain the output voltage of the battery stable.

[0099] Further, the control apparatus 100 includes the electrical parameter detection circuit 102. The electrical parameter detection circuit 102 is electrically coupled to the processor 101 and configured to detect the present electrical parameter of the battery.

[0100] Further, the electrical parameter detection circuit 102 may include at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

[0101] In these embodiments, a present electrical parameter of the battery may be detected, and a voltage compensation amount of the battery may be calculated according to the present electrical parameter. An output voltage of the battery may be compensated according to the voltage compensation amount, such that the output voltage of the battery is held stable. Accordingly, the control signal of the motor may be prevented from fluctuating with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need

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high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0102] In some embodiments, a compensation amount of the control signal of the motor may be calculated according to a present electrical parameter of the battery, and a control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed. A compensation amount of the control signal of the motor may be calculated according to the present electrical parameter of the battery, and the control signal of the motor may be modified according to the compensation amount of the control signal, such that the control signal of the motor is prevented from fluctuating along with the change of the electrical parameter of the battery. Correspondingly, motor control signals under control of a same throttle signal may be prevented from being different. Thus, when a UAV performs actions that need high mobility, occurrence of issues of slow response and decreasing power of the UAV during a flight may be suppressed.

[0103] Those of ordinary skill in the art will appreciate that the exemplary elements and algorithm steps described above can be implemented in electronic hardware, or in a combination of computer software and electronic hardware. Whether these functions are implemented in hardware or software depends on the specific application and design constraints of the technical solution. One of ordinary skill in the art can use different methods to implement the described

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functions for different application scenarios, but such implementations should not be considered as beyond the scope of the present disclosure.

[0104] For the convenience and conciseness of the descriptions, only the above-described functional modules as divided are used as examples for illustrations. In actual applications, the above-described functions may be distributed to and implemented by different functional modules according to various application scenarios. That is, the internal structures of exemplary systems, devices, and units can be divided into different functional modules to complete all or some of the functions described above. For simplification purposes, detailed descriptions of the operations of exemplary systems, devices, and units may be omitted and references can be made to the descriptions of the exemplary methods.

[0105] The disclosed systems, apparatuses, and methods may be implemented in other manners not described here. For example, the devices described above are merely illustrative. For example, the division of units may only be a logical function division, and there may be other manners of dividing the units. For example, multiple units or components may be combined or may be integrated into another system, or some features may be ignored, or not executed. Further, the coupling or direct coupling or communication connection shown or discussed may include a direct connection or an indirect connection or communication connection through one or more interfaces, devices, or units, which may be electrical, mechanical, or in other form.

[0106] The units described as separate components may or may not be physically separate, and a component shown as a unit may or may not be a physical unit. That is, the units may be located in one place or may be distributed over a plurality of network elements. Some or all of the components may be selected according to the actual needs to achieve the object of the present disclosure.

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[0107] In addition, the functional units in the various embodiments of the present disclosure may be integrated in one processing unit, or each unit may be an individual physically unit, or two or more units may be integrated in one unit. The above-described integrated units can be implemented in electronic hardware, or in a combination of computer software and electronic hardware.

[0108] A method consistent with the disclosure can be implemented in the form of computer program stored in a non-transitory computer-readable storage medium, which can be sold or used as a standalone product. The computer program can include instructions that enable a computing device, such as a processor, a personal computer, a server, or a network device, to perform part or all of a method consistent with the disclosure, such as one of the exemplary methods described above. The storage medium can be any medium that can store program codes, for example, a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a magnetic disk, or an optical disk.

[0109] Other embodiments of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the embodiments disclosed herein. It is intended that the specification and examples be considered as exemplary only and not to limit the scope of the disclosure, with a true scope and spirit of the invention being indicated by the following claims.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/075097

A. CLASSIFICATION OF SUBJECT MATTER

B64D 31/00 (2006.01) i; B64D 27/24 (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)

B64D

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

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

CNPAT, CNKI, WPI, EPODOC: DJI-INNOVATIONS COMPANY LIMITED; LAN, Qiu; ZHOU, Changxing; NI, Jinyun; electronic speed governor, internal resistance, actuator, unmanned aerial vehicle, electrical tunable, rotational speed, electronic control unit, electric quantity, power source, speed control, compensat+, engine, UAV, modify, electronic, UAV, speed, battery, amend, control, voltage, aerocraft, ESC, parameter, correct, motor, flyer, power, feedback, resistance, current

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 105093130 A (YANG, Shanshan), 25 November 2015 (25.11.2015), description, paragraphs [0055]-[0106], and figures 1-4	1-32
A	CN 101159340 A (CHERY AUTOMOBILE CO., LTD.), 09 April 2008 (09.04.2008), the whole document	1-32
A	CN 102522796 A (HUIZHOU EPOWER ELECTRONIC CO., LTD.), 27 June 2012 (27.06.2012), the whole document	1-32
A	CN 103527338 A (WEICHAI POWER CO., LTD.), 22 January 2014 (22.01.2014), the whole document	1-32
A	CN 104333068 A (STATE GRID CORPORATION OF CHINA et al.), 04 February 2015 (04.02.2015), the whole document	1-32
A	US 2012197471 A1 (TOYOTA JIDOSHA K. K.), 02 August 2012 (02.08.2012), the whole document	1-32

☐ 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 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
31 October 2016 (31.10.2016)	**30 November 2016 (30.11.2016)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **ZHU, Yanhua** Telephone No.: (86-10) **61648428**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/075097

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 105093130 A	25 November 2015	None	
CN 101159340 A	09 April 2008	CN 101973211 B	03 October 2012
		CN 101973211 A	16 February 2011
		CN 100574000 C	23 December 2009
CN 102522796 A	27 June 2012	CN 102522796 B	28 May 2014
CN 103527338 A	22 January 2014	CN 103527338 B	16 March 2016
CN 104333068 A	04 February 2015	None	
US 2012197471 A1	02 August 2012	US 8483900 B2	09 July 2013
		JP 2012159061 A	23 August 2012
		JP 5273170 B2	28 August 2013

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专 利 合 作 条 约

PCT

国际检索报告

(PCT第18条和细则43和44)

申请人或代理人的档案号 160364GP	关于后续行为	见PCT/ISA/220表和 适用时，见下面第5项
国际申请号 PCT/CN2016/075097	国际申请日 (年/月/日) 2016年 3月 1日	(最早的)优先权日 (年/月/日)
申请人 深圳市大疆创新科技有限公司		

按照条约第18条，本国际检索报告由本国际检索单位做出并送交申请人。报告副本送交国际局。

本国际检索报告总计 4 页。

☐ 它还附有本报告所引用的各现有技术文件的副本。

1. 报告的基础

a. 关于语言，进行国际检索基于：

☑ 国际申请提交时使用的语言。

☐ 该国际申请的_____语言译文，为了国际检索的目的提供该种语言的译文(细则12.3(a)和23.1(b))。

b. ☐ 本国际检索报告考虑了本单位许可或被通知的根据细则91所做出的明显错误更正(细则43.6之二(a))。

c. ☐ 关于国际申请中公开的任何核苷酸和/或氨基酸序列，见第I栏。

2. ☐ 某些权利要求被认为是不能检索的(见第II栏)。

3. ☐ 缺乏发明的单一性(见第III栏)。

4. 关于发明名称，

☑ 同意申请人提出的发明名称。

☐ 发明名称由本单位确定如下：

5. 关于摘要，

☐ 同意申请人提出的摘要。

☑ 根据细则38.2(b)，摘要由本单位制定，如第IV栏中所示。自本国际检索报告发文日起一个月内，申请人可以向本单位提出意见。

6. 关于附图，

a. 随摘要一起公布的附图是： 1

☑ 按照申请人建议的。

☐ 由本单位选择的，因为申请人没有建议一幅图。

☐ 由本单位选择的，因为该图能更好地表示发明的特征。

b. ☐ 没有与摘要一起公布的附图

Textron Specialized Vehicles Inc., Exh. 1003, p. 301

第IV栏　　摘要正文(续第1页第5项)

一种电机(22)的控制方法、装置及系统。该方法包括：获取电池(20)的当前电参数(S101)；依据所述当前电参数，计算电机(22)的控制信号的补偿量(S102)；根据所述控制信号的补偿量，修正所述电机(22)的控制信号(S103)，该方法避免了电机(22)的控制信号随着电池(20)电参数的变化而波动，同时避免了相同的油门信号控制下电机(22)的控制信号不同，解决了无人机在做一些需要高机动性方面的动作时，常常会出现反应迟缓的问题，同时避免了无人机在飞行过程中出现越飞越无力的现象。

Textron Specialized Vehicles Inc., Exh. 1003, p. 302

国际检索报告

国际申请号
PCT/CN2016/075097

A. 主题的分类

B64D 31/00(2006.01)i；B64D 27/24(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

B64D

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用）)

CNPAT，CNKI，WPI，EPODOC：深圳市大疆创新科技有限公司，蓝求，周长兴，倪锦云，功率，电池，电子调速器，马达，内阻，反馈，调速控制器，无人机，校正，电机，电阻，电流，电调，控制，转速，修正，电压，电子控制单元，电量，补偿，飞行器，电源，调速，compensat+，engine，UAV，modify，electronic，UAV，speed，battery，amend，control，voltage，aerocraft，ESC，parameter，correct，motor，flyer，power，feedback，resistance，current

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
A	CN 105093130 A (杨珊珊) 2015年 11月 25日 (2015-11-25) 说明书第[0055]-[0106]段、附图1-4	1-32
A	CN 101159340 A (奇瑞汽车有限公司) 2008年 4月 9日 (2008-04-09) 全文	1-32
A	CN 102522796 A (惠州市亿能电子有限公司) 2012年 6月 27日 (2012-06-27) 全文	1-32
A	CN 103527338 A (潍柴动力股份有限公司) 2014年 1月 22日 (2014-01-22) 全文	1-32
A	CN 104333068 A (国家电网公司 等) 2015年 2月 4日 (2015-02-04) 全文	1-32
A	US 2012197471 A1 (TOYOTA JIDOSHA K.K.) 2012年 8月 2日 (2012-08-02) 全文	1-32

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

“A” 认为不特别相关的表示了现有技术一般状态的文件

“E” 在国际申请日的当天或之后公布的在先申请或专利

“L” 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

“O” 涉及口头公开、使用、展览或其他方式公开的文件

“P” 公布日先于国际申请日但迟于所要求的优先权日的文件

“T” 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

“X” 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

“Y” 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

“&” 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2016年 10月 31日	2016年 11月 30日
ISA/CN的名称和邮寄地址 中华人民共和国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 朱艳华 电话号码 (86-10)61648428

表 PCT/ISA/210 (第2页) (2009年7月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2016/075097

检索报告引用的专利文件			公布日 (年/月/日)	同族专利			公布日 (年/月/日)
CN	105093130	A	2015年 11月 25日	无			
CN	101159340	A	2008年 4月 9日	CN	101973211	B	2012年 10月 3日
				CN	101973211	A	2011年 2月 16日
				CN	100574000	C	2009年 12月 23日
CN	102522796	A	2012年 6月 27日	CN	102522796	B	2014年 5月 28日
CN	103527338	A	2014年 1月 22日	CN	103527338	B	2016年 3月 16日
CN	104333068	A	2015年 2月 4日	无			
US	2012197471	A1	2012年 8月 2日	US	8483900	B2	2013年 7月 9日
				JP	2012159061	A	2012年 8月 23日
				JP	5273170	B2	2013年 8月 28日

Textron Specialized Vehicles Inc., Exh. 1003, p. 304

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	Concurrently
First Named Inventor	Changxing ZHOU
Title	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
Art Unit	
Examiner Name	
Attorney Docket Number	00203.3030.00US

SIGNATURE of Applicant or Patent Practitioner

Signature	/Li Jiang/	Date (Optional)	2018-08-29
Name	Li Jiang	Registration Number	74191
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 3 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, 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 the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 136725

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

SZ DJI Technology Co., Ltd.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	10-16-2016
Name	Xiaodan WANG		
Title	Head of IP department		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 3 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, 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 the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/01 (06-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

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: Changxing ZHOU Date (Optional): 2018.08.27

Signature: Changxing ZHOU

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 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.**

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- [x] The attached application, or
- [ ] United States application or PCT international application number _____ filed on _____.

The above-identified application was made or authorized to be made by me.

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LEGAL NAME OF INVENTOR

Inventor: Qiu LAN Date (Optional): 2018.08.24

Signature: Qiu Lan

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 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.**

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PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
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As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____

filed on _____.

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:

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LEGAL NAME OF INVENTOR

Inventor: Jinyun NI Date (Optional): 2018.8.23

Signature: Jinyun Ni

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 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 the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	33576568
Application Number:	16116279
International Application Number:	
Confirmation Number:	6124
Title of Invention:	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM
First Named Inventor/Applicant Name:	Changxing ZHOU
Customer Number:	136725
Filer:	Wenye Tan/Ting Xue
Filer Authorized By:	Wenye Tan
Attorney Docket Number:	00203.3030.00US
Receipt Date:	29-AUG-2018
Filing Date:	
Time Stamp:	15:48:41
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1720
RAM confirmation Number	083018INTEFSW15503900
Deposit Account	
Authorized User	

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

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	Transmittal002033030.pdf	277196 67084176ec738ba5983e71fed17ff25f22840bf9	no	2
Warnings:					
Information:					
2	Application Data Sheet	ADS002033030.pdf	1822595 6015cce4ee971590e36412f84facff854da926de	no	9
Warnings:					
Information:					
3		Spec002033030.pdf	235433 4a656ecff45e437b5d9739713f3df84e9754b8c9	yes	31

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	25
Claims	26	30
Abstract	31	31

Warnings:					
Information:					
4	Drawings-only black and white line drawings	Draw002033030.pdf	185100 1c964752c9d2e353d8d9ec92b6cb62d5fa6fcdee	no	7
Warnings:					
Information:					
5	Oath or Declaration filed	Decl002033030.pdf	150794 c861beafee7c44be13c2d06ce5d8ed978a24629c	no	3

Warnings:					
Information:					
6	Power of Attorney	POA002033030.pdf	266608 e2a407a35e285fe5b4c00ec3bc590eaf0d133a30	no	2
Warnings:					
Information:					
7	Information Disclosure Statement (IDS) Form (SB08)	IDS002033030.pdf	1034737 3d51e66f85b4a30563fa4075e0e3657c0f06f89c	no	4
Warnings:					
Information:					
8	Foreign Reference	CN105093130A.pdf	4244467 f839d57fd0564231cc8bc07c3c69c703196ba556	no	21
Warnings:					
Information:					
9	Foreign Reference	CN101159340A.pdf	2411670 f74cf8c91a5d391c17d5513ed43d84d317a90041	no	15
Warnings:					
Information:					
10	Foreign Reference	CN102522796A.pdf	756275 e451a694b4253dc1b0b78883e093a3dd1caed3f6	no	6
Warnings:					
Information:					
11	Foreign Reference	CN103527338A.pdf	2219300 53908720811bf767e477acda670d0b0bf03190ee	no	16
Warnings:					
Information:					
12	Foreign Reference	CN104333068A.pdf	3090215 826f57f0c36d868d63512fbc5f406a407fe20e54	no	16
Warnings:					
Information:					

13	Other Reference-Patent/App/Search documents	ISR002033030.pdf	207434 c2b52920288b525657449ef2dd52d476069 58b8c	no	6
Warnings:					
Information:					
14	Fee Worksheet (SB06)	fee-info.pdf	34601 e13d4342eddd8b47bba55199b175b79b0a b49573	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	16936425		

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/SB/08a (02-18)
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	4	103527338	CN	A	2014-01-22	WEICHAI POWER CO LTD		
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Bibliographic data: CN104333068 (A) — 2015-02-04

Lithium battery charging control method, device and system and battery management system

Inventor(s): MA LONGFEI; CHEN YANXIA; CHI ZHONGJUN; GONG CHENG; SHI RUI; LI XIANGLONG; ZHANG BAOQUN; JIAO RAN; MENG YING ± (MA LONGFEI, ; CHEN YANXIA, ; CHI ZHONGJUN, ; GONG CHENG, ; SHI RUI, ; LI XIANGLONG, ; ZHANG BAOQUN, ; JIAO RAN, ; MENG YING)

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Classification: **- international:** ***H02J7/00***
- cooperative: **H02J7/0014**; **H02J7/0021**; **H02J7/0026**; **H02J7/007**; H02J2007/0037; H02J2007/0049 more

Application number: CN20141610513 20141103 Global Dossier

Priority number(s): CN20141610513 20141103

Abstract of CN104333068 (A)

The invention discloses a lithium battery charging control method, device and system and a battery management system. The lithium battery charging control method comprises the following steps of detecting parameters of a lithium battery; calculating charging currents of the lithium battery; controlling a battery charger to charge the lithium battery according to the charging currents. The lithium battery charging control method solves the problem that, in the prior art, the service life of the lithium battery is shortened due to the fact that the lithium battery is easy to be over charged and achieves the effect that the service life of the lithium battery is improved.

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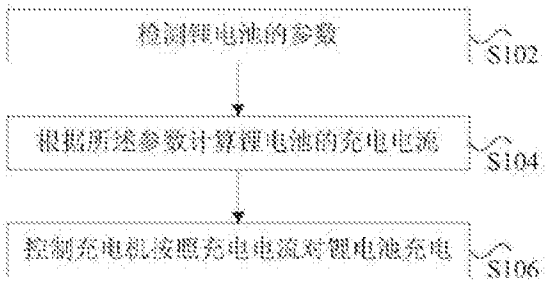
权利要求书2页 说明书10页 附图2页

(54)发明名称

锂电池充电控制方法、装置和系统及电池管理系统

(57)摘要

本发明公开了一种锂电池充电控制方法、装置和系统及电池管理系统，其中，锂电池充电控制方法包括：检测锂电池的参数；根据参数计算锂电池的充电电流；控制充电机按照充电电流对锂电池充电。通过本发明，解决了现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，达到了提高锂电池使用寿命的效果。



CN 104333068 A

1. 一种锂电池充电控制方法，其特征在于，包括：

检测锂电池的参数；

根据所述参数计算所述锂电池的充电电流；以及

控制充电机按照所述充电电流对所述锂电池充电。

2. 根据权利要求 1 所述的锂电池充电控制方法，其特征在于，所述锂电池包括 n 个锂电池单体，其中：

检测锂电池的参数包括：检测所述锂电池单体 Li 的参数 Ci，i 依次取 1 至 n；

根据所述参数计算所述锂电池的充电电流包括：根据所述参数 Ci 计算所述锂电池单体 Li 的充电电流 Ii；

控制充电机按照所述充电电流对所述锂电池充电包括：控制所述充电机按照充电电流 Imin 对每个所述锂电池单体进行充电，其中，所述充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流。

3. 根据权利要求 1 所述的锂电池充电控制方法，其特征在于，所述参数包括电流、电压、温度、荷电状态和电池容量，根据所述参数计算所述锂电池的充电电流包括：

根据所述温度计算温度补偿系数 k_t；

根据所述荷电状态计算荷电状态补偿系数 k_{soc}；

根据修正系数 k_{com} 和电流补偿系数 k_{cur} 计算电池健康系数 k_{soh}，其中，所述修正系数 $k_{com}=QQ_r^{-1}$，Q 为所述锂电池的电池容量，Q_r 为所述锂电池的额定容量，所述电流补偿系数 $k_{cur}=k\ R^{(n-1)}$，k 为所述锂电池的特性系数，R 为所述锂电池的电阻；以及

根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{soc}、所述电池健康系数 k_{soh}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的所述充电电流。

4. 根据权利要求 3 所述的锂电池充电控制方法，其特征在于，根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{soc}、所述电池健康系数 k_{soh}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的充电电流包括：按照公式 $I=k_cQ_rk_tk_{soc}k_{soh}$ 计算所述充电电流。

5. 一种锂电池充电控制装置，其特征在于，包括：

测量单元，用于检测锂电池的参数；

计算单元，用于根据所述参数计算所述锂电池的充电电流；以及

控制单元，用于控制充电机按照所述充电电流对所述锂电池充电。

6. 根据权利要求 5 所述的锂电池充电控制装置，其特征在于，所述锂电池包括 n 个锂电池单体，其中：

所述测量单元包括测量模块，用于检测所述锂电池单体 Li 的参数 Ci，i 依次取 1 至 n；

所述计算单元包括第一计算模块，用于根据所述参数 Ci 计算所述锂电池单体 Li 的充电电流 Ii；

所述控制单元包括控制模块，用于控制所述充电机按照充电电流 Imin 对每个所述锂电池单体进行充电，其中，所述充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流。

7. 根据权利要求 5 所述的锂电池充电控制装置，其特征在于，所述参数包括电流、电压、温度、荷电状态和电池容量，所述计算单元包括：

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第二计算模块，用于根据所述温度计算温度补偿系数 k_t；

第三计算模块，根据所述荷电状态计算荷电状态补偿系数 k_{soc}；

第四计算模块，用于根据修正系数 k_{soh1} 和电流补偿系数 k_{soh2} 计算电池健康系数 k_{soh}，其中，所述修正系数 $k_{soh1} = QQ_r^{-1}$，Q 为所述锂电池的电池容量，Q_r 为所述锂电池的额定容量，所述电流补偿系数 $k_{soh2} = k\ R^{0.5}$，k 为所述锂电池的特性系数，R 为所述锂电池的电阻；

第五计算模块，用于根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{soc}、所述电池健康系数 k_{soh}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的所述充电电流。

8. 根据权利要求 7 所述的锂电池充电控制装置，其特征在于，

所述第五计算模块按照公式 $I = k_c Q_r k_t k_{soc} k_{soh}$ 计算所述充电电流。

9. 一种锂电池充电控制系统，其特征在于，包括：

锂电池；以及

锂电池充电控制装置，所述锂电池充电控制装置为权利要求 5 至 8 中任一项所述的锂电池充电控制装置。

10. 一种电池管理系统，其特征在于，包括：

锂电池，具有多个锂电池单体；

锂电池充电控制装置，所述锂电池充电控制装置为权利要求 5 至 8 中任一项所述的锂电池充电控制装置；以及

均衡装置，用于在所述锂电池充电控制装置的控制下均衡所述多个锂电池单体之间的电压。

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锂电池充电控制方法、装置和系统及电池管理系统

技术领域

[0001] 本发明涉及锂电池领域，具体而言，涉及一种锂电池充电控制方法、装置和系统及电池管理系统。

背景技术

[0002] 锂离子电池具有单体工作电压高、体积小、质量轻、能量密度高、循环使用寿命长、自放电电流小、无记忆效应、无污染和性价比高等优点，近年来，锂离子电池的产量快速发展，应用领域不断扩大，已成为 21 世纪具有重要意义的高新技术产品。锂离子电池的放电曲线很平坦，可以在电池的整个放电期间内产生稳定的功率，因此，锂离子电池成为车用动力电池的首选。但同时锂离子电池的缺点也非常明显，那就是比较“娇气”，对温度、电流和电压都有严格要求，稍不小心，就可能导致电池受损、报废，甚至燃烧、爆炸，造成生命财产的严重损失。

[0003] 电动汽车对锂电池的要求更高，原因是：(1) 需要容量大；(2) 大量串并联使用；(3) 电池的工作电流大且变化迅速；(4) 工作环境恶劣，包括道路颠簸和散热条件有限等。由于在生产和使用电池过程中。单体电池之间会因为初始容量，发热以及自放电等不完全相同而导致实际容量的差异，且容量越低的电池在使用过程中越容易出现过充电和过放电，容量衰减越严重，表现出正反馈，使得电池的一致性越来越差；为了达到均衡的效果，均衡器的容量、体积和质量都大，这与车辆空间以及高的运行效率之间形成矛盾。

[0004] 对于锂离子电池而言，过充电会使得电池的电解液分解，产生的气体压力增加、电池的温度迅速上升。继续充电会导致电池的隔膜热闭合、隔膜溶解、电池的正负极断路大量发热，使得电池着火甚至爆炸，损毁电池。

[0005] 针对相关技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，目前尚未提出有效的解决方案。

发明内容

[0006] 本发明的主要目的在于提供一种锂电池充电控制方法、装置和系统及电池管理系统，以解决现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题。

[0007] 为了实现上述目的，根据本发明的一个方面，提供了一种锂电池充电控制方法。

[0008] 根据本发明的锂电池充电控制方法包括：检测锂电池的参数；根据所述参数计算所述锂电池的充电电流；以及控制充电机按照所述充电电流对所述锂电池充电。

[0009] 进一步地，所述锂电池包括 n 个锂电池单体，其中：检测锂电池的参数包括：检测所述锂电池单体 Li 的参数 Ci，i 依次取 1 至 n；根据所述参数计算所述锂电池的充电电流包括：根据所述参数 Ci 计算所述锂电池单体 Li 的充电电流 Ii；控制充电机按照所述充电电流对所述锂电池充电包括：控制所述充电机按照充电电流 Imin 对每个所述锂电池单体进行充电，其中，所述充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流。

[0010] 进一步地，所述参数包括电流、电压、温度、荷电状态和电池容量，根据所述参数计

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算所述锂电池的充电电流包括：根据所述温度计算温度补偿系数 k_t；根据所述荷电状态计算荷电状态补偿系数 k_{SOC}；根据修正系数 k_{SOH} 和电流补偿系数 k_{comp} 计算电池健康系数 k_{SOH}，其中，所述修正系数 $k_{SOH}=QQ_r^{-1}$，Q 为所述锂电池的电池容量，Q_r 为所述锂电池的额定容量，所述电流补偿系数 $k_{comp}=k\ R^{0.5}$，k 为所述锂电池的特性系数，R 为所述锂电池的电阻；以及根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{SOC}、所述电池健康系数 k_{SOH}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的所述充电电流。

[0011] 进一步地，根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{SOC}、所述电池健康系数 k_{SOH}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的充电电流包括：按照公式 $I=k_tQ_rk_ck_{SOC}k_{SOH}$ 计算所述充电电流。

[0012] 为了实现上述目的，根据本发明的另一方面，提供了一种锂电池充电控制装置。

[0013] 根据本发明的锂电池充电控制装置包括：测量单元，用于检测锂电池的参数；计算单元，用于根据所述参数计算所述锂电池的充电电流；以及控制单元，用于控制充电机按照所述充电电流对所述锂电池充电。

[0014] 进一步地，所述锂电池包括 n 个锂电池单体，其中：所述测量单元包括测量模块，用于检测所述锂电池单体 Li 的参数 Ci，i 依次取 1 至 n；所述计算单元包括第一计算模块，用于根据所述参数 Ci 计算所述锂电池单体 Li 的充电电流 Ii；所述控制单元包括控制模块，用于控制所述充电机按照充电电流 Imin 对每个所述锂电池单体进行充电，其中，所述充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流。

[0015] 进一步地，所述参数包括电流、电压、温度、荷电状态和电池容量，所述计算单元包括：第二计算模块，用于根据所述温度计算温度补偿系数 k_t；第三计算模块，根据所述荷电状态计算荷电状态补偿系数 k_{SOC}；第四计算模块，用于根据修正系数 k_{SOH} 和电流补偿系数 k_{comp} 计算电池健康系数 k_{SOH}，其中，所述修正系数 $k_{SOH}=QQ_r^{-1}$，Q 为所述锂电池的电池容量，Q_r 为所述锂电池的额定容量，所述电流补偿系数 $k_{comp}=k\ R^{0.5}$，k 为所述锂电池的特性系数，R 为所述锂电池的电阻；第五计算模块，用于根据所述温度补偿系数 k_t、所述荷电状态补偿系数 k_{SOC}、所述电池健康系数 k_{SOH}、所述锂电池的额定容量 Q_r 和倍率系数 k_c 确定所述锂电池的所述充电电流。

[0016] 进一步地，所述第五计算模块按照公式 $I=k_tQ_rk_ck_{SOC}k_{SOH}$ 计算所述充电电流。

[0017] 为了实现上述目的，根据本发明的另一方面，提供了一种锂电池充电控制系统。

[0018] 根据本发明的锂电池充电控制系统包括：锂电池；以及锂电池充电控制装置，所述锂电池充电控制装置为上述内容所提供的任一项所述的锂电池充电控制装置。

[0019] 为了实现上述目的，根据本发明的另一方面，提供了一种电池管理系统。

[0020] 根据本发明的锂电池充电控制系统包括：锂电池，具有多个锂电池单体；锂电池充电控制装置，所述锂电池充电控制装置为上述内容所提供的任一项所述的锂电池充电控制装置；以及均衡装置，用于在所述锂电池充电控制装置的控制下均衡所述多个锂电池单体之间的电压。

[0021] 在本发明中，采用检测锂电池的参数，根据参数计算锂电池的充电电流，以及控制充电机按照充电电流对锂电池充电。通过首先根据检测到的锂电池的参数计算出适合对锂电池充电的电流，进而控制充电机按照上述电流进行充电，也就是可以根据锂电池的状

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态参数，及时调整适合对其进行充电的电流，避免了不顾锂电池本身的性能情况，一直按照固定的预设电流对锂电池进行充电导致的过充电的问题，解决了现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，达到了提高锂电池使用寿命的效果。

附图说明

[0022] 构成本申请的一部分的附图用来提供对本发明的进一步理解，本发明的示意性实施例及其说明用于解释本发明，并不构成对本发明的不当限定。在附图中：

[0023] 图 1 是根据本发明实施例的锂电池充电控制方法的流程图；

[0024] 图 2 是根据本发明优选实施例的锂电池充电控制方法的流程图；

[0025] 图 3 是根据本发明实施例的锂电池充电控制装置的示意图；

[0026] 图 4 是根据本发明实施例的电池管理系统的示意图，以及

[0027] 图 5 是根据本发明优选实施例的电池管理系统的示意图。

具体实施方式

[0028] 为了使本技术领域的人员更好地理解本发明方案，下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分的实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有做出创造性劳动前提下所获得的所有其他实施例，都应当属于本发明保护的范围。

[0029] 需要说明的是，本发明的说明书和权利要求书及上述附图中的术语“第一”、“第二”等是用于区别类似的对象，而不必用于描述特定的顺序或先后次序。应该理解这样使用的数据在适当情况下可以互换，以便这里描述的本发明的实施例能够以除了在这里图示或描述的那些以外的顺序实施。此外，术语“包括”和“具有”以及他们的任何变形，意图在于覆盖不排他的包含，例如，包含了一系列步骤或单元的过程、方法、系统、产品或设备不必限于清楚地列出的那些步骤或单元，而是可包括没有清楚地列出的或对于这些过程、方法、产品或设备固有的其它步骤或单元。

[0030] 实施例 1

[0031] 根据本发明实施例，提供了一种可以用于实施本申请装置实施例的方法实施例，需要说明的是，在附图的流程图示出的步骤可以在诸如一组计算机可执行指令的计算机系统中执行，并且，虽然在流程图中示出了逻辑顺序，但是在某些情况下，可以以不同于此处的顺序执行所示出或描述的步骤。

[0032] 根据本发明实施例，提供了一种锂电池充电控制方法，图 1 是根据本发明实施例的锂电池充电控制方法的流程图，如图 1 所示，该方法包括步骤 S102 至步骤 S106：

[0033] S102：检测锂电池的参数，该参数可以包括电流、电压、温度和荷电状态等。

[0034] S104，根据参数计算锂电池的充电电流，根据检测到的参数计算出，在对锂电池进行充电时，适合其的电流。

[0035] S106：控制充电机按照充电电流对锂电池充电。

[0036] 在本发明实施例中，首先根据检测到的锂电池的参数计算出适合对锂电池充电的电流，进而控制充电机按照上述电流进行充电，也就是可以根据锂电池的状态参数，及时调

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整适合对其进行充电的电流，避免了不顾锂电池本身的性能情况，一直按照固定的预设电流对锂电池进行充电导致的过充电的问题，解决了现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，达到了提高锂电池使用寿命的效果。

[0037] 优选地，锂电池包括 n 个锂电池单体，检测锂电池的参数包括：检测锂电池单体 Li 的参数 Ci，i 依次取 1 至 n，即，检测每个锂电池单体的参数；根据参数计算锂电池的充电电流包括：根据参数 Ci 计算锂电池单体 Li 的充电电流 Ii，即，分别计算出每个锂电池单体的充电电流；控制充电机按照充电电流对锂电池充电包括：控制充电机按照充电电流 Imin 对每个锂电池单体进行充电，其中，充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流，即，在计算出每个锂电池单体的充电电流后，按照得出的充电电流中的最小值对 n 个锂电池单体进行充电。

[0038] 在本发明实施例中，根据每个锂电池单体的参数，分别计算出其相对应的充电电流，进而按照计算出的充电电流中的最小值对每个锂电池单体进行充电，考虑到了每个锂电池单体的情况，避免了充电电流高于充电电流中的最小值而超出锂电池单体的承受能力，导致锂电池整体损坏的问题。

[0039] 具体地，检测到的锂电池的参数包括电流、电压、温度、荷电状态和电池容量，根据参数计算锂电池的充电电流包括步骤 1-1 至步骤 1-4；

[0040] 步骤 1-1：根据温度计算温度补偿系数 k_t，具体的可以按照如下公式计算温度补偿系数 k_t：

[0041]

$$k_t=\begin{cases} k_{t1}e^{k_{t2}T} & -20^{\circ}C\le T<20^{\circ}C \\ 1 & 20^{\circ}C\le T<45^{\circ}C \\ (50-T)/5 & 45^{\circ}C\le T<50^{\circ}C \\ 0 & T<-20^{\circ}C\text{或}T>50^{\circ}C \end{cases}$$

[0042] 具体地，根据检测到的温度，按照对应的公式计算出温度补偿系统 k_t，其中，k_{t1}、k_{t2} 为温度系数，可以通过查询锂电池的出厂参数获得。

[0043] 一般情况下，温度与电池的最大允许充电电流可分为 3 段：(1) 温度在 20℃～45℃，这是电池的最佳工作温度范围，电池的倍率特性好而且容量衰减较小；(2) 温度低于 20℃时，电池的内阻上升，电池的可接受充电电流降低；(3) 温度高于 45℃以后，虽然电池可接受的充电电流可能更大，但是电池的容量衰减大大加速，因此也不适合电池充电。因此，为了保证电池能够有较好的充电性能，可以对电池的工作温度进行调节控制，使其最好处于第一段温度范围内，也可以处于第二段温度范围内，但要尽量避免电池充电时的温度落入第三段温度范围内。如果电池的工作温度无法进行调节，此时在知道电池的工作温度的情况下，就可以依据电池的温度补偿系数 k_t 来对电池的充电电流进行调节，使电池的充电电流在电池允许的范围之内。

[0044] 步骤 1-2：根据荷电状态计算荷电状态补偿系数 k_{soc}，具体的可以按照如下公式计算荷电状态补偿系数 k_{soc}：

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[0045] $$k_{SOC}=\begin{cases}k_{SOC1}+\dfrac{(1-k_{SOC1})\times SOC}{10} & 0<SOC\le 10\%\\ 1 & 10\%<SOC\le 90\%\\ 9.1-0.09SOC & 90\%<SOC<100\%\\ 0.1 & SOC=100\%\end{cases}$$

[0046] 具体地，SOC 为荷电状态，可以反映电池剩余的电量，根据检测到的剩余电量按照相应的公式计算出荷电状态补偿系数 k_{soc}，k_{soc1} 为 SOC = 0 时的补偿系数。由于电池充电过程充电效率 <1，所以电池的 SOC = 100% 时，电池可能尚未完全充满，为了更加充分地利用电池的容量，需要对电池进行补充充电，同时为了防止过充电，电池的充电电流限制到约锂电池所允许的最大充电电流的 1/10，这时停止充电的条件由锂电池的电压控制。

[0047] 步骤 1-3：根据修正系数 k_{soh1} 和电流补偿系数 k_{soh2} 计算电池健康系数 k_{soh}，其中，修正系数 $k_{soh1}=QQ_r^{-1}$，Q 为锂电池的电池容量，Q_r 为锂电池的额定容量，电流补偿系数 $k_{soh2}=k\ R^{-0.5}$，k 为锂电池的特性系数，R 为锂电池的电阻。

[0048] 具体地，电池的 SOH 表示的是电池的健康状态，主要考虑电池的容量衰退和电池的内阻增加。对于容量衰退，可以采用容量修正系数 $k_{soh1}=QQ_r^{-1}$ 来进行修正；内阻对电池的充电电流补偿系数为 $k_{soh2}=k\ R^{-0.5}$，此时按照公式 $k_{soh}=k_{soh1}k_{soh2}=kQQ_r^{-1}R^{-0.5}$ 就可以计算出锂电池的电池健康系数 k_{soh}。

[0049] 步骤 1-4：根据温度补偿系数 k_t、荷电状态补偿系数 k_{soc}、电池健康系数 k_{soh}、锂电池的额定容量 Q_r 和锂电池的倍率系数 k_r 确定锂电池的充电电流，锂电池的额定容量 Q_r 和锂电池的倍率系数 k_r 可以通过查询锂电池的出厂参数得知。

[0050] 具体地，按照公式 $I=k_rQ_rk_tk_{soc}k_{soh}$ 计算锂电池的充电电流，其中，温度补偿系数 k_t、荷电状态补偿系数 k_{soc}、电池健康系数 k_{soh}、锂电池的额定容量 Q_r 和倍率系数 k_r。

[0051] 当锂电池包括多个锂电池单体时，对于每个锂电池单体都重复执行步骤 1-1 至步骤 1-4 计算其的充电电流，然后控制充电机按照最小的充电电流对每个锂电池单体进行充电。

[0052] 优选地，图 2 是根据本发明优选实施例的锂电池充电控制方法的流程图，如图 2 所示，该方法包括步骤 S202 至步骤 S210：

[0053] S202：参数初始化设置，用户对锂电池的参数进行初始化设置，初始化设置的参数包括电池、电压、温度。

[0054] S202：接收检测的参数，接收检测模块检测到的参数数据。

[0055] S206：判断检测的参数是否在允许范围内，如果检测到的参数的数值都在初始化设置的参数的数值范围内，执行步骤 S208，如果有任一检测到的参数的数值步骤初始化设置的参数的数值范围内，执行步骤 S210。

[0056] S208：按照原电流进行充电，即，不需要改变锂电池的充电电流。

[0057] S210：发送信息至充电机要求减小充电电流，减小后的充电电流可以根据上述锂电池的充电控制方法中任一实施例所提供的充电控制方法获得。

[0058] 在本发明实施例中，能使充电机根据电池的状态，实时地改变输出电流，达到防止

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电池组中所有电池单体发生过充电以及优化充电的目的。

[0059] 需要说明的是，对于前述的各方法实施例，为了简单描述，故将其都表述为一系列的动作组合，但是本领域技术人员应该知悉，本发明并不受所描述的动作顺序的限制，因为依据本发明，某些步骤可以采用其他顺序或者同时进行。其次，本领域技术人员也应该知悉，说明书中所描述的实施例均属于优选实施例，所涉及的动作和模块并不一定是本发明所必须的。

[0060] 通过以上的实施方式的描述，本领域的技术人员可以清楚地了解到根据上述实施例的方法可借助软件加必需的通用硬件平台的方式来实现，当然也可以通过硬件，但很多情况下前者是更佳的实施方式。基于这样的理解，本发明的技术方案本质上或者说对现有技术做出贡献的部分可以以软件产品的形式体现出来，该计算机软件产品存储在一个存储介质（如 ROM/RAM、磁碟、光盘）中，包括若干指令用以使得一台终端设备（可以是手机，计算机，服务器，或者网络设备等）执行本发明各个实施例所述的方法。

[0061] 实施例 2

[0062] 根据本发明实施例，还提供了一种用于实施上述锂电池充电控制方法的锂电池充电控制装置，该控制装置主要用于执行本发明实施例上述内容所提供的控制方法，以下对本发明实施例所提供的锂电池充电控制装置做具体介绍：

[0063] 根据本发明的实施例，提供了一种锂电池充电控制装置，图 3 是根据本发明实施例的锂电池充电控制装置的示意图，如图 3 所示，该装置主要包括测量单元 10、计算单元 20 和控制单元 30，其中：

[0064] 测量单元 10 用于检测锂电池的参数，该参数可以包括电流、电压、温度和荷电状态等，具体地，可以采用专门的芯片检测锂电池的电压，例如：Linear 公司生产的 LTC6802；采用霍尔电流传感器检测锂电池的电流；采用智能化温度传感器检测锂电池的温度，温度传感器具有测量精度高、转换时间快、方便测量等优点，例如美国 DALLAS 公司生产的单总线智能化温度传感器 DS18B20，可以采用本领域技术人员所熟知的开路电压法或者库伦计量法估算电池的荷电状态，其中，开路电压法对锂电池的荷电状态估算的精确度较低，库仑计量法对锂电池的荷电状态估算的精确度较高，用户可以根据其需求选择估算锂电池的荷电状态方法。

[0065] 计算单元 20 用于根据参数计算锂电池的充电电流，根据检测到的参数计算出，在对锂电池进行充电时，适合其的电流。

[0066] 控制单元 30 用于控制充电机按照充电电流对锂电池充电。

[0067] 在本发明实施例中，首先根据检测到的锂电池的参数计算出适合对锂电池充电的电流，进而控制充电机按照上述电流进行充电，也就是可以根据锂电池的状态参数，及时调整适合对其进行充电的电流，避免了不顾锂电池本身的性能情况，一直按照固定的预设电流对锂电池进行充电导致的过充电的问题，解决了现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，达到了提高锂电池使用寿命的效果。

[0068] 优选地，锂电池包括 n 个锂电池单体，测量单元 10 包括测量模块，用于检测锂电池单体 Li 的参数 Ci，i 依次取 1 至 n，即，检测每个锂电池单体的参数；计算单元 20 包括第一计算模块，用于根据参数 Ci 计算锂电池单体 Li 的充电电流 Ii，即，分别计算出每个锂电池单体的充电电流，控制单元 30 包括控制模块，用于控制充电机按照充电电流 Imin 对每个

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锂电池单体进行充电，其中，充电电流 Imin 为充电电流 I1 至充电电流 In 中最小的充电电流，即，在计算出每个锂电池单体的充电电流后，按照得出的充电电流中的最小值对 n 个锂电池单体进行充电。

[0069] 在本发明实施例中，根据每个锂电池单体的参数，分别计算出其相对应的充电电流，进而按照计算出的充电电流中的最小值对每个锂电池单体进行充电，考虑到了每个锂电池单体的情况，避免了充电电流高于充电电流中的最小值而超出锂电池单体的承受能力，导致锂电池整体损坏的问题。

[0070] 具体地，参数包括电流、电压、温度、荷电状态和电池容量，计算单元 20 包括第二计算模块、第三计算模块、第四计算模块和第五计算模块，其中：

[0071] 第二计算模块用于根据温度计算温度补偿系数 k_t，具体的可以按照如下公式计算温度补偿系数 k_t：

[0072]
$$k_t=\begin{cases}k_{t1}e^{k_t T} & -20^{\circ}C\le T<20^{\circ}C\\ 1 & 20^{\circ}C\le T<45^{\circ}C\\ (50-T)/5 & 45^{\circ}C\le T<50^{\circ}C\\ 0 & T<-20^{\circ}C\text{或}T>50^{\circ}C\end{cases}$$

[0073] 具体地，根据检测到的温度，按照对应的公式计算出温度补偿系统 k_t，其中，k_{t1}、k_t 为温度系数，可以通过查询锂电池的出厂参数获得。

[0074] 一般情况下，温度与电池的最大允许充电电流可分为 3 段：(1) 温度在 20℃～45℃，这是电池的最佳工作温度范围，电池的倍率特性好而且容量衰减较小；(2) 温度低于 20℃时，电池的内阻上升，电池的可接受充电电流降低；(3) 温度高于 45℃以后，虽然电池可接受的充电电流可能更大，但是电池的容量衰减大大加速，因此也不适合电池充电。因此，为了保证电池能够有较好的充电性能，可以对电池的工作温度进行调节控制，使其最好处于第一段温度范围内，也可以处于第二段温度范围内，但要尽量避免电池充电时的温度落入第三段温度范围内。如果电池的工作温度无法进行调节，此时在知道电池的工作温度的情况下，就可以依据电池的温度补偿系数 Kt 来对电池的充电电流进行调节，使电池的充电电流在电池允许的范围之内。

[0075] 第三计算模块根据荷电状态计算荷电状态补偿系数 k_{soc}，具体的可以按照如下公式计算荷电状态补偿系数 k_{soc}：

[0076]
$$k_{SOC}=\begin{cases}k_{SOC1}+\dfrac{(1-k_{SOC1})\times SOC}{10} & 0<SOC\le 10\%\\ 1 & 10\%<SOC\le 90\%\\ 9.1-0.09SOC & 90\%<SOC<100\%\\ 0.1 & SOC=100\%\end{cases}$$

[0077] 具体地，SOC 为荷电状态，可以反映电池剩余的电量，根据检测到的剩余电量按照相应的公式计算出荷电状态补偿系数 k_{soc}，k_{SOC1} 为 SOC = 0 时的补偿系数。由于电池充电过程充电效率 <1，所以电池的 SOC = 100% 时，电池可能尚未完全充满，为了更加充分地利用

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电池的容量，需要对电池进行补充充电，同时为了防止过充电，电池的充电电流限制到约最大充电电流的 1/10，这时停止充电的条件由锂电池的电压控制。

[0078] 第四计算模块用于根据修正系数 k_{SOH1} 和电流补偿系数 k_{SOH2} 计算电池健康系数 k_{SOH}，其中，修正系数 $k_{SOH1}=QQ_r^{-1}$，Q 为锂电池的电池容量，Q_r 为锂电池的额定容量，电流补偿系数 $k_{SOH2}=k\ R^{-1.5}$，k 为锂电池的特性系数，R 为锂电池的电阻。

[0079] 具体地，电池的 SOH 表示的是电池的健康状态，主要考虑电池的容量衰退和电池的内阻增加。对于容量衰退，可以采用容量修正系数 $k_{SOH1}=QQ_r^{-1}$ 来进行修正；内阻对电池的充电电流补偿系数为 $k_{SOH2}=k\ R^{-0.5}$，此时按照公式 $k_{SOH}=k_{SOH1}k_{SOH2}=kQQ_r^{-1}R^{-0.5}$ 就可以计算出锂电池的电池健康系数 k_{SOH}。

[0080] 第五计算模块用于根据温度补偿系数 k_t、荷电状态补偿系数 k_{SOC}、电池健康系数 k_{SOH}、锂电池的额定容量 Q_r 和锂电池的倍率系数 k_c 确定锂电池的充电电流，具体地，按照公式 $I=k_cQ_rk_tk_{SOC}k_{SOH}$ 计算锂电池的充电电流，锂电池的额定容量 Q_r 和锂电池的倍率系数 k_c 可以通过查询锂电池的出厂参数得知。

[0081] 当锂电池包括多个锂电池单体时，对于每个锂电池单体都重复执行第二计算模块至第五计算看计算其的充电电流，然后控制充电机按照最小的充电电流对每个锂电池单体进行充电。

[0082] 此外，本发明实施例还提供了一种锂电池充电控制系统，该锂电池充电控制系统包括锂电池以及本发明实施例上述内容所提供的任一种锂电池充电控制装置。

[0083] 根据本发明实施例，提供了一种电池管理系统，图 4 是根据本发明实施例的电池管理系统的示意图，如图 4 所示，本发明实施例中的电池管理系统包括锂电池、锂电池控制装置 100 和均衡装置 200，其中，锂电池包括多个锂电池单体；锂电池充电控制装置 100 为本发明实施例上述内容所提供的任一种锂电池充电控制装置，均衡装置 200 用于在锂电池充电控制装置的控制下均衡多个锂电池单体之间的电压。

[0084] 具体地，锂电池充电控制装置检测到参数后，会将参数中关于锂电池单体的电压相关数据传递给均衡装置，当均衡装置判断出任意两个锂电池单体之间的电压达到预设差值时，锂电池控制装置控制均衡装置可以通过本领域技术人员所熟知的电阻方案、开关电容方案或者独立充电方案中任意一种方案使电压较高的锂电池单体的电压与其它锂电池单体的电压差值在预设差值内。

[0085] 在本发明实施例中，通过设置均衡装置，改善了锂电池在在使用过程中电压的不一致性，达到了延长锂电池的寿命的效果。

[0086] 优选地，如图 5 所示，锂电池管理系统还包括温度管理装置 300，用于在锂电池充电控制装置 100 的控制下调控锂电池温度。

[0087] 电池性能发挥好坏与电池的温度密切相关：温度过高时，电池能量和容量可以充分利用，但是电池寿命会缩短；温度过低时，电池的内阻和极化电压增加，放电能力下降，使得电池的实际可用容量减小，能量利用效率下降。通常，锂电池工作温度范围为：充电时，-10 ～ 45℃。因此，根据检测到的锂电池参数对锂电池的温度进行调控，使锂电池在最佳温度范围内进行充电。锂电池充电控制装置 100 检测到锂电池的参数后，会将参数中关于锂电池单体的温度相关数据传递给温度管理装置 300，并控制温度管理装置 300 根据检

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测到的温度进行调节。具体调节方式为，温度管理装置可以连接外扩装置，外扩装置可以包括散热器和加热器，当检测到锂电池单体之间的整体温度较高时，可以通过散热器进行降温；当检测到锂电池单体之间的整体温度较低时，可以通过加热器进行升温。

[0088] 在本发明实施例中，通过设置温度管理装置，改善了锂电池在充电过程中温度的不一致性，达到了延长锂电池的寿命的效果。

[0089] 优选地，如图 5 所示，电池管理系统还包括保护装置 400，用于在锂电池充电控制装置的控制下控制充电机对锂电池充电。

[0090] 锂电池在充电时可能会出现过充或者温度过高等不正常状态，因此需要对其采取保护措施，防止出现异常状况损坏电池的问题，或者是其他安全性问题。锂电池充电控制装置 100 检测到锂电池的参数后，会将参数中关于锂电池单体的温度，电压和电流的相关数据传递给保护装置 400，并控制保护装置 400 根据检测到的温度、电压和电流控制充电机是否对锂电池进行充电。

[0091] 当检测到的温度、电压或者电流超过保护装置中设置的温度、电压或者电流相应的范围值时，锂电池充电控制装置中的控制模块会发送指令给保护装置，保护装置会根据控制模块发送的指令控制充电机是否停止对锂电池进行充电。

[0092] 在本发明实施例中，通过设置保护装置，在锂电池充电时出现的异常状况（如温度过高、电流过大等）的情况下，阻止充电机继续对锂电池进行充电，避免了锂电池损坏，达到了提高了锂电池安全性的效果。

[0093] 优选地，如图 5 所示，锂电池管理系统还包括通讯装置 500，与锂电池充电控制装置 100 连接，用于实现通讯装置与电池管理系统中其它装置之间的数据交互，具体可以采用 SMBUS 总线、CAN 总线、RS232 总线或者 RS485 总线在上述各个装置之间传递信息。

[0094] 从以上的描述中，可以看出，本发明解决了现有技术中锂电池容易因过充而导致缩短锂电池使用寿命的问题，达到了提高锂电池使用寿命的效果。

[0095] 上述本发明实施例序号仅仅为了描述，不代表实施例的优劣。

[0096] 在本发明的上述实施例中，对各个实施例的描述都各有侧重，某个实施例中没有详述的部分，可以参见其他实施例的相关描述。

[0097] 在本申请所提供的几个实施例中，应该理解到，所揭露的客户端，可通过其它的方式实现。其中，以上所描述的装置实施例仅仅是示意性的，例如所述单元的划分，仅仅为一种逻辑功能划分，实际实现时可以有另外的划分方式，例如多个单元或组件可以结合或者可以集成到另一个系统，或一些特征可以忽略，或不执行。另一点，所显示或讨论的相互之间的耦合或直接耦合或通信连接可以是通过一些接口，单元或模块的间接耦合或通信连接，可以是电性或其它的形式。

[0098] 所述作为分离部件说明的单元可以是或者也可以不是物理上分开的，作为单元显示的部件可以是或者也可以不是物理单元，即可以位于一个地方，或者也可以分布到多个网络单元上。可以根据实际的需要选择其中的部分或者全部单元来实现本实施例方案的目的。

[0099] 另外，在本发明各个实施例中的各功能单元可以集成在一个处理单元中，也可以是各个单元单独物理存在，也可以两个或两个以上单元集成在一个单元中。上述集成的单元既可以采用硬件的形式实现，也可以采用软件功能单元的形式实现。

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[0100] 所述集成的单元如果以软件功能单元的形式实现并作为独立的产品销售或使用时，可以存储在一个计算机可读取存储介质中。基于这样的理解，本发明的技术方案本质上或者说对现有技术做出贡献的部分或者该技术方案的全部或部分可以以软件产品的形式体现出来，该计算机软件产品存储在一个存储介质中，包括若干指令用以使得一台计算机设备（可为个人计算机、服务器或者网络设备等）执行本发明各个实施例所述方法的全部或部分步骤。而前述的存储介质包括：U 盘、只读存储器（ROM，Read-Only Memory）、随机存取存储器（RAM，Random Access Memory），移动硬盘、磁碟或者光盘等各种可以存储程序代码的介质。

[0101] 以上所述仅是本发明的优选实施方式，应当指出，对于本技术领域的普通技术人员来说，在不脱离本发明原理的前提下，还可以做出若干改进和润饰，这些改进和润饰也应视为本发明的保护范围。

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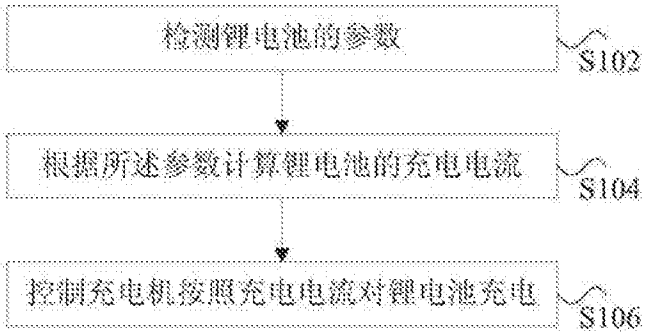


图 1

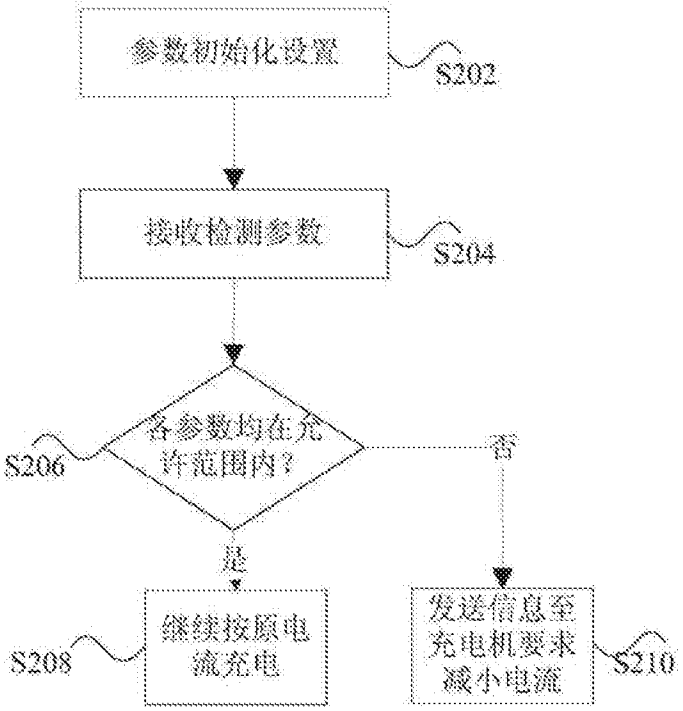


图 2

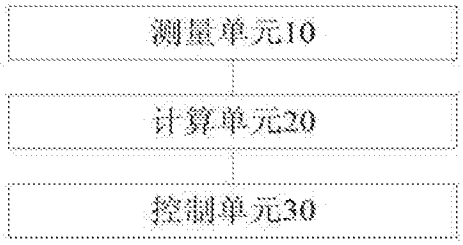


图 3

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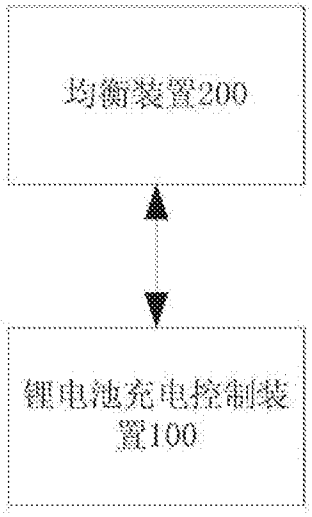


图 4

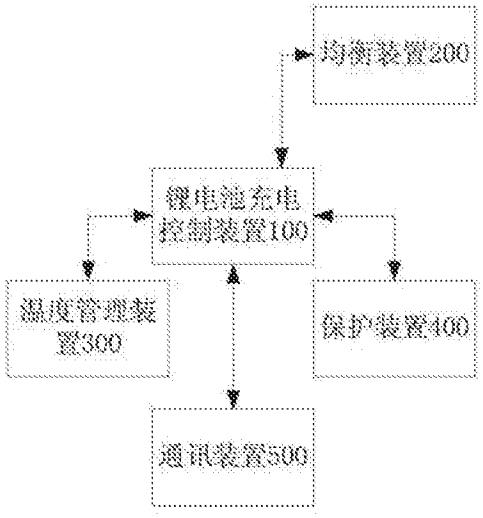


图 5

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Espacenet

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Oil injection correction method and system

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Application number: CN20131522631 20131029 Global Dossier

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Abstract of CN103527338 (A)

The invention provides an oil injection correction method and system. The method includes acquiring the voltage of a battery; determining power-up compensation factors according to acquired voltage of the battery; utilizing the power-up compensation factors to correct power-up time; controlling the oil injecting time of an oil injector according to the corrected power-up time to determine the power-up compensation factors by detecting the voltage of the battery; and utilizing the power-up compensation factors to correct the power-up time. Thus, oil injecting characteristic changes due to dropping of the solenoid drive current caused by motor damages can be compensated; according to the power-up time corrected by the method, oil injecting characteristics can be maintained constantly when the maintaining current drops.

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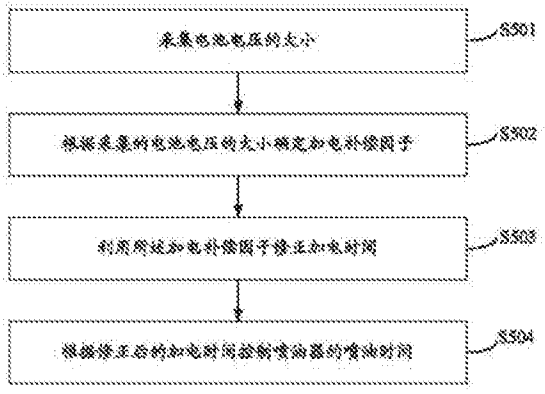
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(54)发明名称

一种喷油修正方法及系统

(57)摘要

本发明提供一种喷油修正方法及系统，方法包括：采集电池电压的大小；根据采集的电池电压的大小确定加电补偿因子；利用所述加电补偿因子修正加电时间；根据修正后的加电时间控制喷油器的喷油时间通过检测电池电压来确定加电补偿因子，利用加电补偿因子来修正加电时间，这样可以弥补电机损坏造成的电磁阀驱动电流下降引起的喷油特性变化。通过本发明提供的方法修正后的加电时间，可以使保持电流降低时，喷油特性保持不变。



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1. 一种喷油修正方法，其特征在于，包括以下步骤：

采集电池电压的大小；

根据采集的电池电压的大小确定加电补偿因子；

利用所述加电补偿因子修正加电时间；

根据修正后的加电时间控制喷油器的喷油时间。

2. 根据权利要求 1 所述的喷油修正方法，其特征在于，所述利用所述加电补偿因子修正加电时间，具体为：

将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

3. 根据权利要求 1 或 2 所述的喷油修正方法，其特征在于，所述根据所述采集的电池电压的大小确定加电补偿因子，具体为：

根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

4. 根据权利要求 1 所述的喷油修正方法，其特征在于，还包括：

检测环境温度，根据环境温度确定修正因子；

所述利用所述加电补偿因子修正加电时间具体为：将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

5. 根据权利要求 4 所述的喷油修正方法，其特征在于，所述根据环境温度确定修正因子，具体为：

根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

6. 一种喷油修正系统，其特征在于，包括：电池电压采集单元、加电补偿因子确定单元、修正单元和控制单元；

所述电池电压采集单元，用于采集电池电压的大小；

所述加电补偿因子确定单元，用于根据采集的电池电压的大小确定加电补偿因子；

所述修正单元，用于利用所述加电补偿因子修正加电时间；

所述控制单元，用于根据修正后的加电时间控制喷油器的喷油时间。

7. 根据权利要求 6 所述的喷油修正系统，其特征在于，所述修正单元包括：相加子单元；

所述相加子单元，用于将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

8. 根据权利要求 6 或 7 所述的喷油修正系统，其特征在于，所述加电补偿因子确定单元包括：加电补偿因子查找子单元；

所述加电补偿因子查找子单元，用于根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

9. 根据权利要求 6 所述的喷油修正系统，其特征在于，还包括：环境温度检测单元，用于检测环境温度，根据环境温度确定修正因子；

所述修正单元用于利用所述加电补偿因子修正加电时间，具体为：将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

10. 根据权利要求 9 所述的喷油修正系统，其特征在于，所述环境温度检测单元包括：修正因子确定子单元；

所述修正因子确定子单元，用于根据环境温度的大小通过查询环境温度与修正因子的

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曲线图确定修正因子。

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一种喷油修正方法及系统

技术领域

[0001] 本发明涉及柴油机喷油控制技术领域，特别涉及一种喷油修正方法及系统。

背景技术

[0002] 高压共轨电控系统喷油是通过对喷油器电磁阀精确控制，从而实现喷油压力、喷油速率和喷油量等参数的灵活调节，使柴油机在排放、油耗、噪声和动力性等方面得到改善。电磁阀作为燃油喷射的系统执行器，其驱动电压直接影响喷射系统以及整个发动机的性能。

[0003] 驱动电压来源于车上储能系统的电池电压，电池电压直接影响驱动电压，当电池电压较低时，驱动电压也较低。当驱动电压低时，驱动电流也随之降低，而驱动电流的降低会影响喷油特性的变化。

[0004] 因此，本领域技术人员需要解决电池电压变化对喷油特性的影响。

发明内容

[0005] 本发明要解决的技术问题是提供一种喷油修正方法及系统，能够弥补电机损坏造成的电磁阀驱动电流下降引起的喷油特性变化，保证喷油速率和喷油量正常。

[0006] 本发明实施例提供一种喷油修正方法，包括以下步骤：

[0007] 采集电池电压的大小；

[0008] 根据采集的电池电压的大小确定加电补偿因子；

[0009] 利用所述加电补偿因子修正加电时间；

[0010] 根据修正后的加电时间控制喷油器的喷油时间。

[0011] 优选地，所述利用所述加电补偿因子修正加电时间，具体为：

[0012] 将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

[0013] 优选地，所述根据所述采集的电池电压的大小确定加电补偿因子，具体为：

[0014] 根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

[0015] 优选地，还包括：

[0016] 检测环境温度，根据环境温度确定修正因子；

[0017] 所述利用所述加电补偿因子修正加电时间具体为：将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

[0018] 优选地，所述根据环境温度确定修正因子，具体为：

[0019] 根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

[0020] 本发明实施例还提供一种喷油修正系统，包括：电池电压采集单元、加电补偿因子确定单元、修正单元和控制单元；

[0021] 所述电池电压采集单元，用于采集电池电压的大小；

[0022] 所述加电补偿因子确定单元，用于根据采集的电池电压的大小确定加电补偿因

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子；

[0023] 所述修正单元，用于利用所述加电补偿因子修正加电时间；

[0024] 所述控制单元，用于根据修正后的加电时间控制喷油器的喷油时间。

[0025] 优选地，所述修正单元包括：相加子单元；

[0026] 所述相加子单元，用于将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

[0027] 优选地，所述加电补偿因子确定单元包括：加电补偿因子查找子单元；

[0028] 所述加电补偿因子查找子单元，用于根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

[0029] 优选地，还包括：环境温度检测单元，用于检测环境温度，根据环境温度确定修正因子；

[0030] 所述修正单元用于利用所述加电补偿因子修正加电时间，具体为：将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

[0031] 优选地，所述环境温度检测单元包括：修正因子确定子单元；

[0032] 所述修正因子确定子单元，用于根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

[0033] 与现有技术相比，本发明具有以下优点：

[0034] 通过检测电池电压来确定加电补偿因子，利用加电补偿因子来修正加电时间。这样可以弥补电机损坏造成的电磁阀驱动电流下降引起的喷油特性变化。通过本发明提供的方法修正后的加电时间，可以使保持电流降低时，喷油特性保持不变。

附图说明

[0035] 为了更清楚地说明本发明实施例或现有技术中的技术方案，下面将对实施例或现有技术描述中所需要使用的附图作简单地介绍，显而易见地，下面描述中的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。

[0036] 图 1 是电磁阀驱动电流与喷油时间的对应关系图；

[0037] 图 2 是喷油速率曲线图；

[0038] 图 3 是电池电压对应的驱动电流示意图；

[0039] 图 4 是电池电压对应的喷油速率示意图；

[0040] 图 5 是本发明提供的喷油修正方法实施例一流程图；

[0041] 图 6 是本发明提供的喷油修正方法实施例二流程图；

[0042] 图 7 是本发明提供的喷油修正方法实施例三流程图；

[0043] 图 8 是本发明提供的喷油修正系统实施例一示意图；

[0044] 图 9 是本发明提供的喷油修正系统实施例二示意图；

[0045] 图 10 是本发明提供的喷油修正系统实施例三示意图。

具体实施方式

[0046] 首先，为了使本领域技术人员能够更好地理解和实施本发明提供的技术方案，下

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面首先结合几个附图介绍柴油机发动机的喷油特性。

[0047] 参见图 1，该图为电磁阀驱动电流与喷油时间的对应关系图。

[0048] 从图 1 中可以看出，纵坐标是电磁阀的驱动电流，横坐标是喷油器的喷油时间。

[0049] 图 1 中 A 点是喷油器驱动电流开启时刻，B 点是驱动电流达到峰值时刻，BC 段为停顿周期，CD 段为驱动电流保持阶段，相应地，将 CD 段对应的驱动电流称为保持电流。

[0050] 参见图 2，该图为喷油速率曲线图。

[0051] 喷油速率是指：高压燃油从喷油器到汽缸时的流量。

[0052] 从图 2 中可以看出，随着喷油时间的递增，喷油速率有一段时间内基本是保持不变的。

[0053] 参见图 3，该图为电池电压对应的驱动电流示意图。

[0054] 图 3 中与图 1 中相同的是：纵坐标是电磁阀的驱动电流，横坐标是喷油器的喷油时间。

[0055] 从图 3 中可以看出，随着电池电压的变化（例如，从 36V 降低到 9V），对应的保持电流也在逐渐降低。此时，喷油器的驱动电流开启时刻、达到峰值的时刻以及停顿的周期相同。但是，喷油速率曲线并不像传统中所认为的那样喷油速率下降的时刻相同。而是随着电池电压从 36V 减小到 9V，保持电流下降，喷油速率降低的时刻不断提前。如图 4 所示。

[0056] 参见图 4，该图为电池电压对应的喷油速率示意图。

[0057] 对图 4 中喷油速率曲线进行分段积分，通过喷油速率计算局部喷油量，不同保持电流时总喷油量和局部喷油量的趋势与降幅完全一致，这样充分说明喷油量的差异主要是由于喷油速率降低时刻不同导致的。

[0058] 因此，本发明正是基于这样的原理，对电池电压造成的喷油速率降低所引起的喷油量不同进行了修正。

[0059] 下面将结合本发明实施例中的附图，对本发明实施例中的技术方案进行清楚、完整地描述，显然，所描述的实施例仅仅是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有做出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

[0060] 为使本发明的上述目的、特征和优点能够更加明显易懂，下面结合附图对本发明的具体实施方式做详细的说明。

[0061] 方法实施例一：

[0062] 参见图 5，该图为本发明提供的喷油修正方法实施例一流程图。

[0063] 本发明实施例提供的喷油修正方法，包括以下步骤：

[0064] S501：采集电池电压的大小；

[0065] 需要说明的是，车上都有储能系统，通过储能系统的管理系统可以获得储能系统的电池电压。

[0066] 由于电池电压直接会影响保持电流的大小，因此检测电池电压，根据电池电压的大小来对喷油时间进行修正。

[0067] S502：根据采集的电池电压的大小确定加电补偿因子；

[0068] 电池电压的大小不同，对应的加电补偿因子也不相同。

[0069] S503：利用所述加电补偿因子修正加电时间；

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[0070] 需要说明的是，加电补偿因子是一个时间值，用来修正加电时间。例如，检测的电池电压为 9V 时，对应的加电补偿因子为 50ms。

[0071] S504：根据修正后的加电时间控制喷油器的喷油时间。

[0072] 本发明实施例提供的喷油修正方法，通过检测电池电压来确定加电补偿因子，利用加电补偿因子来修正加电时间。这样弥补了因为电机损坏造成的电磁阀驱动电流下降引起的喷油特性变化。通过本发明提供的方法修正后的加电时间，可以使保持电流降低时，喷油特性保持不变。

[0073] 方法实施例二：

[0074] 参见图 6，该图为本发明提供的喷油修正方法实施例二流程图。

[0075] 本实施例提供的喷油修正方法，S601 与 S501 相同，在此不再赘述。

[0076] S602：根据所述采集的电池电压的大小确定加电补偿因子，具体为：

[0077] 根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

[0078] 需要说明的是，电池电压与加电补偿因子的曲线图是预先根据试验获得的经验值，不同的电池电压对应不同的加电补偿因子。

[0079] 实际操作过程中，可以将该曲线图对应的数据表存储在系统中，通过查表的形式查询电池电压对应的加电补偿因子。

[0080] S603：所述利用所述加电补偿因子修正加电时间，具体为：将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

[0081] 例如，将电池电压降低以后，通过加电补偿因子使得修正后的加电时间比当前加电时间长。即加电时间延长。

[0082] S604 和 S504 相同，在此不再赘述。

[0083] 方法实施例三：

[0084] 参见图 7，该图为本发明提供的喷油修正方法实施例三流程图。

[0085] 方法实施例一和方法实施例二均是以电池电压一个参数为依据来修正加电时间，本实施例中以电池电压和环境温度两个参数为依据来修正加电时间。

[0086] S701：采集电池电压的大小；根据采集的电池电压的大小确定加电补偿因子；

[0087] 需要说明的是，电池电压与加电补偿因子的曲线图是预先根据试验获得的经验值，不同的电池电压对应不同的加电补偿因子。

[0088] 实际操作过程中，可以将该曲线图对应的数据表存储在系统中，通过查表的形式查询电池电压对应的加电补偿因子。

[0089] S702：检测环境温度，根据环境温度确定修正因子；

[0090] 需要说明的是，具体实施过程中，可以用车上的水温来代表环境温度。环境温度对喷油速率的影响比电池电压对喷油速率的影响要小。

[0091] 所述根据环境温度确定修正因子，具体为：

[0092] 根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

[0093] 可以理解的是，环境温度与修正因子的关系也是根据试验获得的经验值，不同的环境温度对应不同的修正因子。

[0094] 修正因子与加电补偿因子不同的是，修正因子仅是一个系数，没有单位，例如修正

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因子的取值范围为 0.9-1.1；而加电补偿因子是一个时间值，例如当检测的电池电压为 9V 时，对应的加电补偿因子为 50ms。

[0095] S703，将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

[0096] 本实施例中，既对电池电压带来的影响进行修正，又对环境温度带来的影响进行修正。例如，加电补偿因子为 50ms，修正因子为 0.9，则两者的成绩为 50ms*0.9=45ms。则修正的加电时间为 45ms，修正后的加电时间便是当前加电时间与 45ms 之和。

[0097] S704，根据修正后的加电时间控制喷油器的喷油时间。

[0098] 本实施例提供的方法，弥补了因为电池电压较低或者外界环境较低造成的驱动电流不足引起的喷油时间变化，通过本发明的修正使得喷油速率和喷油量正常，进而不会影响喷射系统以及整个发动机的性能。

[0099] 基于以上实施例提供的喷油修正方法，本发明实施例还提供一种喷油修正系统，下面结合具体实施例来详细介绍其工作原理。

[0100] 系统实施例一：

[0101] 参见图 8，该图为本发明提供的喷油修正系统实施例一示意图。

[0102] 本实施例提供的喷油修正系统，包括：电池电压采集单元 801、加电补偿因子确定单元 802、修正单元 803 和控制单元 804；

[0103] 所述电池电压采集单元 801，用于采集电池电压的大小；

[0104] 需要说明的是，车上都有储能系统，通过储能系统的管理系统可以获得储能系统的电池电压。

[0105] 由于电池电压直接会影响保持电流的大小，因此检测电池电压，根据电池电压的大小来对喷油时间进行修正。

[0106] 所述加电补偿因子确定单元 802，用于根据采集的电池电压的大小确定加电补偿因子；

[0107] 电池电压的大小不同，对应的加电补偿因子也不相同。

[0108] 所述修正单元 803，用于利用所述加电补偿因子修正加电时间；

[0109] 需要说明的是，加电补偿因子是一个时间值，用来修正加电时间。例如，检测的电池电压为 9V 时，对应的加电补偿因子为 50ms。

[0110] 所述控制单元 804，用于根据修正后的加电时间控制喷油器的喷油时间。

[0111] 本发明实施例提供的喷油修正系统，通过检测电池电压来确定加电补偿因子，利用加电补偿因子来修正加电时间。这样弥补了因为电机损坏造成的电磁阀驱动电流下降引起的喷油特性变化。通过本发明提供的系统修正后的加电时间，可以使保持电流降低时，喷油特性保持不变。

[0112] 系统实施例二：

[0113] 参见图 9，该图为本发明提供的喷油修正系统实施例二示意图。

[0114] 本实施例提供的喷油修正系统中：

[0115] 所述修正单元 803 包括：相加子单元 803a；

[0116] 所述相加子单元 803a，用于将加电补偿因子与当前加电时间相加后作为修正后的加电时间。

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[0117] 需要说明的是，电池电压与加电补偿因子的曲线图是预先根据试验获得的经验值，不同的电池电压对应不同的加电补偿因子。

[0118] 实际操作过程中，可以将该曲线图对应的数据表存储在系统中，通过查表的形式查询电池电压对应的加电补偿因子。

[0119] 所述加电补偿因子确定单元 802 包括：加电补偿因子查找子单元 802a；

[0120] 所述加电补偿因子查找子单元 802a，用于根据电池电压的大小通过查询电池电压与加电补偿因子的曲线图确定加电补偿因子。

[0121] 例如，将电池电压降低以后，通过加电补偿因子使得修正后的加电时间比当前加电时间长。即加电时间延长。

[0122] 系统实施例三：

[0123] 参见图 10，该图为本发明提供的喷油修正系统实施例三示意图。

[0124] 系统实施例一和系统实施例二均是以电池电压一个参数为依据来修正加电时间，本实施例中以电池电压和环境温度两个参数为依据来修正加电时间。

[0125] 本实施例提供的喷油修正系统，还包括：环境温度检测单元 805，用于检测环境温度，根据环境温度确定修正因子；

[0126] 需要说明的是，具体实施过程中，可以用车上的水温来代表环境温度。环境温度对喷油速率的影响比电池电压对喷油速率的影响要小。

[0127] 所述根据环境温度确定修正因子，具体为：

[0128] 根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

[0129] 可以理解的是，环境温度与修正因子的关系也是根据试验获得的经验值，不同的环境温度对应不同的修正因子。

[0130] 修正因子与加电补偿因子不同的是，修正因子仅是一个系数，没有单位，例如修正因子的取值范围为 0.9-1.1；而加电补偿因子是一个时间值，例如当检测的电池电压为 9V 时，对应的加电补偿因子为 50ms。

[0131] 所述修正单元 803 用于利用所述加电补偿因子修正加电时间，具体为：将所述修正因子与所述加电补偿因子相乘，将乘积与当前加电时间相加后作为修正后的加电时间。

[0132] 本实施例中，既对电池电压带来的影响进行修正，又对环境温度带来的影响进行修正。例如，加电补偿因子为 50ms，修正因子为 0.9，则两者的成绩为 50ms*0.9=45ms。则修正的加电时间为 45ms，修正后的加电时间便是当前加电时间与 45ms 之和。

[0133] 所述环境温度检测单元 805 包括：修正因子确定子单元 805a；

[0134] 所述修正因子确定子单元 805a，用于根据环境温度的大小通过查询环境温度与修正因子的曲线图确定修正因子。

[0135] 本实施例提供的方法，弥补了因为电池电压较低或者外界环境较低造成的驱动电流不足引起的喷油时间变化，通过本发明的修正使得喷油速率和喷油量正常，进而不会影响喷射系统以及整个发动机的性能。

[0136] 以上所述，仅是本发明的较佳实施例而已，并非对本发明作任何形式上的限制。虽然本发明已以较佳实施例揭露如上，然而并非用以限定本发明。任何熟悉本领域的技术人员，在不脱离本发明技术方案范围情况下，都可利用上述揭示的方法和技术内容对本发明技术方案做出许多可能的变动和修饰，或修改为等同变化的等效实施例。因此，凡是未脱离

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本发明技术方案的内容，依据本发明的技术实质对以上实施例所做的任何简单修改、等同变化及修饰，均仍属于本发明技术方案保护的范围内。

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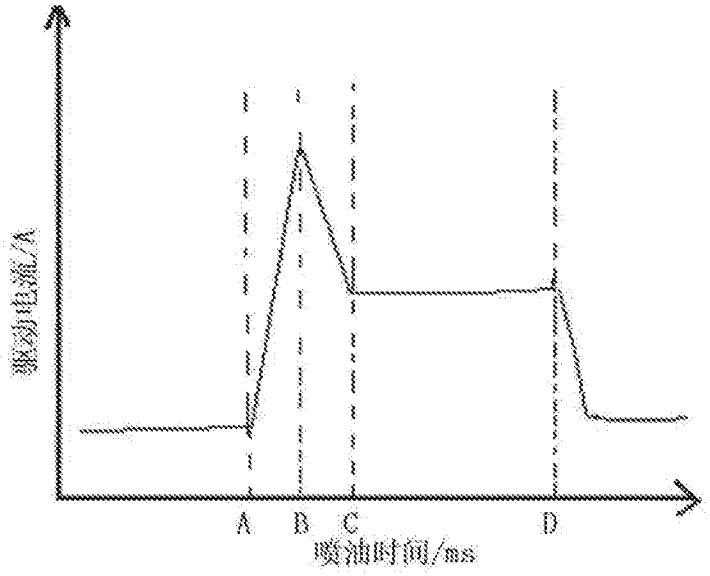


图 1

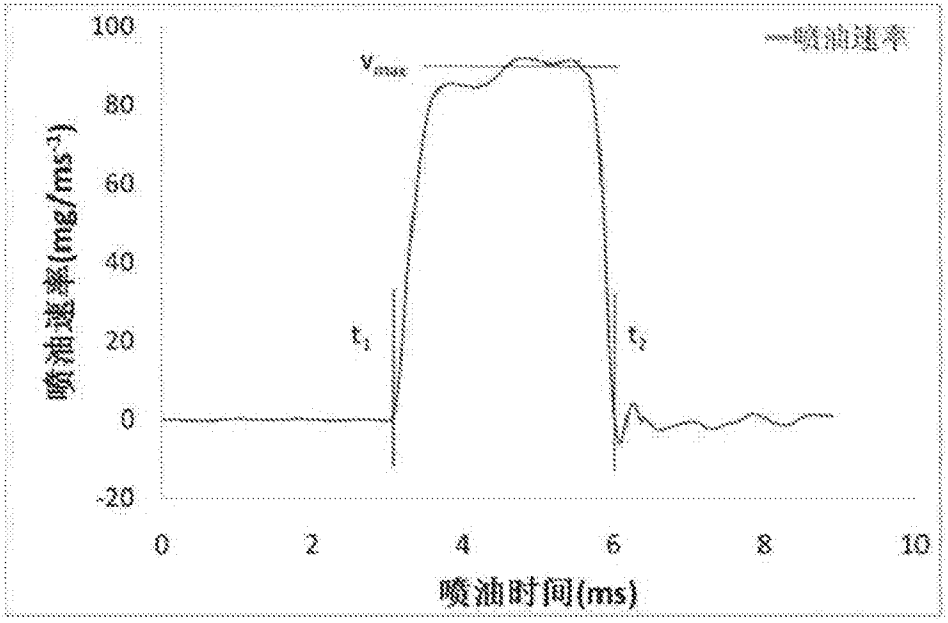


图 2

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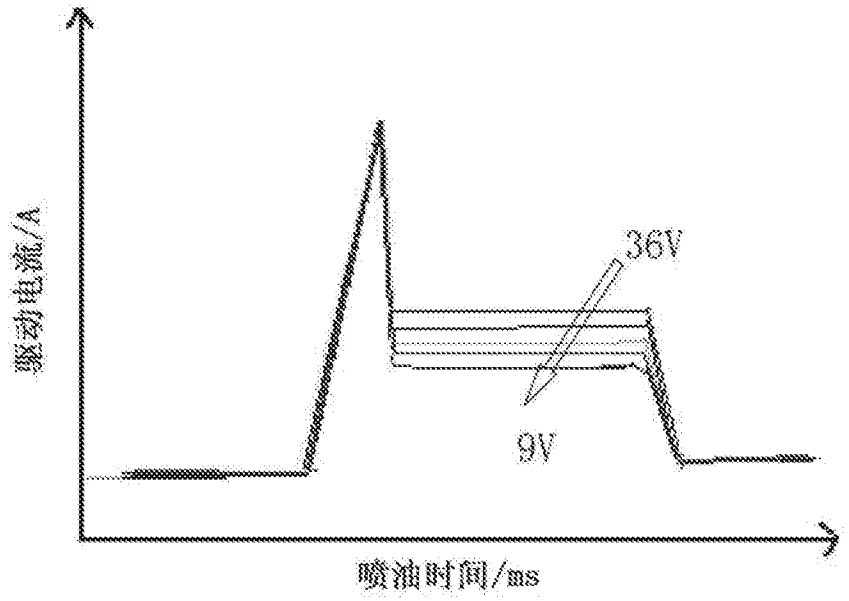


图 3

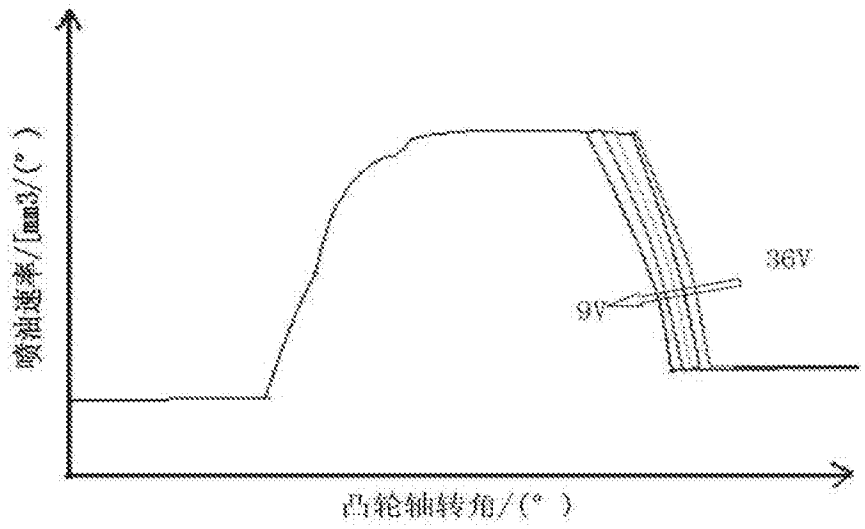


图 4

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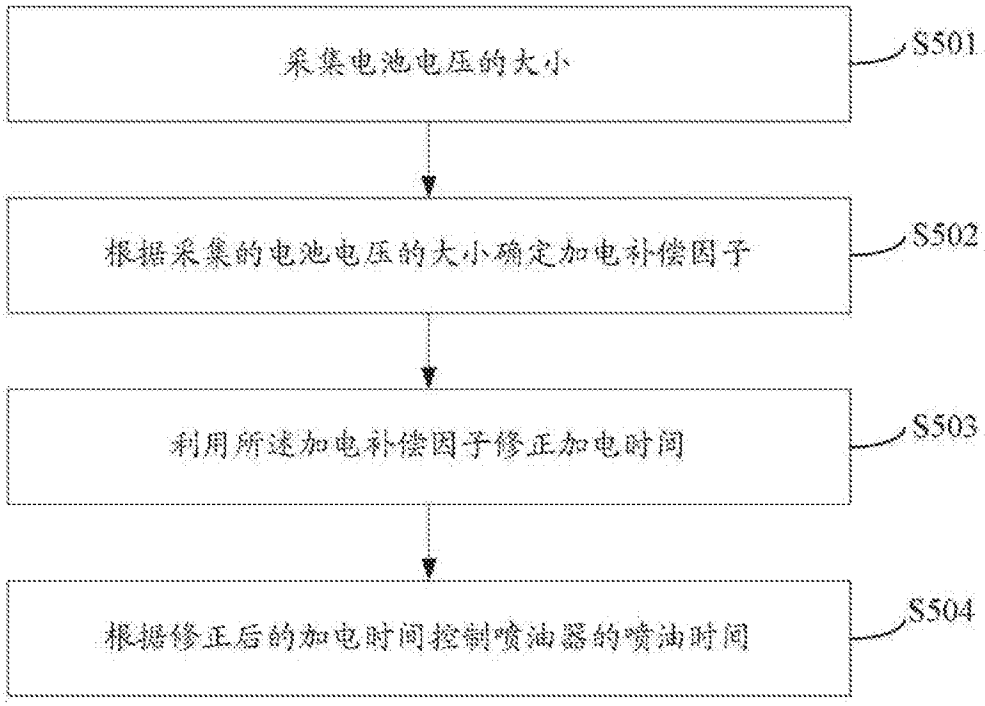


图 5

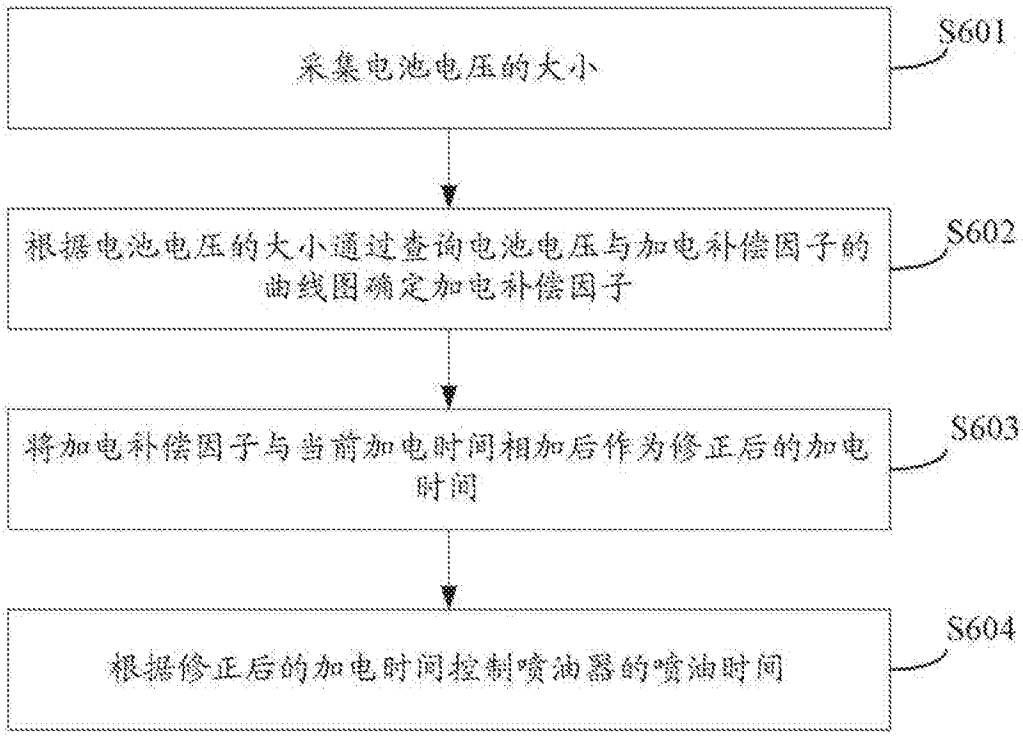


图 6

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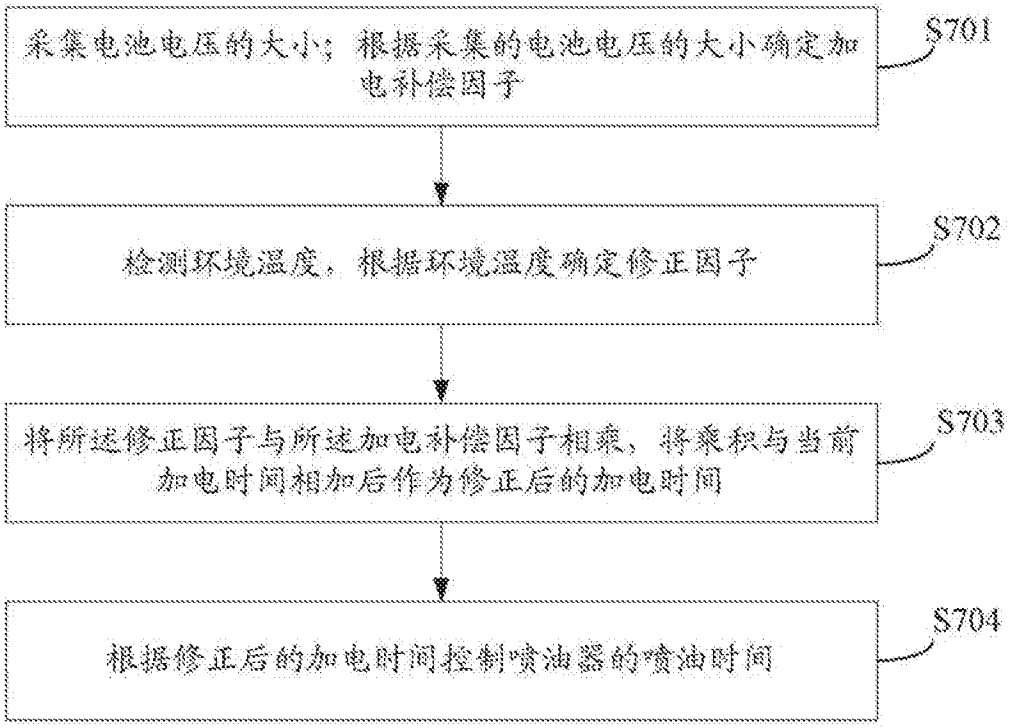


图 7

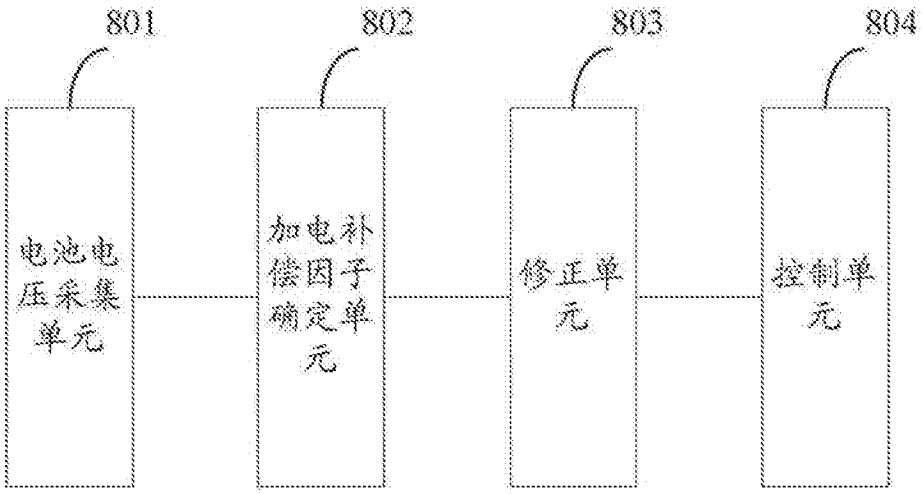


图 8

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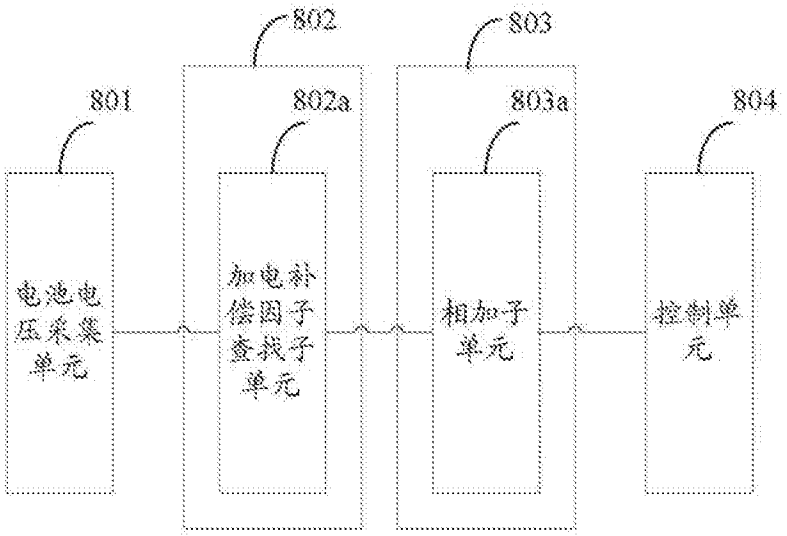


图 9

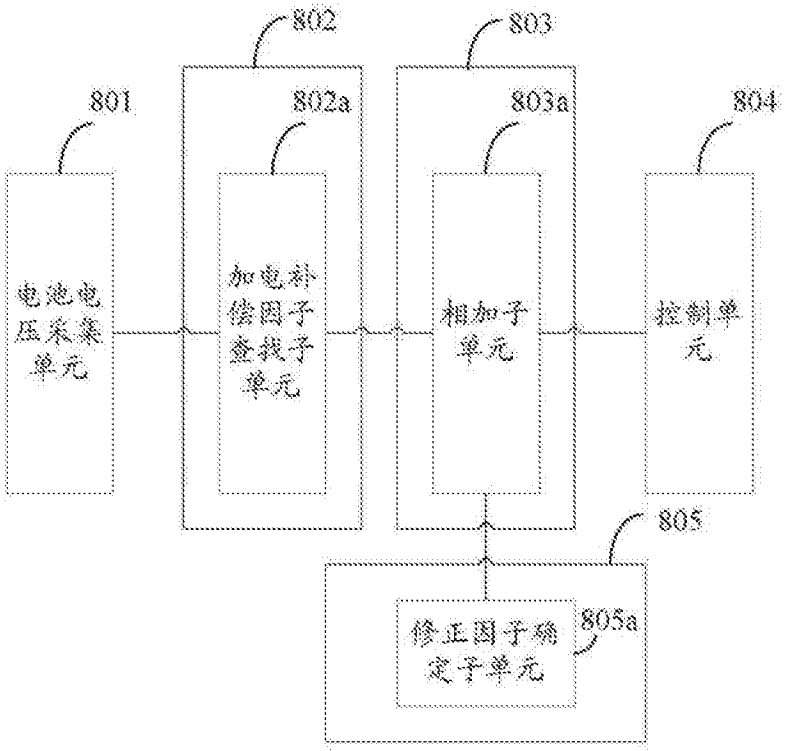


图 10

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Espacenet

Bibliographic data: CN102522796 (A) — 2012-06-27

Method for stably giving power to power battery system

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Classification: **- international:** ***G05F1/66; H02J7/00***
- cooperative:

Application number: CN20111440921 20111226 Global Dossier

Priority number(s): CN20111440921 20111226

Also published as: CN102522796 (B)

Abstract of CN102522796 (A)

Provided is a method for stably giving power to a power battery system. The power battery system comprises a single battery body. The steps for stably giving power include a battery management system collects residual capacity state of charge (SOC) and work temperature data of the system at real time to obtain P0; the battery management system collects a voltage value of the single battery body at real time and compares the voltage value with a voltage maximum value (Vmax) and a voltage minimum value (Vmin) of the rated voltage of the single battery body to obtain comparative data of differential voltage (Vdiff); the battery management system enables the data obtained in the step A and the step B to be processed through a proportional-integral (PI) regulator to obtain a correction factor alpha of the P0; the battery management system obtains an actual power given value Pset of the system according to the correction factor alpha obtained in the step C and a power MAP; and the Pset is supplied to a vehicle control unit through a CAN bus, the vehicle control unit makes a response, voltage changes of the single battery body in the system are influenced, the PI regulator enters the next closed loop regulation, and stable power giving of the power battery system is achieved.

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权利要求书 1 页 说明书 2 页

(54)发明名称

一种动力电池系统功率稳定给定方法

(57)摘要

一种动力电池系统功率稳定给定方法，所述的电池系统包括单体电池，其功率稳定给定的步骤为，A、电池管理系统实时采集系统的剩余电量SOC和工作温度数据，得P_0；B、系统实时采集单体电池电压值，并同单体电池的额定电压上下值Vmax、Vmin作比较，得比较数据Vdiff；C、电池管理系统将A、B步骤的数据通过比例积分PI调节器，得出P_0的修正系数α；D、电池管理系统根据步骤C的α修正系数和功率对照表MAP，得出系统的实际功率给定值Pset；E、将Pset通过CAN总线提供给整车控制器，整车控制器做出响应，又影响系统中的电池单体的电压变化，PI调节器又进入下一个闭环调节，达到动力电池系统功率平稳给定。

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1. 一种动力电池系统功率稳定给定方法，所述的电池系统包括单体电池，其特征在于：功率稳定给定的步骤为，

A、电池管理系统实时采集系统的剩余电量 SOC 和工作温度数据，根据电池的功率对照表 MAP，得出当前系统的电池功率值 P_0；

B、电池管理系统实时采集单体电池的电压信息值，并同单体电池的额定电压上下值 Vmax、Vmin 作比较，得比较数据 Vdiff；

C、电池管理系统将 A、B 步骤的数据通过比例积分 PI 调节器，得出 P_0 的修正系数 α；

D、电池管理系统根据步骤 C 的 α 修正系数和功率对照表 MAP，得出系统的实际功率给定值 Pset；

E、将 Pset 通过 CAN 总线提供给整车控制器，整车控制器做出响应，又影响系统中的电池单体的电压变化，PI 调节器又进入下一个闭环调节。

2. 根据权利要求要求 1 所述的动力电池系统功率稳定给定方法，其特征在于，所述步骤 A 的电池功率值 P_0 是由下述方程所得：

P_0=MAP（SOC，T），式中 SOC 表示系统的剩余电量，T 是系统的工作温度；

所述步骤 C 的修正系数 α 是由下述方程所得：

$$\alpha = K_p * Vdiff + \frac{1}{T} * \int Vdiff\, dt$$

所述 K_p 是 PI 环节中的比例调节系数，其中 T 是积分环节的时间常数；

所述步骤 D 的实际功率给定值是由下述方程所得：

Pset=P_0*α，中，P_0 是电池功率值，α 是修正系数。

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一种动力电池系统功率稳定给定方法

技术领域

[0001] 本发明涉及电池技术领域，尤其涉及应用在电动汽车领域的动力电池系统功率稳定给定方法。

背景技术

[0002] 电动汽车是未来汽车发展的里程碑式的方向，它在目前的发展阶段仍处于初级阶段。在整车实际应用中，整车更希望得到的是动力电池系统当前能够输出的功率大小，并以此对整车的功率需求和功率输出进行合理分配和调节。而目前的动力电池在成组方面的应用缺乏对电池功率特性的关注，把动力电池的应用主要集中在成组电池系统的状态监控和SOC估算，而对于整车系统本质需求的考虑并不完全，并不能很好解决整车动力电池的功率输出特性的需求。

发明内容

[0003] 本发明要解决的技术问题是提供一种对动力电池的功率输出进行预估和平稳实时调节的动力电池系统功率稳定给定方法。

[0004] 本发明要解决的技术问题是通过以下技术方案实现的：一种动力电池系统功率稳定给定方法，所述的电池系统包括单体电池，功率稳定给定的步骤为，A、电池管理系统实时采集系统的剩余电量SOC和工作温度数据，根据电池的功率对照表MAP，得出当前系统的电池功率值P_0；B、电池管理系统实时采集单体电池的电压信息值，并同单体电池的额定电压上下值Vmax，Vmin作比较，得比较数据Vdiff；C、电池管理系统将A，B步骤的数据通过比例积分PI调节器，得出P_0的修正系数α；D、电池管理系统根据步骤C的α修正系数和功率对照表MAP，得出系统的实际功率给定值Pset；E、将Pset通过CAN总线提供给整车控制器，整车控制器做出响应，又影响系统中的电池单体的电压变化，PI调节器又进入下一个闭环调节。

[0005] 进一步：在上述动力电池系统功率稳定给定方法中，所述步骤A的电池功率值P_0是由下述方程所得：P_0=MAP（SOC，T），式中SOC表示系统的剩余电量，T是系统的工作温度；所述步骤C的修正系数α是由下述方程所得：

$$\alpha = K_p * Vdiff + \frac{1}{T} * \int Vdiff\,dt$$

所述K_p是PI环节中的比例调节系数，其中T是积分环节的时间常数；

所述步骤D的实际功率给定值是由下述方程所得：

Pset=P_0*α，中，P_0是电池功率值，α是修正系数。

[0006] 与现有的技术相比，借助剩余电量SOC估算和电池温度测量进行功率预估，同时需要根据动力电池的单体电压的变化情况对输出功率进行调整，修正因剩余电量SOC估算误差和温度测量误差带来的功率预估偏差，并对输出功率给定进行PI调节，完成快速而又

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平滑的功率控制算法。目前的功率控制表直接得到电池的当前输出功率，这是可以直接从电池的外特性进行获取的。如果直接把这个功率值提供整车，存在两个问题：1、功率值会突变，导致车身动力不稳定。2、外特性中的剩余电量 SOC 和温度存在误差，得到的功率输出势必存在误差。通过功率调节器的作用就是根据单体电池的电压变化特性对 MAP 表输出给定的功率进行平滑和限制，不让单体电压超限。

具体实施方式

[0007] 为了便于本领域技术人员的理解，下面将结合具体实施方式对本发明原理作进一步详细描述。

[0008] 一种动力电池系统功率稳定给定方法，所述的电池系统包括单体电池，功率稳定给定的步骤为，A、电池管理系统实时采集系统的剩余电量 SOC 和工作温度数据，根据电池的功率对照表 MAP，得出当前系统的电池功率值 P_0；B、电池管理系统实时采集单体电池的电压信息值，并同单体电池的额定电压上下值 Vmax、Vmin 作比较，得比较数据 Vdiff；C、电池管理系统将 A、B 步骤的数据通过比例积分 PI 调节器，得出 P_0 的修正系数 α；D、电池管理系统根据步骤 C 的 α 修正系数和功率对照表 MAP，得出系统的实际功率给定值 Pset；E、将 Pset 通过 CAN 总线提供给整车控制器，整车控制器做出响应，又影响系统中的电池单体的电压变化，PI 调节器又进入下一个闭环调节。所述步骤 A 的电池功率值 P_0 是由下述方程所得：

P_0=MAP（SOC，T），式中 SOC 表示系统的剩余电量，T 是系统的工作温度；所述步骤 C 的修正系数 α 是由下述方程所得：

$$\alpha = K_p * Vdiff + \frac{1}{T} * \int Vdiff\, dt$$

所述 K_p 是 PI 环节中的比例调节系数，其中 T 是积分环节的时间常数；

所述步骤 D 的实际功率给定值是由下述方程所得：

Pset=P_0*α，中，P_0 是电池功率值，α 是修正系数。

[0009] 通过功率调节器的作用就是根据单体电池的电压变化特性对 MAP 表输出给定的功率进行平滑和限制，不让单体电压超限，达到动力电池系统功率平稳给定。

[0010] 上述仅为本发明较佳的实施方式，除此之外，本发明还可以有其他实现方式。也就是说，在没有脱离本发明构思的前提下，任何显而易见的替换均应落入本发明的保护范围之内。

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Vehicle power management system

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The invention relates to an automobile power supply management system. Firstly, by monitoring the state of the storage battery, the application state of an electrical apparatus used in an entire automobile is controlled, simultaneously the generation power and the output power of a generator is controlled, and the state information of the storage battery is provided to a driver, thereofore maximally optimizing the electric balance of the entire automobile; besides, the static current of the entire automobile is controlled, and the consumption of the electric quantity of the storage battery caused by the static current is reduced, ensuring the time for normally starting after the automobile stops, as well as optimizing the charging and discharging state of the storage battery and prolonging the service life of the storage battery.

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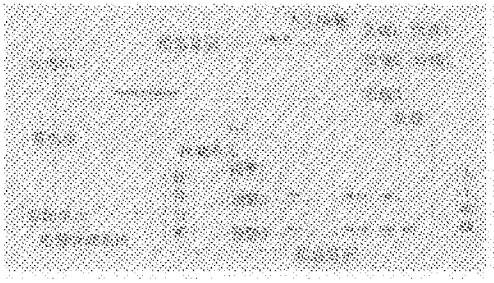
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[54] 发明名称

汽车电源管理系统

[57] 摘要

本发明涉及一种汽车电源管理系统，首先，通过监测蓄电池的状态，控制整车用电器的适用状态，同时控制发电机的发电功率以及输出电压，并向驾驶员提供蓄电池的状态信息，最大程度的优化整车的电平衡；其次，控制整车静态电流，降低静态电流对于蓄电池电量的损耗，保证车辆停放后可正常起动的时间；另外，优化蓄电池的充放电状态，延长蓄电池的使用寿命。



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1、一种电源管理系统，包括监测单元和控制单元，监测单元用来监测蓄电池的参数，并进行简单分析；控制单元包括分析单元和处理单元，分析单元接收监测单元监测到的参数信息，进行分析判断，处理单元接收分析单元的指令，发出相应的处理信息。

2、根据权利要求 1 的电源管理系统，其特征在于：监测的蓄电池参数包括端电压 U、蓄电池的充放电电流 I 以及蓄电池的表面温度 t。

3、根据权利要求 1 或 2 的电源管理系统，其特征在于：处理单元进行预警处理、静态电流管理以及蓄电池充放电管理。

4、根据权利要求 3 的电源管理系统，其特征在于：预警处理包括多级预警，每一级预警对应于蓄电池荷电状态的一个预警状态。

5、根据权利要求 4 的电源管理系统，其特征在于：当分析单元判断出蓄电池的荷电状态达到第一级预警时，将分别向用电系统和发电机发出第一指令，要求优先级较低的第一负载被屏蔽，增加发电机的发电功率并调节输出电压，同时给驾驶人员发出第一警告，此时，驾驶人员可以通过人工唤醒功能将被屏蔽的负载唤醒，恢复被屏蔽负载的正常使用，通过电源管理系统的调节，当蓄电池的荷电状态得到缓解，通过检测得出的数据分析得出蓄电池已经达到退出第一级预警的条件时，电源管理系统将自动解除第一指令，退出第一级预警状态。

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6、根据权利要求 5 的电源管理系统，其特征在于：所述分析处理过程依优先级可重复多次。

7、根据权利要求 6 的电源管理系统，其特征在于：当分析单元判断出蓄电池的荷电状态达到最高级预警时，除了安全驾驶所必需的负载外，其他负载全部屏蔽，并要求增加发电机的发电功率和调节发电机的输出电压，补偿蓄电池的电量；在最高级预警状态，驾驶人员无法唤醒被屏蔽的负载，随着蓄电池荷电状态的好转，当达到退出最高级预警条件后，系统将自动退出最高级预警，进入次高级预警。

8、根据权利要求 3 的电源管理系统，其特征在于：静态电流管理包括熄火未防盗电流管理和停车防盗电流管理。

9、根据权利要求 8 的电源管理系统，其特征在于：当车辆处于熄火但防盗系统未启动状态时，监测蓄电池的状态，并根据监测的蓄电池的参数分析蓄电池的荷电状态和健康状态，向负载发出指令，控制负载的通断。

10、根据权利要求 9 的电源管理系统，其特征在于：当蓄电池的电量不足或者即将不足时，发出屏蔽负载的指令，使车辆进入电源保护模式。

11、根据权利要求 8 的电源管理系统，其特征在于：当电源管理系统通过对蓄电池的监测，以及对防盗指令的判断，分析判断出

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车辆处于停车防盗状态时，在最短的时间内屏蔽或者断开与防盗以及安全无关的所有负载。

12、根据权利要求 3 的电源管理系统，其特征在于：蓄电池充放电管理需要适时监测蓄电池的相关参数，并分析蓄电池的状态。

13、根据权利要求 12 的电源管理系统，其特征在于：电源管理系统根据蓄电池的状态，采取对负载和发电机发电功率的管理，优化蓄电池的充放电状态。

14、根据权利要求 12 的电源管理系统，其特征在于：电源管理系统根据监测的蓄电池参数，计算蓄电池的健康状态 SOH。

15、根据权利要求 14 的电源管理系统，其特征在于：电源管理系统根据健康状态 SOH 与预设的预警值比较，当健康状态 SOH 达到预警值时，发出预警。

汽车电源管理系统

技术领域

本发明涉及一种电源管理系统，特别是一种汽车的电源管理系统。

背景技术

目前，汽车电子技术已发展到控制系统综合化和信息共享化的新阶段。电器零部件及控制单元的大量增加，使得整车的负载功率也随之上升，加大了对电能的需求；如果不能很好的管理和控制电能的使用，可能会因为发电机供电不足，导致蓄电池对外供电，若蓄电池放电时间过长，则会使蓄电池电量不足，影响车辆的正常起动和安全行使，甚至影响蓄电池的使用寿命。电器零部件及控制单元的大量增加也给静态电流的控制增加了难度，如果不能很好的控制整车的静态电流，将影响整车的停放时间，甚至导致满足不了部分市场的法规要求。因此我们需要对蓄电池状态进行适时监控，并依此对整车电器实施控制，并且适当的调节发电机的发电功率和输出电压，优化整车的电平衡，保证用电系统的稳定运行，提高乘坐的舒适度；同时可以通过对蓄电池的荷电状态和健康状态的监控，来控制蓄电池的充放电状态，保证蓄电池的充放电平衡，优化蓄电池的使用情况，从而延长蓄电池的使用寿命。在车辆停放时，利用电源管理系统来控制用电系统与蓄电池之间的通断，使直接与蓄电池相接的零部件降低到最少，从而使静态电流降到最小，保证在一定的停放时间内，车辆可以正常起动。

发明内容

本发明所要解决的问题一：优化整车的电平衡。监测蓄电池的状态，控制整车用电器的适用状态，同时控制发电机的发电功率以及输出电压，并向驾驶员提供蓄电池的状态信息，最大程度的优化整车的电平衡。

本发明需要解决的问题二:控制整车静态电流，降低静态电流对于蓄电池电量的损耗，保证车辆停放后可正常起动的时间。

本发明需要解决问题三：优化蓄电池的充放电状态，延长蓄电池的使用寿命。

为了优化整车的电平衡，我们通过电源管理系统监测蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t；根据 U、I、t 判断蓄电池的荷电状态 SOC、健康状态 SOH，控制单元根据蓄电池的荷电状态 SOC、健康状态 SOH，控制整车用电器的使用状态，同时将信息传递给驾驶员；当蓄电池状态不够理想时，控制单元屏蔽部分舒适性负载，发出警告信息，引起驾驶员的注意，同时调节发电机的发电功率和输出电压，随着蓄电池状态的好转，电源管理系统将自动唤醒被屏蔽的负载；此时驾驶人员可以手工唤醒被屏蔽的负载并中断对发电机发电功率的调节。若蓄电池的状态进一步恶化，控制单元屏蔽所有舒适性负载，发出警告信息，引起驾驶员的注意，同时调节发电机的发电功率和输出电压，随着蓄电池状态的好转，电源管理系统将自动唤醒被屏蔽的负载；此时驾驶人员可以手工唤醒被屏蔽的负载并中断对发电机发电功率的调节。当蓄电池的状态可能会影响车辆正常驾驶时，控制单元将屏蔽除安全驾驶必需的负载外的所有负载，发出警告信息，同时调节发电机的发电功率和输出电压随着蓄电池状态的好转，逐级唤醒被屏蔽的负载，此时驾驶人员无法手工唤醒被屏蔽的负载。

在车辆停止运行时，在车辆没有进入设防状态下，电源管理系统根据蓄电池的状态，判断是否屏蔽负载，在蓄电池电量充足时，所有

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负载可以正常使用，随着蓄电池电量的降低，将逐步屏蔽或同时屏蔽所有舒适性负载，并进入某种模式，此时可以通过起动发动机等方式来退出该模式。在防盗模式下，电源管理系统，通过对蓄电池、整车用电系统的检测，根据各电器零部件的功能和划分的等级，将所有与车辆安全无关的用电器全部切断（保留对有极易功能的模块的供电），从而使整车的静态电流降低到最小，对蓄电池的电能消耗最小，能够保证在规定的停放时间内，可以正常起动。

在本发明中，我们还对蓄电池的健康状态进行了监控。我们通过蓄电池的检测单元检测的得出的数据，通过专用软件，分析出蓄电池的健康状态，并根据蓄电池的健康状态和车辆对蓄电池的使用情况，预先判断蓄电池还可以正常使用的时间。同时在车辆的正常运行过程中，我们通过检测蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t，判断蓄电池荷电状态 SOC 和健康状态 SOH，通过专业软件的分析判断，再通过电源管理系统的控制部分，对用电系统和发电机发出指令，调节流过蓄电池的电流以及发电机的输出电压，从而可以优化蓄电池的充放电平衡，使蓄电池处于最佳的工作状态，最大限度的延长蓄电池的使用寿命。

附图说明

图 1，优化整车的电平衡的原理框图；

图 2，控制静态电流的原理框图；

图 3，优化蓄电池充发电的原理框图。

具体实施方式

下面参照附图，对本发明方案做进一步详细的阐述。

为了能够优化整车的电平衡、控制整车的静态电流以及优化蓄电

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池的充放电状态，我们采用以下 3 种措施:

措施 1、优化整车的电平衡

如图 1 所示，在本发明专利中，我们对整车所有负载按照负载的功能以及整车的电器原理，划分为不同优先级的负载类型。在此为阐述方便，我们将整车负载按照优先级从底到高命名为负载 1、负载 2、负载 3、负载 4、负载 5，同时根据蓄电池的健康状态，将蓄电池的荷电状态相应的划分为几个预警级别，在此以预警 1、预警 2、预警 3 为例来阐述我们的设计理念。

在本发明专利中，在电源管理系统中设计了一个监测单元和控制单元，监测单元用来监测蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t，并做简单的分析，将最终监测的结果发送给控制单元，控制单元根据监测的结果，通过专业的软件，分析判断，从而给用电系统及发电机、发动机发出相应的指令，控制负载、发电机的状态，并向驾驶员提供相应的信息。

当电源管理系统判断出蓄电池的荷电状态达到预警 1 级别时（例如 U=12.6V、I=0.5A、T=23℃），将分别向用电系统和发电机发出指令 1，要求优先级较低的负载 1 被屏蔽，增加发电机的发电功率并调节输出电压，同时给驾驶人员警告 1（蓄电池电量不足，负载 1 被屏蔽）；此时，驾驶人员可以通过人工唤醒功能将被屏蔽的负载唤醒，恢复被屏蔽负载的正常使用。通过电源管理系统的调节，若蓄电池的荷电状态得到缓解，通过检测得出的数据分析得出蓄电池已经达到退出预警 1 的条件（例如 U=12.65V、I=0.5A、T=23℃），电源管理系统将自动解除指令 1，退出预警 1 状态。

如果在蓄电池荷电状态达到预警 1 后，在电源管理控制部分采取措施后，由于驾驶人员唤醒了被屏蔽的负载 1，或者其他原因，导致蓄电池的荷电状态没有得到好转并进一步恶化，达预警 2 时（例如

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U=12.5V、I=0.5A、T=23℃），电源管理系统将发出指令2，要求屏蔽负载1、负载2，增加发电机发电功率并对输出电压进行调节，同时给驾驶人员警告2（蓄电池电量严重不足，负载1、负载2被屏蔽）；此时，驾驶人员可以通过人工唤醒功能将被屏蔽的负载唤醒，恢复被屏蔽负载的正常使用。随着蓄电池荷电状态的好转，当达到退出预警2条件后（例如U=12.55V、I=0.5A、T=23℃），系统将自动退出预警2，进入预警1；

如果在蓄电池荷电状态达到预警2后，在电源管理控制部分采取措施后，由于驾驶人员唤醒了被屏蔽的负载1、负载2，或者其他原因，导致蓄电池的荷电状态没有得到好转，并进一步恶化，达到预警3时（例如U=12.4V、I=0.5A、T=23℃），电源管理系统将发出指令3，要求强行屏蔽负载1、负载2、负载3，增加发电机发电功率并调节输出电压，同时给驾驶人员警告3(蓄电池电量严重不足，已经屏蔽负载1、负载2、负载3,蓄电池剩余电量按照现在的行使状态还可以行使**Km)；此时除了安全驾驶所必需的负载4、负载5外，其他负载全部屏蔽，并要求增加发电机的发电功率和调节发电机的输出电压，补偿蓄电池的电量。在预警3，驾驶人员无法唤醒被屏蔽的负载，随着蓄电池荷电状态的好转，当达到退出预警3条件后（例如U=12.45V、I=0.5A、T=23℃），系统将自动退出预警3，进入预警2。

通过以上的监测控制，达到了优化整车供电系统与用电系统的电平衡，保证车辆的安全驾驶，同时最大程度的提高了驾乘的舒适度。

措施2：控制整车的静态电流

为了便于阐述，我们沿用措施1中划分负载的方案，将整车负载按照优先级从底到高命名为负载1、负载2、负载3、负载4、负载5。假设负载5包含安全性负载、防盗系统，具有记忆功能的模块。

如图3所示，电源管理系统将车辆停放分为两种类型，在本发明

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中权且命名为熄火、防盗。熄火指发动机停止运转，在车辆没有点火且没有进入防盗的状态；防盗状态指发动机停止运转，并且得到防盗指令开始进入或者已经进入防盗模式的状态。

熄火状态：此时电源管理系统通过对蓄电池的监测，以及对防盗指令的判断，分析判断得出车辆处于熄火状态，按照整车的电器原理，此时大多数负载是可以正常使用。在这种状态下，我们需要适时监测蓄电池的状态，并且根据蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t 来分析蓄电池的荷电状态 SOC 和健康状态 SOH，并依此作为依据，给负载发出指令，控制负载的通断，当蓄电池的电量不足或者即将不足时，将发出屏蔽负载的指令（可以根据蓄电池的荷电状态，按照负载的优先级逐级屏蔽负载 1、负载 2、负载 3、负载 4，也可以同时屏蔽与防盗以及安全无关的所有负载，即同时断开负载 1、负载 2、负载 3、负载 4），使车辆进入电源保护模式，此时只有通过起动发动机才能解除（或者其它解除方式）。从而达到保护蓄电池，保证车辆正常起动的作用。

防盗状态：电源管理系统通过对蓄电池的监测，以及对防盗指令的判断，分析判断出车辆处于防盗状态。此时防盗系统开始工作或者已经工作，电源管理系统需要在最短的时间内屏蔽或者断开与防盗以及安全无关的所有负载，此时电源管理系统将发出指令，断开负载 1、负载 2、负载 3、负载 4，使这些负载与蓄电池之间处于断开状态（对于一些有记忆功能的模块需要保持供电），从而尽可能的降低整车的静态电流，减少对蓄电池电能的损耗。

通过以上的措施，既可以保证在停车等待时的舒适性，也可以保证蓄电池的电量足以保证车辆的正常行使，同时又使静态电流控制在比较理想的范围内。

措施 3：优化蓄电池的充放电状态

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如图 3，在整车运行过程中，通过电源管理系统的监测单元对蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t 的监测，对这些参数做简单的分析处理后，将最终数据发送给电源管理系统的控制单元，控制单元对监测结果进行进一步的处理，得出蓄电池的荷电状态 SOC 以及健康状态 SOH，再将 SOC、SOH 信息输送给专用分析软件，分析判断蓄电池的具体状态，为能更好的阐述本发明专利的设计理念，我们将蓄电池状态化分为以下几种：

状态 1：电量不足并对外供电，蓄电池电量还没有达到预警级别，

状态 2：电量不足并对外供电，蓄电池电量已经达到预警级别，

状态 3：电量不足，不对外供电，也没有得到补偿，蓄电池电量还没有达到预警级别，

状态 4：电量不足，不对外供电，也没有得到补偿，蓄电池电量已经达到预警级别

状态 5：电量不足，蓄电池电量还没有达到预警级别，发电机正在给蓄电池进行充电，

状态 6：电量不足，蓄电池电量已经达到预警级别，发电机正在给蓄电池进行充电。

状态 7：电量充足，但是蓄电池正在并对外供电，

状态 8：电量充足，不对外供电，也没有得到补偿，

状态 9：电量充足，但是发电机正在给蓄电池进行充电。

当蓄电池处于状态 1、状态 7 时，电源管理系统将发出指令，增加发电机的发电功率并调节发电机的输出电压，使蓄电池停止对外供电，或者降低蓄电池对外供电的程度；当蓄电池处于状态 2、状态 4、状态 6 时，将按措施 1，通过对负载的控制，以及对发电机的发电功率和输出电压的调节，补偿蓄电池的电量；当蓄电池处于状态 3、状态 5、状态 8 时，电源管理系统的控制单元不发出控制指令；当蓄电池处于状

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态 9 时，为了节约能源，也为了避免因为蓄电池电量饱和，却始终对蓄电池充电，导致蓄电池内温度增高，酸液蒸发而影响蓄电池的寿命，这时电源管理系统的控制单元将发出指令，使发电机的发电功率降低并对发电机的输出电压进行调节。终止蓄电池的充电状态。

在以上的方案中，我们需要经常通过对发电机的输出功率和输出电压的调节来保证蓄电池充放电的平衡，在调节发电机的输出功率的同时，需要调节发电机的输出电压，使发电机的输出电压控制在对蓄电池健康最有利的范围之内。在对发电机的输出功率和发电机的输出电压进行调节的同时，需要根据发动机的实际负载，对发动机的转速做出相应的调节，从而确保发电机可以顺利的接电源管理系统的指令进行调节。

通过对蓄电池的端电压 U、蓄电池的充放电电流 I、蓄电池的表面温度 t、负载、发电机、发动机的检测和调节，达到优化蓄电池的充放电状态，延长蓄电池的使用寿命。同时根据 U、I、t，分析计算蓄电池的内阻，并判断蓄电池的健康状态 SOH，当健康状态恶化到预警状态时（例如电压降 Ud=0.4V、输出电流 I=50A、T=23℃），将向驾驶员发出警告信息。

上述实施方案只是体现本发明技术方案的优选方案，本技术领域的技术人员对其中的某些部分所可能做出的一些变动均体现了本发明的原理，属于本发明的保护范围之内。

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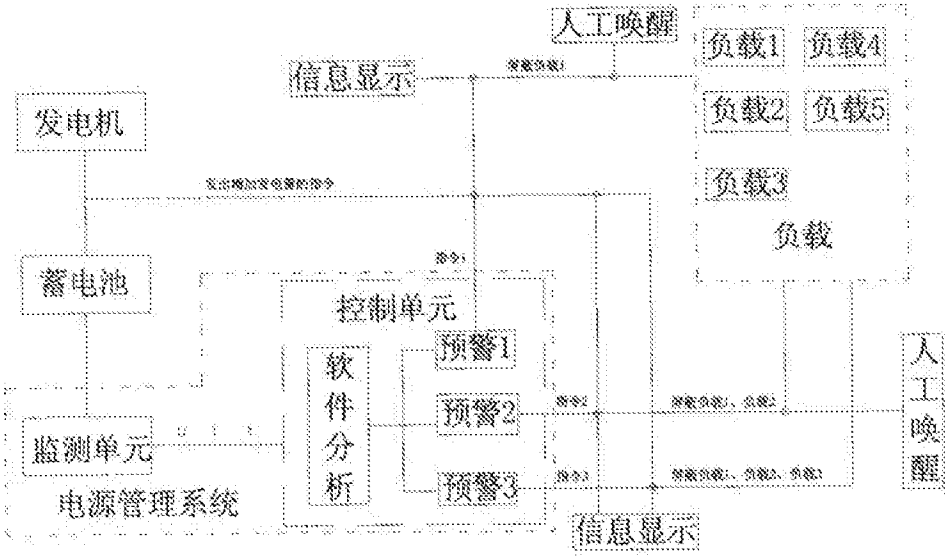


图 1

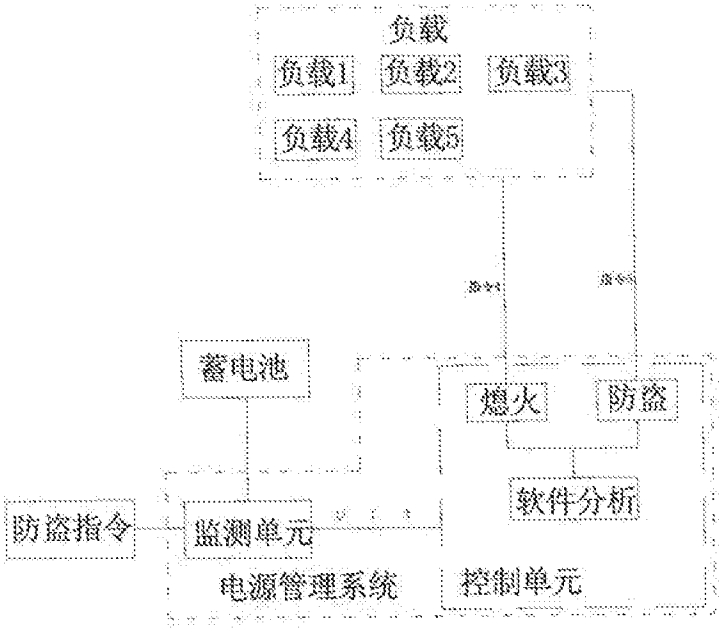


图 2

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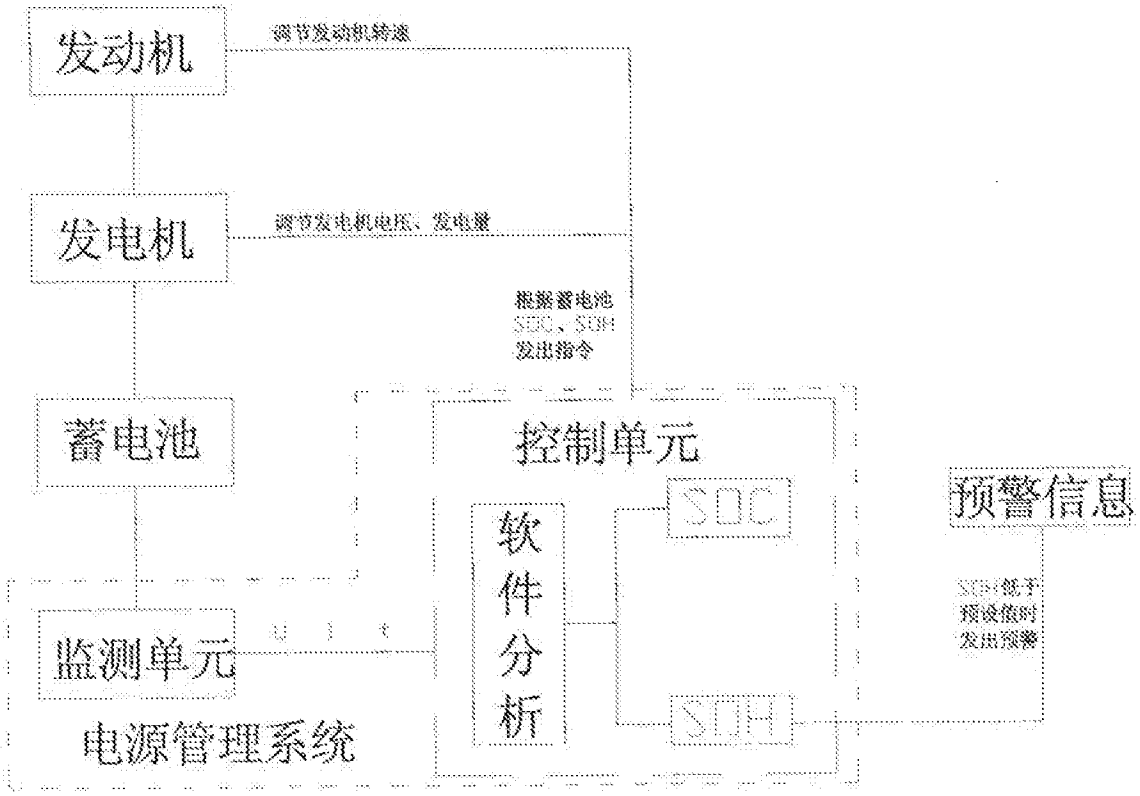


图 3

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Espacenet

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Unmanned aerial vehicle cruising capacity monitoring system and method

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Classification: **- international:** ***G01C21/16; G01R31/36; G05D1/10***
- cooperative:

Application number: CN20151595655 20150917 Global Dossier

Priority number(s): CN20151595655 20150917

Abstract of CN105093130 (A)

The invention discloses an unmanned aerial vehicle cruising capacity monitoring system and method, and belongs to the field of unmanned aerial vehicles. The system comprises an unmanned aerial vehicle and a flight control station, a signal processing module and a data communication module. The unmanned aerial vehicle further comprises a signal input module, a flight control panel and a battery. The signal input module acquires energy consumption information of the unmanned aerial vehicle. The flight control panel acquires battery information and controls flight of the unmanned aerial vehicle. The signal processing module is suitable for calculating cruising capacity of the unmanned aerial vehicle according to the energy consumption information and the battery information. Energy consumption of the unmanned aerial vehicle is analyzed to accurately estimate cruising capacity of the unmanned aerial vehicle, and cruising capacity of the unmanned aerial vehicle is marked by cruising time and/or cruising distance. Meanwhile, influence of environment temperature on battery energy efficiency is also considered so that accuracy of prediction of cruising capacity of the unmanned aerial vehicle is further enhanced.

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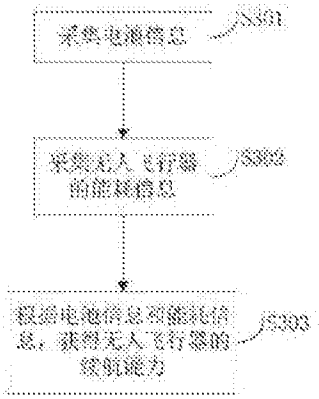
权利要求书2页 说明书14页 附图3页

(54)发明名称

一种无人飞行器续航能力监测系统及方法

(57)摘要

本发明公开了一种无人飞行器续航能力监测系统及方法，属于无人机领域。该系统包括无人飞行器和飞控台、信号处理模块、数据通信模块，无人飞行器进一步包括信号输入模块、飞行控制板和电池，信号输入模块采集无人飞行器的能耗信息；飞行控制板采集电池信息，控制无人飞行器的飞行；信号处理模块通用于根据能耗信息和电池信息，计算无人飞行器的续航能力。本发明对无人飞行器的能耗进行分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和/或续航距离标识出来，同时还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。



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1. 一种无人飞行器续航能力监测系统，其特征在于：包括无人飞行器和飞控台、信号处理模块、数据通信模块，所述无人飞行器和所述飞控台通过所述数据通信模块能够双向通信，所述无人飞行器进一步包括信号输入模块、飞行控制板和电池，所述飞行控制板分别与所述信号输入模块、所述数据通信模块和所述电池连接，所述信号处理模块与所述飞行控制板连接，其中，

所述信号输入模块适用于采集所述无人飞行器的能耗信息并发送至所述飞行控制板；

所述飞行控制板适用于采集所述电池信息、控制所述无人飞行器的飞行；

所述信号处理模块适用于根据所述能耗信息和所述电池信息，计算所述无人飞行器的续航能力。

2. 根据权利要求 1 所述的无人飞行器续航能力监测系统，其特征在于：还包括存储模块，所述存储模块与所述信号处理模块连接，所述存储模块适用于存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和 / 或平均飞行速度。

3. 根据权利要求 2 所述的无人飞行器续航能力监测系统，其特征在于：还包括电量检测单元，所述电量检测单元分别与所述电池和所述飞行控制板连接，其适用于检测所述电池的总电量和电池的当前剩余电量。

4. 根据权利要求 3 所述的无人飞行器续航能力监测系统，其特征在于：所述信号输入模块包括惯性传感器，所述惯性传感器适用于检测所述无人飞行器的飞行运动参数并发送给所述信号处理模块。

5. 根据权利要求 4 所述的无人飞行器续航能力监测系统，其特征在于：所述信号处理模块进一步包括姿态解算单元、比对判断单元、计算单元，所述姿态解算单元连接所述比对判断单元，所述比对判断单元连接所述计算单元，其中，

所述姿态解算单元适用于根据所述飞行运动参数确定所述无人飞行器当前的飞行状态；

所述比对判断单元适用于根据所述飞行状态和所述存储模块中存储的预定义的能耗级别，判定所述无人飞行器当前的能耗级别；

所述计算单元适用于根据所述能耗级别确定对应的理想续航时间和 / 或平均飞行速度、所述电池的总电量和所述电池的当前剩余电量，计算得到所述无人飞行器当前的续航能力。

6. 根据权利要求 1 至 5 任一所述的无人飞行器续航能力监测系统，其特征在于：所述信号输入模块还包括温度传感器，其适用于采集所述电池的环境温度，并输入至信号处理模块，对所述电池信息进行补偿。

7. 一种无人飞行器续航能力监测方法，所述无人飞行器利用电池供电，包括以下步骤：

采集电池信息；

采集无人飞行器的能耗信息；

根据所述电池信息和所述能耗信息，获得所述无人飞行器的续航能力。

8. 根据权利要求 7 所述的无人飞行器续航能力监测方法，其特征在于：所述采集步骤之前还包括预定义能耗级别步骤，具体包括以下步骤：

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所述无人飞行器的飞行状态分别对应预设数量的能耗级别；

分别测定各个能耗级别，所述无人飞行器满电情况下的理想续航时间；

分别测定所述无人飞行器在不同能耗级别下的平均飞行速度；

存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和/或平均飞行速度。

9. 根据权利要求 8 所述的无人飞行器续航能力监测方法，其特征在于：所述电池信息包括所述电池的总电量和电池的当前剩余电量。

10. 根据权利要求 7 至 9 任一所述的无人飞行器续航能力监测方法，其特征在于：还包括温度补偿步骤，具体包括以下步骤：

采集所述电池的环境温度；

利用所述环境温度对所述电池信息进行补偿计算，获得修正后的电池信息。

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一种无人飞行器续航能力监测系统及方法

技术领域

[0001] 本发明涉及无人机技术领域，具体涉及一种无人飞行器续航能力监测系统及方法。

背景技术

[0002] 随着航拍用小微型无人飞行器开始普及，并进入消费级市场，原来由专业人员使用而不会关注的一些需求开始凸显。无人飞行器平台上装备有大量电子设备，如自动驾驶系统、舵机和云台等，为保证无人飞行器平台安全稳定工作，这些电子设备需要稳定有效的电力供应。无人飞行器平台的电能由各种高能电池提供，包括：太阳能、蓄电池和燃料电池。其中以锂电池为代表的蓄电池供电方式是目前应用最广泛的一种。

[0003] 现有技术主要是通过燃油、太阳能、锂离子电池等混合电源供应，或者在飞行动力结构上进行改进，来提高无人飞行器的续航能力。

[0004] 例如：申请号为201310543169.7、发明名称为《零点电源与锂离子电池的电池组作为无人机电源的应用》的中国发明专利申请公开了一种零点电源与锂离子电池的电池组作为无人机电源的应用，该电池组包括至少一个零点电源单体和至少一个锂离子电池单体，所述零点电源单体与所述锂离子电池单体能够串联和/或并联，也可以断开连接。例如，在使用时，如果锂离子电池的电量能够满足使用要求，则可以将零点电源单体与锂离子电池单体断开连接，锂离子电池与用电设备相连提供稳定的电压和电流；当锂离子电池使用一段时间之后，在电量不足时，零点电源可以持续不断地位锂离子电池充电，解决了电池续航的问题。

[0005] 再例如，申请号为201220292712.1、发明名称为《一种无人机遥感平台的供电系统》的中国实用新型专利公开一种无人机遥感平台的供电系统，包括主供电电源、副供电电源、主开关、副开关、通道开关、控制器、非门、主检测电路、n个主开关电源和n个副开关电源；采用容量不同的主副两块电池供电，当主电池电量不足时，可切换副电池备用，并向地面监控人员报警，使得监控人员可及时采取措施使无人机迫降，提高无人机的安全可靠性。

[0006] 在专业人员使用的情况下，由于对产品非常了解和熟悉，因此，关于无人机的一些维护、使用的知识都不那么透明。例如，无人飞行器的飞行时间，往往是由飞手根据经验来分析和判断的，这种依赖经验的方式提高了对操作人员的要求，而且经验并不十分准确，降低了电池的使用效率。即使有的无人飞行器能够提供电池余量报警，这种报警行为也是不很准确的。

[0007] 当无人飞行器进入消费级市场，这个问题就不能忽视了。普通消费者由于对无人飞行器的操控和使用经验不足，因此非常依赖无人飞行器上给出的电池余量提示信息。但是，本身现有的消费级无人飞行器续航总时间就不是很长，短的5-10分钟，长的一般也不超过30分钟，在这种情况下，如果电池余量提示再不准确，那么很可能难以起到提示用户的作用。一方面，如果用户一察觉电池余量报警，就赶紧回收无人飞行器，那么会导致无人飞行器的实际操作时间远小于总续航时间；而另一方面，如果用户察觉电池余量报警后，仍

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然坚持使用无人飞行器，那么就可能面临无人飞行器掉电坠落的风险。

[0008] 现有技术仅根据电池余量情况来报警，而不考虑无人飞行器的飞行状态。例如，无人飞行器悬停和做高速运动，它的耗能情况是很不一样的。如果不考虑无人飞行器的能量消耗，去做续航能力分析，是很不准确的。

[0009] 另外，由于环境温度能够极大地影响电池的蓄电水平，因此，如何在不同环境温度下，准确对电池的余量进行统计和计算，也是一个问题。

发明内容

[0010] 本发明的发明目的是提供一种无人飞行器续航能力监测系统及方法，其能够实时、有效、智能地保护无人飞行器，避免无人飞行器出现因电量不足引起的事故，并且可以提高电池的利用率。

[0011] 本发明的另一个发明目的是提供一种无人飞行器续航能力监测系统及方法，考虑了温度对电池的蓄电水平的影响，进一步提高了电池余量监测的准确性。

[0012] 不仅仅基于电池余量做续航能力分析，而是综合考虑到无人飞行器的飞行耗能情况以及环境温度情况等，对无人飞行器的续航能力做准确分析，将续航能力警示信息转换成直观的时间或者飞行距离。

[0013] 为了解决上述技术问题，本发明采用的技术方案如下：

[0014] 一种无人飞行器续航能力监测系统，包括无人飞行器和飞控台、信号处理模块、数据通信模块，所述无人飞行器和所述飞控台通过所述数据通信模块能够双向通信，所述无人飞行器进一步包括信号输入模块、飞行控制板和电池，所述飞行控制板分别与所述信号输入模块、所述数据通信模块和所述电池连接，所述信号处理模块与所述飞行控制板连接，其中，

[0015] 所述信号输入模块适用于采集所述无人飞行器的能耗信息并发送至所述飞行控制板；

[0016] 所述飞行控制板适用于采集所述电池信息，控制所述无人飞行器的飞行；

[0017] 所述信号处理模块适用于根据所述能耗信息和所述电池信息，计算所述无人飞行器的续航能力。

[0018] 进一步的，还包括存储模块，所述存储模块与所述信号处理模块连接，所述存储模块适用于存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和/或平均飞行速度。

[0019] 进一步的，还包括电量检测单元，所述电量检测单元分别与所述电池和所述飞行控制板连接，其适用于检测所述电池的总电量和电池的当前剩余电量。

[0020] 进一步的，所述信号输入模块包括惯性传感器，所述惯性传感器适用于检测所述无人飞行器的飞行运动参数并发送给所述信号处理模块。

[0021] 进一步的，所述信号处理模块进一步包括姿态解算单元、比对判断单元、计算单元，所述姿态解算单元连接所述比对判断单元，所述比对判断单元连接所述计算单元，其中，

[0022] 所述姿态解算单元适用于根据所述飞行运动参数确定所述无人飞行器当前的飞行状态；

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[0023] 所述比对判断单元适用于根据所述飞行状态和所述存储模块中存储的预定义的能耗级别，判定所述无人飞行器当前的能耗级别；

[0024] 所述计算单元适用于根据所述能耗级别确定对应的理想续航时间和/或平均飞行速度、所述电池的总电量和所述电池的当前剩余电量，计算得到所述无人飞行器当前的续航能力。

[0025] 进一步的，所述信号输入模块还包括温度传感器，其适用于采集所述电池的环境温度，并输入至信号处理模块，对所述电池信息进行补偿。

[0026] 根据本发明的另一个方面，提供了一种无人飞行器续航能力监测方法，所述无人飞行器利用电池供电，包括以下步骤：

[0027] 采集电池信息；

[0028] 采集无人飞行器的能耗信息；

[0029] 根据所述电池信息和所述能耗信息，获得所述无人飞行器的续航能力。

[0030] 进一步的，所述采集步骤之前还包括预定义能耗级别步骤，具体包括以下步骤：

[0031] 所述无人飞行器的飞行状态分别对应预设数量的能耗级别；

[0032] 分别测定各个能耗级别，所述无人飞行器满电情况下的理想续航时间；

[0033] 分别测定所述无人飞行器在不同能耗级别下的平均飞行速度；

[0034] 存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和/或平均飞行速度。

[0035] 进一步的，所述电池信息包括所述电池的总电量和电池的当前剩余电量。

[0036] 进一步的，还包括温度补偿步骤，具体包括以下步骤：

[0037] 采集所述电池的环境温度；

[0038] 利用所述环境温度对所述电池信息进行补偿计算，获得修正后的电池信息。

[0039] 本发明公开了一种无人飞行器续航能力监测系统及方法，通过惯性传感器获取无人飞行器当前的飞行状态及预先定义的能耗级别，确定当前的能耗级别，根据所述当前的能耗级别和电池的当前剩余电量，预测无人飞行器的续航能力，这种预测不同于现有的仅仅考虑电池的当前剩余电量的预测方式，而是综合考虑了无人飞行器的飞行运动参数，从而使得预测更加准确。同时，本发明还将所述续航能力转换为续航时间与里程直观的显示给用户查看，更加便于非专业人员的理解和操作。本发明可以降低无人飞行器掉电坠落事故发生率，并提高电池的利用效率。

[0040] 另一方面，本发明对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0041] 上述说明仅是本发明技术方案的概述，为了能够使得本发明的技术手段更加清楚明白，达到本领域技术人员可依照说明书的内容予以实施的程度，并且为了能够让本发明的上述和其它目的、特征和优点能够更明显易懂，下面以本发明的具体实施方式进行举例说明。

附图说明

[0042] 通过阅读下文优选的具体实施方式中的详细描述，本发明各种其他的优点和益处对于本领域普通技术人员将变得清楚明了。说明书附图仅用于示出优选实施方式的目的，

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而并不认为是对本发明的限制。显而易见地，下面描述的附图仅仅是本发明的一些实施例，对于本领域普通技术人员来讲，在不付出创造性劳动的前提下，还可以根据这些附图获得其他的附图。而且在整个附图中，用相同的附图标记表示相同的部件。在附图中：

[0043] 图 1 示出了根据本发明实施例一的无人飞行器续航能力监测系统结构示意图；

[0044] 图 2 示出了根据本发明实施例二的无人飞行器续航能力监测系统结构示意图；

[0045] 图 3 示出了根据本发明实施例三的无人飞行器续航能力监测方法流程图；

[0046] 图 4 示出了根据本发明实施例四的无人飞行器续航能力监测方法流程图。

具体实施方式

[0047] 下面将参照附图更详细地描述本发明的具体实施例。虽然附图中显示了本发明的具体实施例，然而应当理解，可以以各种形式实现本发明而不应被这里阐述的实施例所限制。相反，提供这些实施例是为了能够更透彻地理解本发明，并且能够将本发明的范围完整的传达给本领域的技术人员。

[0048] 需要说明的是，在说明书及权利要求当中使用了某些词汇来指称特定组件。本领域技术人员应可以理解，硬件制造商可能会用不同名词来称呼同一个组件。本说明书及权利要求并不以名词的差异来作为区分组件的方式，而是以组件在功能上的差异来作为区分的准则。如在通篇说明书及权利要求当中所提及的“包含”或“包括”为一开放式用语，故应解释成“包含但不限定于”。说明书后续描述为实施本发明的较佳实施方式，然所述描述乃以说明书的一般原则为目的，并非用以限定本发明的范围。本发明的保护范围当视所附权利要求所界定者为准。

[0049] 为便于对本发明实施例的理解，下面将结合附图以几个具体实施例为例做进一步的解释说明，且各个附图并不构成对本发明实施例的限定。

[0050] 无人飞行器简称“无人机”，英文缩写为“UAV(unmanned aerial vehicle)”，是利用无线电遥控设备和自备的程序控制装置操纵的不载人飞机。从技术角度定义可以分为：无人直升机、无人固定翼机、无人多旋翼飞行器、无人飞艇、无人伞翼机等。近年来，随着传感器工艺的提高、微处理器技术的进步、动力装置的改善以及电池续航能力的增加，使其在军事、民用方面的用途不断高速拓展，无人机市场具有广阔前景。

[0051] 本发明实施例中优选的急救无人机为多旋翼无人飞行器（或称为多旋翼飞行器），可以是四旋翼、六旋翼及旋翼数量大于六的无人飞行器。优选的，机身由碳纤维材料制成，在满足较高使用强度和刚度的前提下，可大幅减轻机身的重量，从而降低多旋翼无人飞行器的动力需求以及提高多旋翼无人飞行器的机动性。当然，在本发明的其他实施例中，机身还可以由塑料或者其他任意使用的材料制成。机身上设有多个相对于所述机身中的对称平面呈对称分布的桨臂，每一个桨臂远离所述机身的一端设有桨叶组件，所述桨叶组件包括安装在所述桨臂上的电机和连接在所述电机的输出轴上的桨叶，每一片桨叶的旋转轴线均位于同一圆柱面上。

[0052] 本发明技术方案采用的急救无人机主要是指小、微型多旋翼无人飞行器，这种无人飞行器体积小、成本低，飞行稳定性较好，飞行成本低等。本发明使用的飞行器，典型的以四轴多旋翼飞行器为代表。

[0053] 实施例一、一种无人飞行器续航能力监测系统。

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[0054] 如上述背景技术中所述，无人飞行器在空中飞行过程中，一旦发生动力不足的情况，就会非常危险，可能直接导致坠机。因此，准确的续航能力判断非常重要，但是现有的续航能力判断方式过于简单，仅是基于电池余量的分析来给出警示信息。但实际飞行过程中，无人飞行器的能耗并非一成不变，仅依靠电池来做判断，是不客观也不直观的。

[0055] 图 1 为本发明实施例一的飞行器续航能力监测无人飞行器续航能力监测系统结构示意图，本发明实施例将结合图 1 进行具体说明。

[0056] 如图 1 所示，本发明实施例提供了一种飞行器续航能力监测无人飞行器续航能力监测系统 100，包括无人飞行器 101 和飞控台 102、信号处理模块 103、数据通信模块 104，所述无人飞行器 101 和所述飞控台 102 通过所述数据通信模块 104 能够双向通信，所述无人飞行器 101 进一步包括信号输入模块 105、飞行控制板 106 和电池 107，所述飞行控制板 106 分别与所述信号输入模块 105、所述数据通信模块 104 和所述电池 107 连接，所述信号处理模块 103 与所述数据通信模块 104 连接，其中，

[0057] 所述信号输入模块 105 适用于采集所述无人飞行器 101 的能耗信息并发送至所述飞行控制板 106；

[0058] 所述飞行控制板 106 适用于采集所述电池信息，控制所述无人飞行器 101 的飞行；

[0059] 所述信号处理模块 103 适用于根据所述能耗信息和所述电池信息，计算所述无人飞行器的续航能力。

[0060] 本发明实施例中优选的，所述信号处理模块 103 可以内置于所述无人飞行器 101 中，也可以设置在所述飞控台 102 上，还可以是一个单独的物理模块，也可以利用所述无人飞行器 101 的所述飞行控制板 106 实现信号处理功能。在另一实施例中，考虑到无人飞行器的负重问题，将所述信号处理模块 103 设置在所述飞控台 102 中，所述无人飞行器 101 采集的信息通过所述数据通信模块 104 传输至所述飞控台 102 中进行处理。

[0061] 本发明实施例中优选的，还包括信号预处理模块，所述信号预处理模块用于对所述采集的信息进行平滑与预处理之后，再发送至所述信号处理模块 103 中进行运算。

[0062] 本发明实施例中优选的，所述数据通信模块 104 包括位于所述无人飞行器 101 内的第一双工通信接口和位于所述飞控台 102 的第二双工通信接口，所述第一双工通信接口和所述第二双工通信接口无线连接，可以通过 3G、4G 无线网络或者卫星通信网络以及任意网络类型实现双向无线通讯功能。

[0063] 本发明实施例中优选的，还包括存储模块，所述存储模块与所述信号处理模块 103 连接，所述存储模块适用于存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和 / 或平均飞行速度。

[0064] 本发明实施例中优选的，还包括电量检测单元，所述电量检测单元分别与所述电池 107 和所述飞行控制板 106 连接，其适用于检测所述电池的总电量和电池的当前剩余电量。

[0065] 本发明实施例中优选的，所述电池的当前剩余电量通过 AD 采集电路采集电压的方法或 / 及电流计测量电流的方法获得。

[0066] 在其中一个实施例中，所述电量检测单元采用电压测量法。电池的电量是指电池所能输出的总电荷之和，通常以 AH 单位来表示，可以通过 AD 采集电路采集采样器件两端的

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电压，采样器件点连接在电池的负极线路，并按照电压与电流的关系 I = U/R 来计算当前电流的大小。电量与电流的关系为 Q = IT。所述飞行控制板会定期的采集该信号，例如，每隔 t 时间采集一次，则放电或者充电过程中电量的变化量为 Q1 =，假设电池原有电量为 Q0，则当前电量为 Q = Q1+Q0。若电池的总容量为 Qall，则，当前电量的百分比为 P = Qall/Q。

[0067] 在其他实施例中，可以采用电流测量法。电流测量法可以通过电流计直接采集采样器件上的电流，然后按照电量与电流的关系计算电池的当前电量。

[0068] 在其他实施例中，可以采用电流、电压综合测量法。通过 AD 采集电路采集电池输出端上的电压，并通过电流计采集采样器件上的电流，然后按照 Q = Pt = Ult 的关系计算电池的当前剩余电量。

[0069] 本发明实施例中优选的，由于电池电压会随着 RFPA(radio frequency power amplifier，射频功率放大器）的功率发射发生突变，通常会变小 0.2V-0.3V。如果一味的使用电压模拟电量方法，就会误差更大。为了解决电池电压突然变小的测量问题，可以利用软件算法进行均值滤波，对一段时间内的电池电压进行均值化，如果该时间段的平均电池电压确实下降了，则预估电量确实变少了，否则即认为电量并未变化。

[0070] 本发明实施例中优选的，所述电池为自动检测自身剩余电量的智能电池，所述飞行控制板与所述智能电池通讯连接而获取所述智能电池的当前剩余电量。

[0071] 本发明实施例中优选的，所述信号输入模块 105 包括惯性传感器，所述惯性传感器适用于检测所述无人飞行器 101 的飞行运动参数并发送给所述信号处理模块。

[0072] 本发明实施例中优选的，所述惯性传感器包括 3 轴加速度传感器、3 轴陀螺仪、3 轴地磁传感器中的至少一种或者任意组合。其中，所述 3 轴加速度传感器感应无人飞行器在立体空间三个维度的加速度信号；所述 3 轴陀螺仪感应无人飞行器在立体空间三个维度的角速度信号；所述 3 轴地磁传感器感应无人飞行器在立体空间三个维度的地磁信号。

[0073] 本发明实施例中优选的，所述 3 轴加速度传感器为石英挠性加速度计，其输出 X、Y、Z 轴向的 3 路加速度计脉冲信号；所述 3 轴陀螺仪为高精度光纤陀螺仪（即偏置漂移可达 0.01° /h），其输出 X、Y、Z 轴向的 3 路陀螺脉冲信号。3 路加速度计脉冲信号和 3 路陀螺脉冲信号通过光耦隔离电路隔离发送给所述信号处理模块。

[0074] 因为，挠性陀螺仪虽然体积重量最小，使用环境温度动态范围较小，在 -30° ~ +60° 之间，但其随机漂移较为严重，且对飞行环境的振动干扰最敏感，容易产生误差，测量精度较低，难以达到无人飞行器的高精度要求。而目前应用较多的是激光陀螺仪虽然各项测量精度高，但其重量体积大。而光纤陀螺仪虽然受环境温度影响较大，在温度梯度变化和温度速率变化都很小的情况下，对光纤陀螺仪影响不大。同时，其重量体积相对于激光陀螺仪较小，而测量精度相对于挠性陀螺仪较高，符合无人飞行器的重量体积小、精度高、抗干扰能力强等要求。由此，选择光纤陀螺仪作为其惯性测量单元。

[0075] 本发明实施例中优选的，所述信号输入模块 105 还包括导航定位单元。进一步的，所述导航定位单元为 GPS 卫星定位装置，其用于感应无人飞行器在立体空间的经纬度信息，并发送给所述飞行控制板。

[0076] 本发明实施例中优选的，所述信号输入模块 105 还可以包括转速传感器，用于采集无人飞行器发动机的转速信息并输入至所述信号处理模块 103。

[0077] 本发明实施例中优选的，所述信号输入模块 105 还可以包括高度传感器，用于采

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集无人飞行器的高度信息。所述高度传感器包括气压高度计、激光高度计、无线电高度计、超声波高度计、图像测距传感器中的至少一种。

[0078] 本发明实施例中优选的，所述信号输入模块 105 还可以包括测距传感器，例如超声波测距传感器，可以采用 HC-SR04 来测量所述无人飞行器与地面之间的距离或者与障碍物之间的距离。

[0079] 本发明实施例中优选的，所述信号处理模块 103 进一步包括姿态解算单元、比对判断单元、计算单元，所述姿态解算单元连接所述比对判断单元，所述比对判断单元连接所述计算单元，其中，

[0080] 所述姿态解算单元适用于根据所述飞行运动参数确定所述无人飞行器 101 当前的飞行状态；

[0081] 所述比对判断单元适用于根据所述飞行状态和所述存储模块中存储的预定义的能耗级别，判定所述无人飞行器 101 当前的能耗级别；

[0082] 所述计算单元适用于根据所述能耗级别确定对应的理想续航时间和 / 或平均飞行速度、所述电池的总电量和所述电池的当前剩余电量，计算得到所述无人飞行器 101 当前的续航能力。

[0083] 本发明实施例中优选的，所述信号处理模块 103 获得 3 轴加速度传感器、3 轴陀螺仪、3 轴地磁传感器、及 GPS 等传感设备发来的感应数据，采用捷联惯导算法可解算出无人飞行器在三维空间的姿态信息，同时以 3 轴地磁传感器和 GPS 等接受的绝对地理信息对惯导解算的姿态进行修正，得到一个具有高可信度的姿态信息。

[0084] 本发明实施例中优选的，所述信号处理模块 103 可以选用 32 位单片机作为微控制器，完成基于传感器所提供信息的无人飞行器姿态解算，并读取位置信息，连续记录姿态信息以及通过所述姿态信息和位置信息进行无人飞行器的飞行状态判断。

[0085] 本发明实施例中优选的，所述信号输入模块 105 还包括温度传感器，其适用于采集所述电池的环境温度，并输入至信号处理模块，对所述电池信息进行补偿。

[0086] 本发明实施例中优选的，所述温度传感器采用数字温度传感器，其直接读取电池的环境温度信息，并发送给所述信号预处理模块，所述信号预处理模块对这些信息进行平滑与预处理之后，将其发送给数据通信模块，数据通信模块则利用无线网络或卫星通信网络将采集到的数字温度数据打包输出给飞控台。

[0087] 本发明实施例中优选的，如果所述温度传感器采用模拟温度传感器（例如，AD590），需要配置运放电路和 A/D 转换电路，将其转换为数字脉冲信号再发送给所述飞行控制板。

[0088] 本发明实施例中优选的，所述信号处理模块 103 可以包括 FPGA 芯片和配置芯片，其中所述 FPGA 芯片完成 3 路陀螺脉冲信号、3 路加速度计脉冲信号和数字温度信号的采集与处理并将处理结果发送给飞控台进行显示，所述配置芯片为所述 FPGA 芯片存储软件程序。

[0089] 本发明实施例中优选的，所述信号处理模块 103 进一步包括安全电量分析单元，所述安全电量分析单元用于计算所述无人飞行器从当前位置安全返航到预设位置或者从所述当前位置直接降落所需要的电池电量。

[0090] 本发明实施例中优选的，根据所述电量检测单元实时获取电池的当前剩余电量，

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利用无人飞行器上的定位装置实时获取无人飞行器当前位置的坐标信息或者利用无人飞行器上的高度传感器实时获取无人飞行器当前位置的离地高度，并根据所述坐标信息或者离地高度和所述无人飞行器当前飞行状态下的能耗级别计算所述无人飞行器从所述当前位置安全返航或者安全降落所需要的电池电量、判断所述当前剩余电量是否大于所述安全电量；若所述电池的当前剩余电量不大于所述安全电量，则立即执行返航或者降落命令，或者所述飞控台向用户发出警示信号。

[0091] 本发明实施例中优选的，所述安全电量分析单元包括用于根据所述无人飞行器的所述当前位置的坐标信息及所述预设位置的坐标信息计算所述无人飞行器安全返航所需要的安全电量的计算子单元，以及用于判断所述电池的当前剩余电量与所述安全电量大小的比较器；

[0092] 或者，所述安全电量分析单元包括用于根据所述无人飞行器的所述当前位置的坐标信息及所述预设位置的坐标信息计算所述无人飞行器安全返航所需要的安全电量、且判断所述电池的当前剩余电量与所述安全电量大小的微处理器。

[0093] 本发明实施例中优选的，所述无人飞行器从所述当前位置安全返航到所述预设位置的路径为如下一种：原飞行路径、先沿所述当前位置与所述预设位置在水平方向的直线路径然后再沿竖直方向直线路径飞行的路径，所述当前位置与所述预设位置之间的直线路径。

[0094] 本发明实施例中优选的，计算所述无人飞行器从所述当前位置安全返航到所述预设位置所需要的电量时，所述无人飞行器根据预设标准自动选取返航路径，并根据所选取的返航路径计算所述无人飞行器从所述当前位置安全返航到所述预设位置所需要的电池电量。

[0095] 本发明实施例中优选的，所述预设标准包括如下至少一种：消耗电量最少，返航行程最短，变速次数最少。

[0096] 本发明实施例中优选的，所述无人飞行器从所述当前位置安全返航到所述预设位置的路径可自动设定或者由用户设定。

[0097] 本发明实施例中优选的，所述无人飞行器从所述当前位置直接降落或者安全返航所需要的电池电量包括预留电量。

[0098] 本发明实施例中优选的，所述预设位置为所述无人飞行器的起飞点或用户指定的目标点。当然，在本发明中，无人飞行器返航的预设位置不限于上述地点，也可以为其它地点，例如，当无人飞行器装载有探测地面的地理相貌的传感器时，无人飞行器返航的预设位置可以为自动选取的最佳降落点。预设位置的坐标信息可以事先存储在无人飞行器内，或者由用户直接输入。

[0099] 本发明实施例中优选的，计算所述无人飞行器当前的续航能力时，所述电池的当前剩余电量为所述电池的实际剩余电量减去安全电量之后的电量，由此计算出的续航时间与续航里程。这样，进一步方便了非专业人员对无人飞行器的安全飞行的需求，其可以直观的根据飞控台上显示的续航时间与续航里程控制飞行器继续飞行，而不用担心所述无人飞行器无法安全返航或者安全降落的问题。

[0100] 本发明实施例中优选的，计算所述无人飞行器当前的续航能力时，所述电池的当前剩余电量为所述电池的实际剩余电量减去安全电量及预设电量之后的电量，所述预设电

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量作为所述安全电量的计算误差的补偿。

[0101] 本发明实施例中优选的，所述飞行控制板能够通过中央处理器（CPU）和/或协处理器、现场可编程门阵列（FPGA）、数字信号处理器（DSP）、特定用途基础电路（ASIC）以及嵌入式微处理器（ARM）实现。

[0102] 本发明实施例公开了一种无人飞行器续航能力监测系统，基于无人飞行器能耗情况，将传统的电池余量提示功能升级为续航时间和续航里程的提示，并且这种提示是基于无人飞行器这样一种特殊的工作模式，将无人飞行器不规则的飞行过程，利用惯性传感器的监测数据，转化为可量化的指标，根据对无人飞行器的能耗分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和/或续航距离标识出来。

[0103] 另一方面，本发明实施例基于准确估计续航能力的需求，对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0104] 本发明实施例所述无人飞行器续航能力监测系统，还通过实时获取无人飞行器的当前位置的坐标信息，计算出无人飞行器在所述当前位置执行安全返航或者安全降落所需要的安全电量，当电池的当前剩余电量不大于安全电量时，立即执行相应的命令，从而实时保护无人飞行器，避免无人飞行器因电量不足引起的事故。

[0105] 本发明实施例所述无人飞行器续航能力监测系统，还可以根据当前位置的安全电量及电池的当前剩余电量，而自动判断是否需要执行返航或者降落命令，不需要用户根据自身经验来判断，从而使得上述监测系统及方法能够更加有效、智能地保护无人飞行器。

[0106] 本发明实施例所述无人飞行器续航能力监测系统，所采用的安全电量根据当前位置的坐标信息的变化而实时变化，无需无人飞行器提前返回或提前降落，从而提高电池的利用率。

[0107] 实施例二、一种无人飞行器续航能力监测系统。

[0108] 图2为本发明实施例2的无人飞行器续航能力监测系统结构示意图，本发明实施例将结合图2进行具体说明。

[0109] 如图2所示，本发明实施例提供了一种无人飞行器续航能力监测系统，包括：无人飞行器201和飞控台202，所述无人飞行器进一步包括飞行控制板203、惯性传感器204、第一通信接口205、温度传感器206、电池207、舵机208、电机209和旋翼210，所述飞控台202进一步包括第二通信接口211、中央处理器212、续航能力分析单元213和显示设备214，其中，所述飞行控制板203通过所述第一通信接口205和第二通信接口211连接所述中央处理器212，所述飞行控制板分别与所述惯性传感器204、所述温度传感器206、所述电池207和所述舵机208连接，所述舵机208连接所述电机209，所述电机209连接所述旋翼210，所述中央处理器212分别与所述续航能力分析单元213和所述显示设备214连接。

[0110] 续航能力如果从能耗的角度分析，其根本上取决于能量储备与能量消耗速度，具体到无人飞行器领域，就是电池电量分析与电池电量消耗预测。其中，电池电量分析现有技术中已有很多方法实现，比如电压测量法。但是电量消耗预测就会存在不同的解决方案，如果仍然依据电池的电量使用情况作分析，那么可能成本较高。

[0111] 本发明实施例中优选的，可以根据无人飞行器的不同飞行动作，对无人飞行器电池的能量消耗情况进行统计。利用无人飞行器上的所述惯性传感器即可实现对无人飞行器

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能力消耗情况的预测。例如，无人飞行器在悬停或者巡航飞行时，相对能量消耗较低，但是在全速冲刺、高速变向、转弯以及抗风环境下的飞行等情况下，明显能耗较高。这些动作全部都能经由所述惯性传感器监测得到。

[0112] 综合考虑监测成本与监测效果，下面举例说明本发明实施例所述无人飞行器续航能力监测系统。

[0113] 通过所述惯性传感器实时监测所述无人飞行器的飞行状态，并将所述无人飞行器的飞行状态依次分为四种级别：第一种低耗能，例如类似无风悬停情况下的能耗；第二种中耗能，例如无风巡航飞行、抗3级以下风悬停情况下的能耗；第三种高耗能，例如高速飞行、频繁上升下降情况下的能耗；第四种超高能耗，例如急速冲刺、类似花样飞行那样的频繁高速飞行加急转弯情况下的能耗。

[0114] 分别测定在上述四种能耗级别情况下，所述无人飞行器在满电的情况下，分别能够飞行的平均时长，该时间长度T1至T4为理想状态下的续航时间；然后调整无人飞行器的飞行输出功率和飞行速度，使得在T1至T4这四种时间长度的情况下，正好分别能够将无人飞行器的电力释放完毕的平均飞行速度V1至V4。该飞行速度为不同能耗级别所分别对应的理想续航速度。

[0115] 本发明实施例中优选的，计算所述无人飞行器当前的续航能力的方法具体为：

[0116] 假设电池的总电量为P，电池的当前剩余电量为Pc，P1-4为无人飞行器当前所处的能耗级别为一至四的续航能力：

[0117] 那么，P1的续航能力（即所述无人飞行器当前飞行状态处于能耗级别为第一种低能耗时的续航时间与里程）为：

[0118]

$$续航时间=T1\times\frac{Pc}{P}$$

[0119]

$$续航里程=T1\times V1\times\frac{Pc}{P}$$

[0120] 这样，将不特定的无人飞行器飞行动作近似为较为规律的飞行参数，并能依据所述飞行参数计算续航能力。

[0121] 本发明实施例中优选的，所述惯性传感器可以以一个周期来统计本周期的能耗情况，例如以5秒为一个周期，判定本周期的能耗级别。当然，所述惯性传感器也可以实时检测所述无人飞行器的飞行状态，实时得到当前时刻无人飞行器所处的能耗级别。

[0122] 本发明实施例中优选的，所述惯性传感器将检测到的飞行状态信息传输给所述中央处理器，由所述中央处理器对其进行姿态解算、判定所述无人飞行器当前所对应的能耗级别，所述续航能力分析单元根据当前电池余量情况以及当前能耗级别来预测在本能耗级别的消耗情况下，计算所述无人飞行器还能续航飞行的时间与里程。

[0123] 当本周期结束后，在下一周期，所述无人飞行器重新计算和预测新的续航时间与里程。

[0124] 本发明实施例中优选的，所述续航能力分析单元将该预测结果实时传输给所述飞控台的所述显示设备，向用户显示所述续航飞行时间与里程。当然，本发明实施例并不限于所述显示设备，还可以通过其他方式向用户提示无人飞行器当前的续航飞行时间与里程，

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例如通过语音设备实时或者在预定间隔周期内播报。

[0125] 为了进一步提高上述预测的准确性，还需要提升电池的当前剩余电量的分析准确程度。

[0126] 现在大多数电子设备采用的电量测量方法还比较简单，缺乏精确度。目前主流的检测方法是简单测量电池电压，估算相对应的电池剩余电量。总电量除以 4 或 5，也就是通常能在手机屏幕上看见的 4 格或者 5 格的电量 Bar，这种情况下，每格的精确度即是 25％或者 20％，这样的精度显然无法满足高精度要求的应用。

[0127] 这种电压估测电量的方法通常如下：一块电池在放电的时候，电池的电压会随着电池电量的流失逐渐地下降。这样就可以得到一个比较简单而有效的对应关系，就是电压对应电量。通过电池正常使用（比如 100mA 放电）的放电曲线，对时间进行 4 等分，以充电限制电压为 4.2V 的锂电池为例，可以列出这样一个对应关系，4.20V—100％，3.85V—75％，3.75V—50％，3.60V—25％，3.40V—5％（因为基本不可能完全用光电池的电量，假设该设备的工作电压范围最低是 3.4V，那么一般低于 3.40V 时就可能自动关机了）。

[0128] 很显然，这种精度最高只有 25％。另外，电池电压会随着 RFPA(radio frequency power amplifier，射频功率放大器）的功率发射发生突变，通常会变小 0.2V-0.3V。如果一味的使用电压模拟电量方法，就会误差更大。

[0129] 本发明实施例中优选的，为了解决电池电压突然变小的测量问题，可以利用软件算法进行均值滤波，对一段时间内的电池电压进行均值化，如果该时间段的平均电池电压确实下降了，则预估电量确实变少了，否则即认为电量并未变化。

[0130] 同时再考虑到温度对电池的能力可能产生较大的影响。本发明实施例能够在不同环境温度下，准确的对电池的当前剩余电量统计进行有效补偿，从而得到更为精准的余电分析数据，并进一步为无人飞行器的飞行提供数据支持。

[0131] 通常，在低温环境下，物质的活动倾向于更为不活跃，对于电池而言，其相应的充放电能力、充放电速度都会受到影响。由于无人飞行器上使用电池作为动力，无人飞行器在不同环境温度下，需要的动力情况差别不大，也就是意味着电池的输出功率差别不大，那么低温环境下，由于电池的蓄电能力降低，必然导致无人飞行器的续航能力降低，但是这种降低在传统技术中，并不考虑其影响。因此，导致在不同环境温度下，对无人飞行器的续航能力估计不够准确。

[0132] 本发明实施例中优选的，可以通过查找表法 (Look Up Table) 来对电池的当前剩余电量统计进行有效补偿。

[0133] 具体的，利用温度补偿的思路，给予在不同环境温度下测试得到的电池余量与电压之间关系的查找表，能够在一定程度上，解决无人飞行器电池余量估计不准确的问题。

[0134] 查找表示例如下表 1 所示：

[0135]

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	100%	75%	50%	25%	5%
电压（V）常温	4.20	3.85	3.75	3.60	3.40
电压（V）高温	4.51	4.14	3.97	3.81	3.59
电压（V）低温	3.94	3.58	3.45	3.35	3.23

[0136] 表 1 温度与电池的当前剩余电量之间的查找表

[0137] 作为本申请的一个示例，这里的高温一般是 30 摄氏度以上，常温就是 15-25 摄氏度之间，低温一般指 0 摄氏度左右。当然，具体的温度设置是可以随着具体应用环境变化而改变的，在此并不构成对本发明的限制。

[0138] 本发明实施例中优选的，还可以通过参数法来对电池的当前剩余电量统计进行有效补偿。

[0139] 具体的，将温度传感器测得的环境温度作为一个变量，在考虑该变量影响的情况下，去针对电池余量数据进行补偿，也能够一定程度上解决无人飞行器电池余量估计不准确的问题。其原理为：由于温度的变化与电池能力在一定范围内是正相关的，即温度越高电池能力越高，所以该变量对电池余量分析结果的影响也是正相关的。具体的，所述正相关关系与电池所使用的材料以及具体构成有关。例如，在电池不损坏的前提下都是正相关，一般来说电池的极限工作温度是 -40 摄氏度到 75 摄氏度，但是正常工作温度 0 到 40 摄氏度比较正常。

[0140] 本发明实施例中优选的，所述温度传感器是测量电池的工作温度的，所以一般是贴着电池安置的，测得的温度比环境温度通常会高一些，不过温度传感器的具体位置并不对本发明构成限制，也可以是其他放置方式。

[0141] 本发明实施例中优选的，所述存储模块 209 可以是但不局限于随机存取存储器（RAM）和 / 或闪存。所述存储模块 209 的大小可以根据需求的功能定制。

[0142] 本发明实施例公开了一种无人飞行器续航能力监测系统，基于无人飞行器能耗情况，将传统的电池余量提示功能升级为续航时间和续航里程的提示，并且这种提示是基于无人飞行器这样一种特殊的工作模式，将无人飞行器不规则的飞行过程，利用惯性传感器的监测数据，转化为可量化的指标，根据对无人飞行器的能耗分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和 / 或续航距离标识出来。对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0143] 本发明实施例中其它内容参见上述发明实施例中的内容，在此不再赘述。

[0144] 实施例三、一种无人飞行器续航能力监测方法。

[0145] 图 3 为本发明实施例三的无人飞行器续航能力监测方法流程图，本发明实施例将结合图 3 进行具体说明。

[0146] 如图 3 所示，本发明实施例提供了一种无人飞行器续航能力监测方法，所述无人

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飞行器利用电池供电，包括以下步骤：

[0147] 步骤 S301：采集电池信息；

[0148] 步骤 S302：采集无人飞行器的能耗信息；

[0149] 步骤 S303：根据所述电池信息和所述能耗信息，获得所述无人飞行器的续航能力。

[0150] 本发明实施例中优选的，所述采集步骤之前还包括预定义能耗级别步骤，具体包括以下步骤：

[0151] 所述无人飞行器的飞行状态分别对应预设数量的能耗级别；

[0152] 分别测定各个能耗级别，所述无人飞行器满电情况下的理想续航时间；

[0153] 分别测定所述无人飞行器在不同能耗级别下的平均飞行速度；

[0154] 存储所述无人飞行器的预定义的能耗级别及相应能耗级别对应的理想续航时间和 / 或平均飞行速度。

[0155] 本发明实施例中优选的，所述电池信息包括所述电池的总电量和电池的当前剩余电量。

[0156] 本发明实施例中优选的，还包括温度补偿步骤，具体包括以下步骤：

[0157] 采集所述电池的环境温度；

[0158] 利用所述环境温度对所述电池信息进行补偿计算，获得修正后的电池信息。

[0159] 本发明实施例公开了一种无人飞行器续航能力监测方法，基于无人飞行器能耗情况，将传统的电池余量提示功能升级为续航时间和续航里程的提示，并且这种提示是基于无人飞行器这样一种特殊的工作模式，将无人飞行器不规则的飞行过程，利用惯性传感器的监测数据，转化为可量化的指标，根据对无人飞行器的能耗分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和 / 或续航距离标识出来。对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0160] 本发明实施例中其它内容参见上述发明实施例中的内容，在此不再赘述。

[0161] 实施例四、一种无人飞行器续航能力监测方法。

[0162] 图 4 为本发明实施例四的无人飞行器续航能力监测方法流程图，本发明实施例将结合图 4 进行具体说明。

[0163] 如图 4 所示，本发明实施例提供了一种无人飞行器续航能力监测方法，该方法包括以下步骤：

[0164] 步骤 S401：开始；

[0165] 步骤 S402：采集电池信息；

[0166] 步骤 S403：采集能耗信息；

[0167] 步骤 S404：根据所述电池信息和所述能耗信息，计算所述无人飞行器的续航能力；

[0168] 步骤 S405：输出续航时间与续航里程；

[0169] 步骤 S406：显示所述续航时间与续航里程；

[0170] 步骤 S407：计时判断是否超时？如果超时，则跳回到步骤 S401，反之，跳回到步骤 S406。

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[0171] 本发明实施例中优选的，所述步骤 S404 中计算所述无人飞行器当前的续航能力的方法具体为：

[0172] 假设电池的总电量为 P，电池的当前剩余电量为 Pc，P1-4 为无人飞行器当前所处的能耗级别为一至四的续航能力；

[0173] 那么，P1 的续航能力（即所述无人飞行器当前飞行状态处于能耗级别为第一种低能耗时的续航时间与里程）为：

[0174]

$$续航时间=T1\times\frac{Pc}{P}$$

[0175]

$$续航里程=T1\times V1\times\frac{Pc}{P}。$$

[0176] 本发明实施例公开了一种无人飞行器续航能力监测方法，基于无人飞行器能耗情况，将传统的电池余量提示功能升级为续航时间和续航里程的提示，并且这种提示是基于无人飞行器这样一种特殊的工作模式，将无人飞行器不规则的飞行过程，利用惯性传感器的监测数据，转化为可量化的指标，根据对无人飞行器的能耗分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和 / 或续航距离标识出来。对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0177] 本发明实施例中其它内容参见上述发明实施例中的内容，在此不再赘述。

[0178] 本发明可以带来这些有益的技术效果：本发明实施例公开的无人飞行器续航能力监测系统及方法，基于无人飞行器能耗情况，将传统的电池余量提示功能升级为续航时间和续航里程的提示，并且这种提示是基于无人飞行器这样一种特殊的工作模式，将无人飞行器不规则的飞行过程，利用惯性传感器的监测数据，转化为可量化的指标，根据对无人飞行器的能耗分析，来准确估算无人飞行器的续航能力，并将其续航能力用续航时间和 / 或续航距离标识出来。对于无人飞行器续航能力的评估还考虑到了环境温度对于电池能效的影响，进一步提高了无人飞行器续航能力预测的准确性。

[0179] 显然，本领域的技术人员可以对本发明进行各种改动和变型而不脱离本发明的精神和范围。这样，倘若本发明的这些修改和变型属于本发明权利要求及其等同技术的范围之内，则本发明也意图包含这些改动和变型在内。

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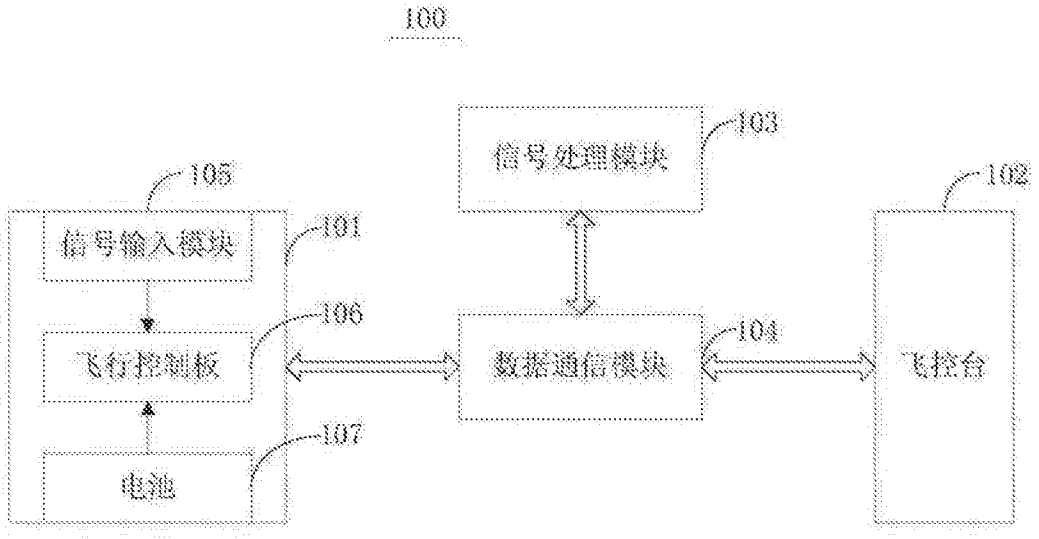


图 1

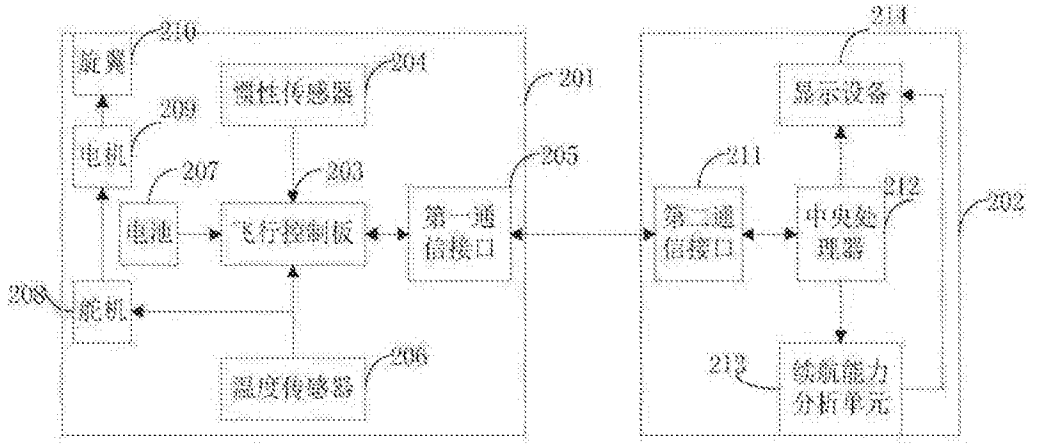


图 2

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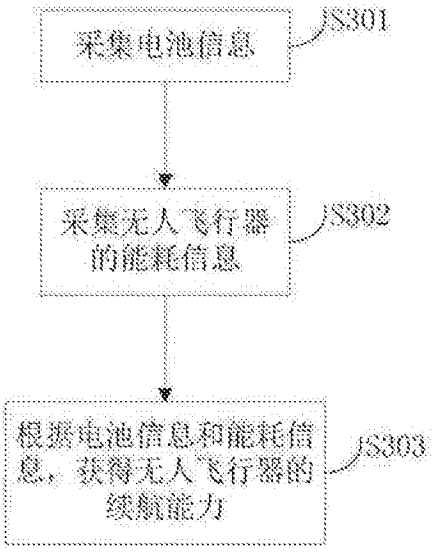


图 3

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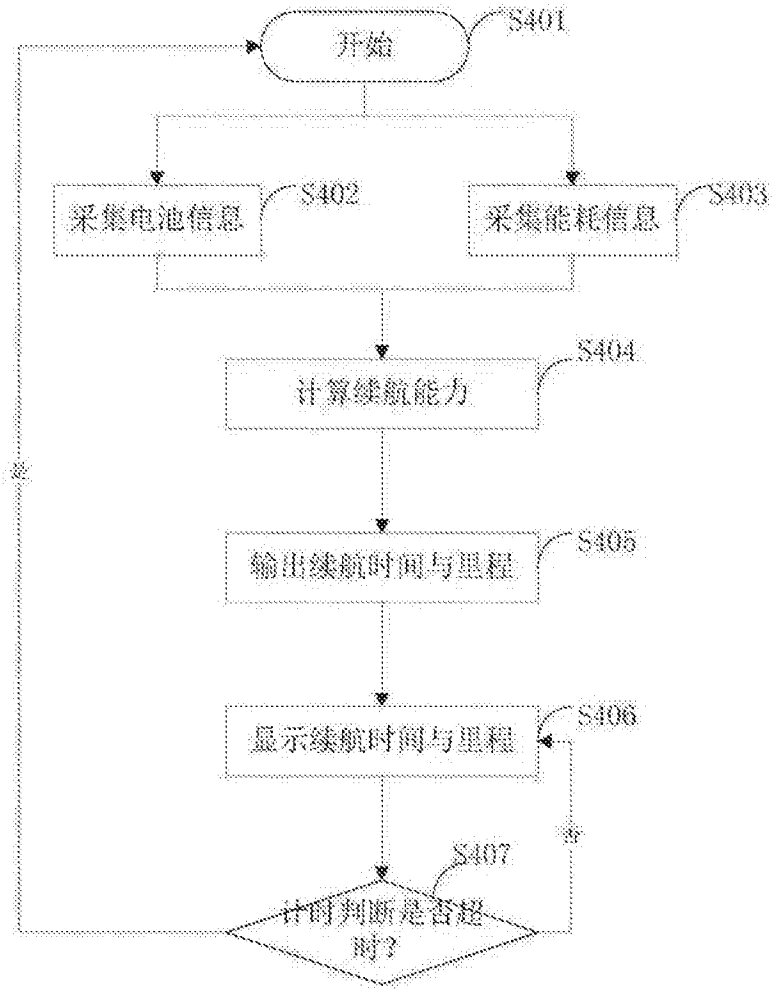


图 4

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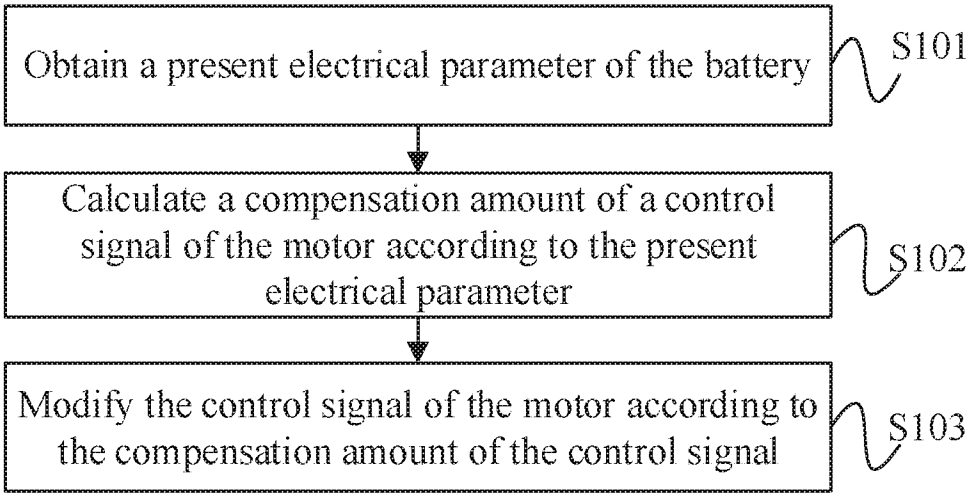

Obtain a present electrical parameter of the battery
S101
Calculate a compensation amount of a control signal of the motor according to the present electrical parameter
S102
Modify the control signal of the motor according to the compensation amount of the control signal
S103

FIG. 1

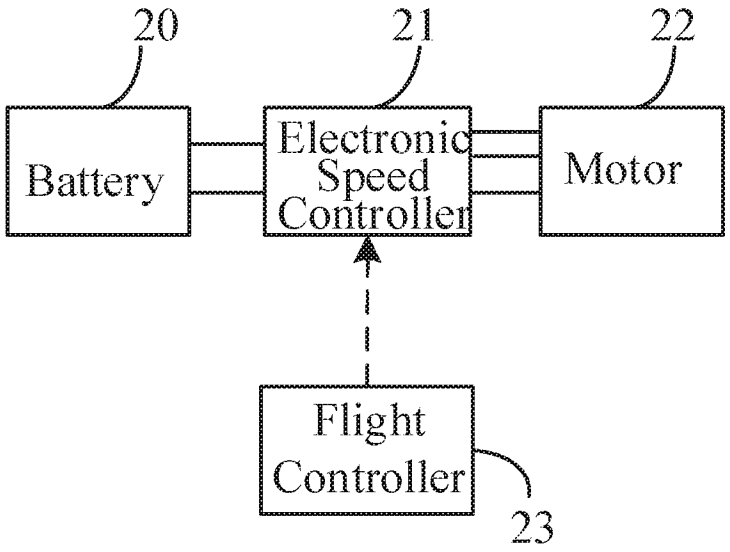

20
21
22
Battery
Electronic Speed Controller
Motor
Flight Controller
23

FIG. 2

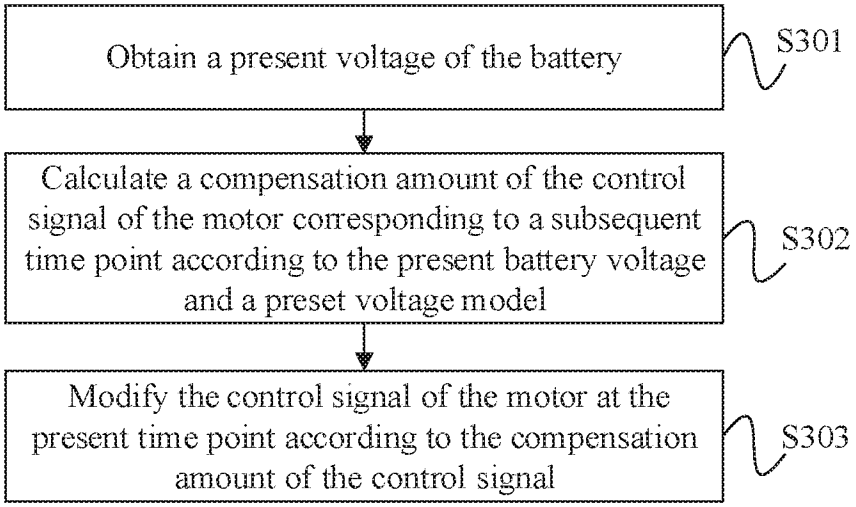

Obtain a present voltage of the battery
S301
Calculate a compensation amount of the control signal of the motor corresponding to a subsequent time point according to the present battery voltage and a preset voltage model
S302
Modify the control signal of the motor at the present time point according to the compensation amount of the control signal
S303

FIG. 3

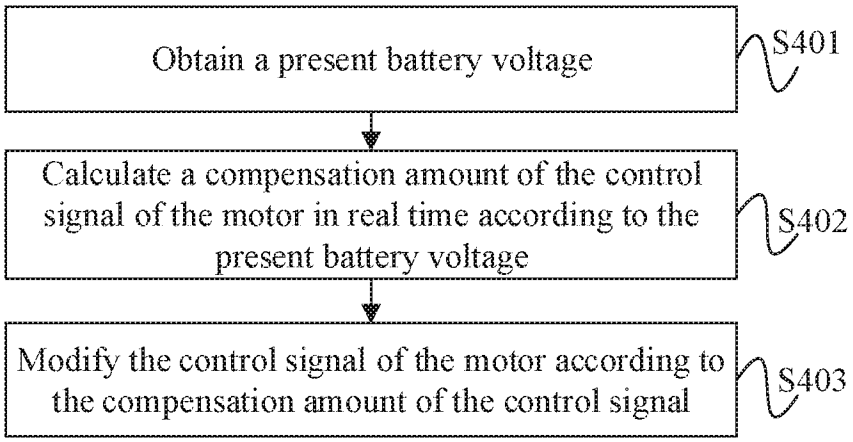

Obtain a present battery voltage
S401
Calculate a compensation amount of the control signal of the motor in real time according to the present battery voltage
S402
Modify the control signal of the motor according to the compensation amount of the control signal
S403

FIG. 4

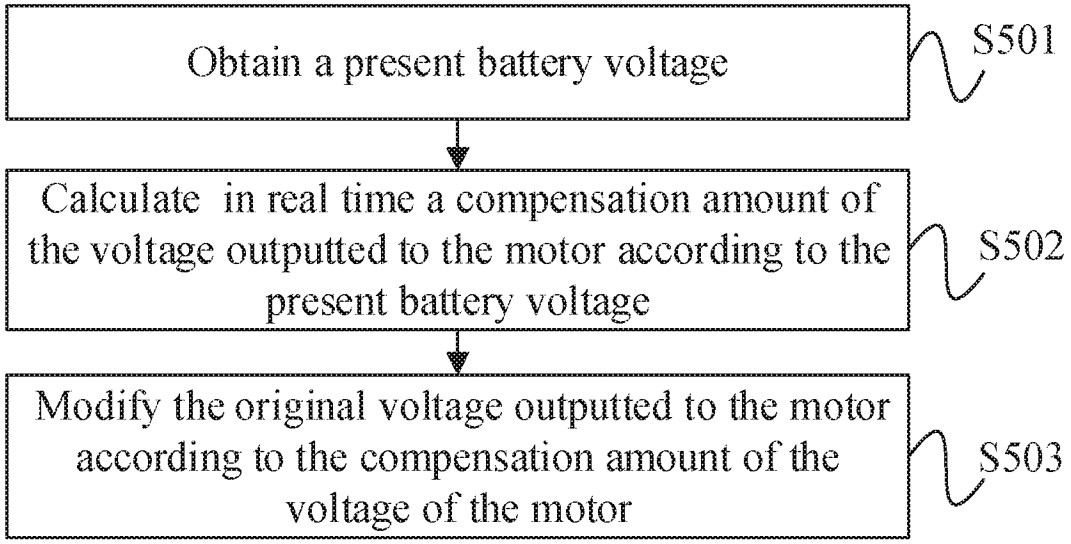

Obtain a present battery voltage
S501
Calculate in real time a compensation amount of the voltage outputted to the motor according to the present battery voltage
S502
Modify the original voltage outputted to the motor according to the compensation amount of the voltage of the motor
S503

FIG. 5

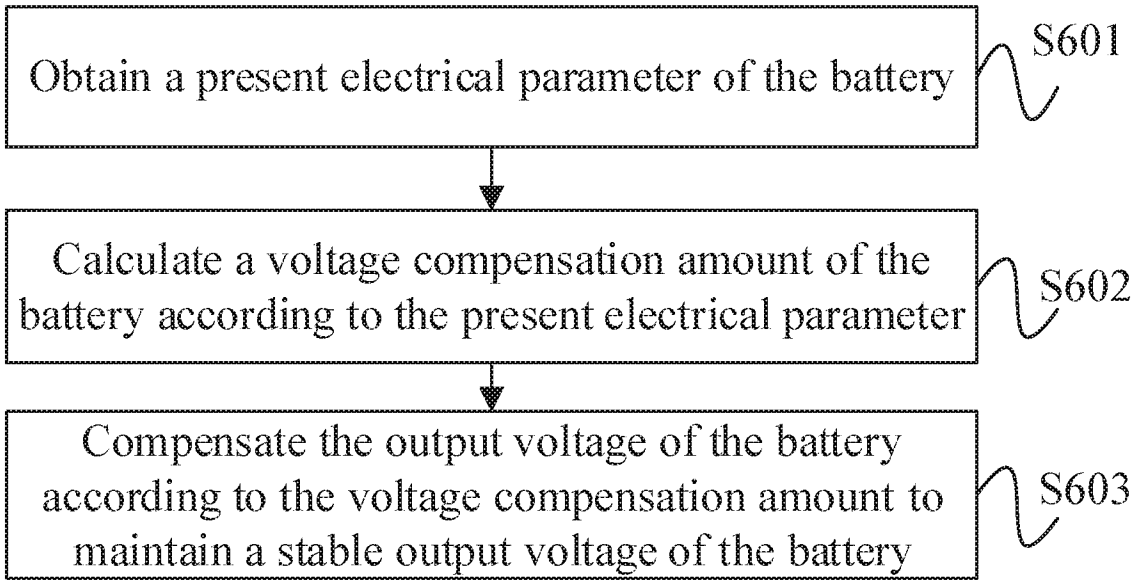

Obtain a present electrical parameter of the battery
S601
Calculate a voltage compensation amount of the battery according to the present electrical parameter
S602
Compensate the output voltage of the battery according to the voltage compensation amount to maintain a stable output voltage of the battery
S603

FIG. 6

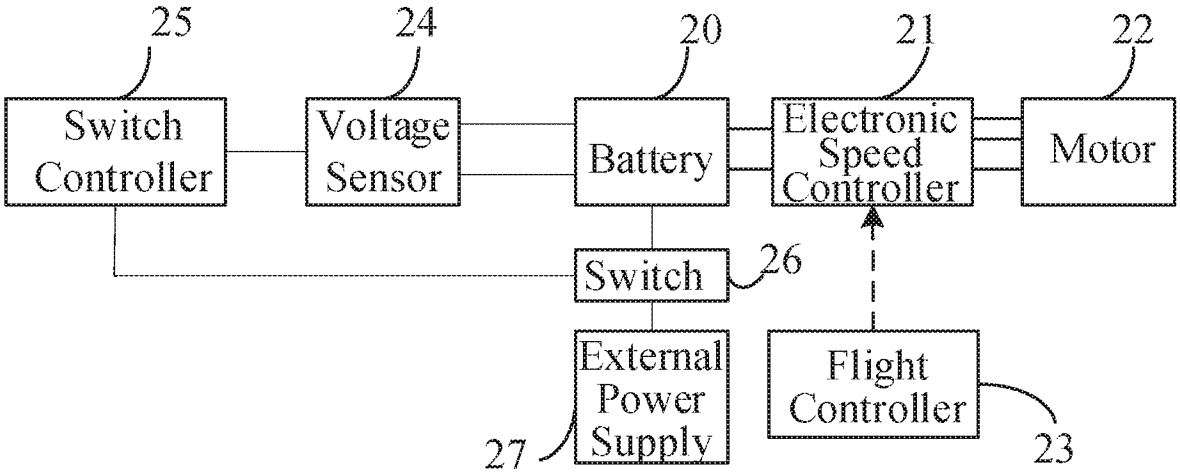

25
24
20
21
22
Switch Controller
Voltage Sensor
Battery
Electronic Speed Controller
Motor
Switch
26
External Power Supply
27
Flight Controller
23

FIG. 7

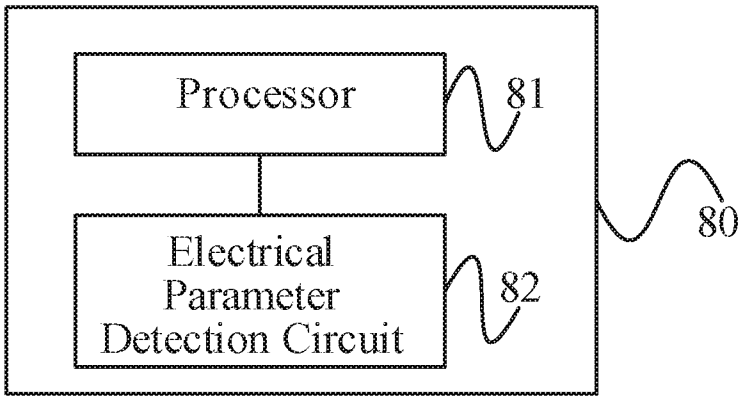

Processor
81
Electrical Parameter Detection Circuit
82
80

FIG. 8

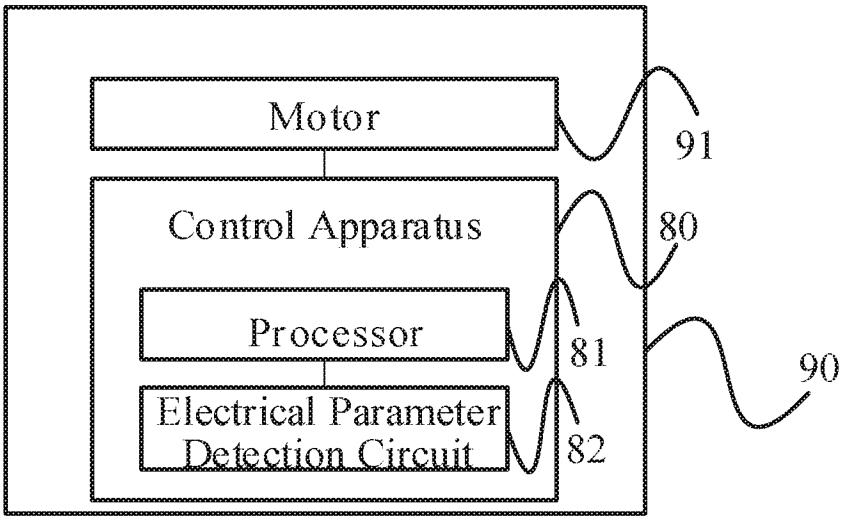

Motor
91
Control Apparatus
80
Processor
81
90
Electrical Parameter Detection Circuit
82

FIG. 9

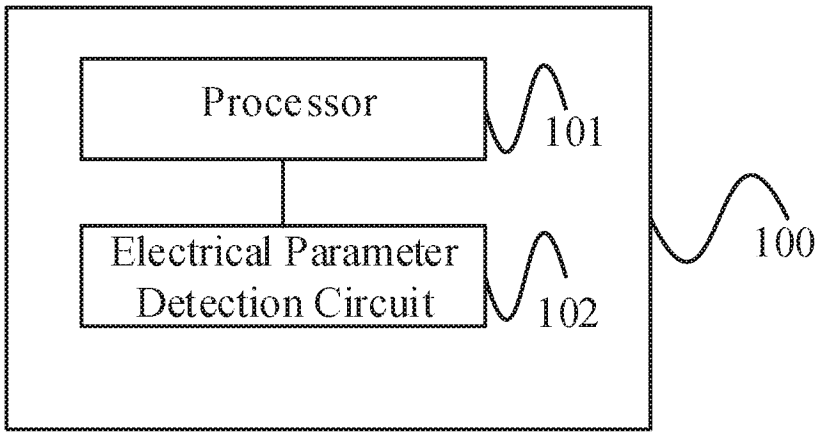

Processor
101
Electrical Parameter Detection Circuit
102
100

FIG. 10

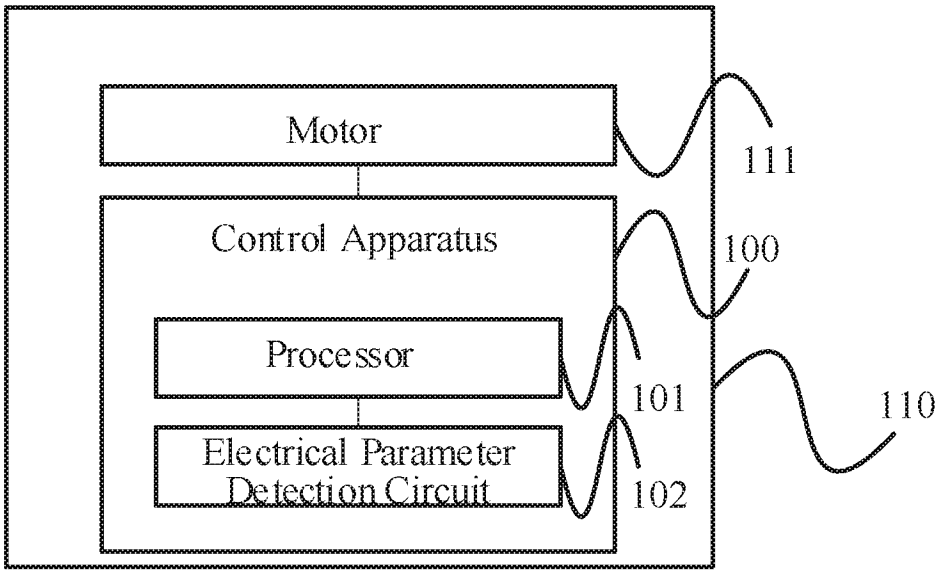

Motor
111
Control Apparatus
100
Processor
101
110
Electrical Parameter Detection Circuit
102

FIG. 11

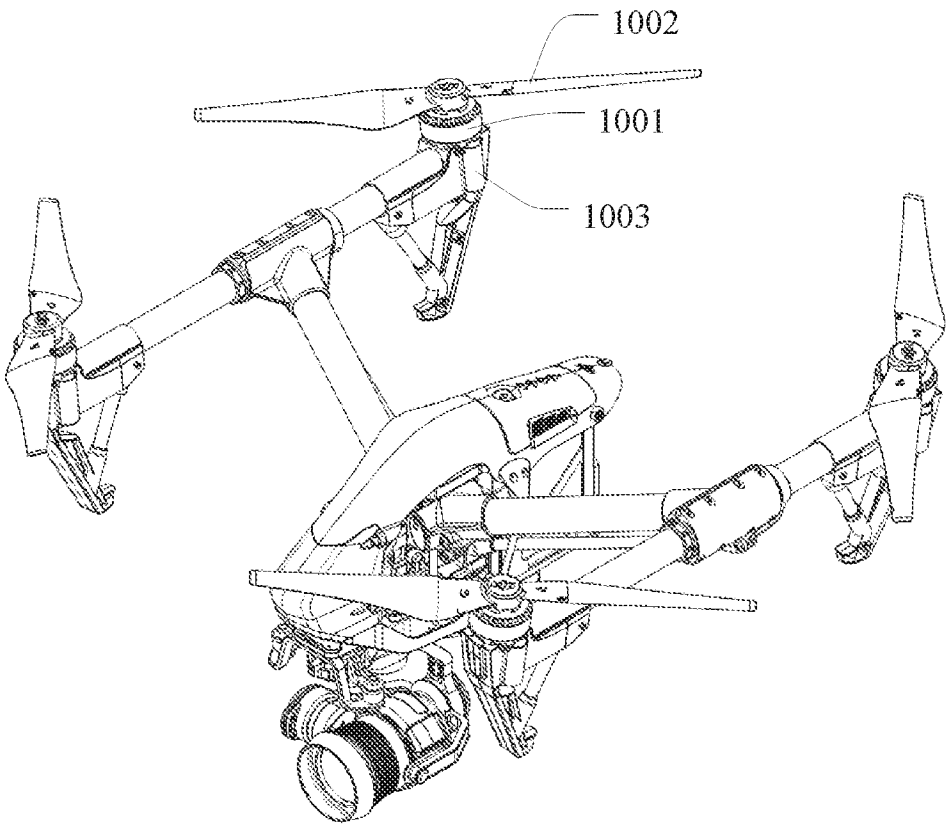


FIG. 12

CLAIMS

WHAT IS CLAIMED IS:

1. A method for controlling a motor comprising:

obtaining a present electrical parameter of a battery;

calculating a compensation amount of a control signal of the motor according to the present electrical parameter; and

modifying the control signal according to the compensation amount.

2. The method according to claim 1, wherein the present electrical parameter includes at least one of a present charge quantity of the battery, a present voltage of the battery, a present output electrical current of the battery, or a present internal resistance of the battery.

3. The method according to claim 2, wherein the control signal includes at least one of a control signal configured to control a rotation speed of the motor or a control signal configured to control an output power of the motor.

4. The method according to claim 3, wherein:

the present electrical parameter of the battery includes the present voltage of the battery; and

calculating the compensation amount includes:

calculating the compensation amount of the control signal of the motor corresponding to a subsequent time point according to the present voltage of the battery

Textron Specialized Vehicles Inc., Exh. 1003, p. 399

and a preset voltage model including one-to-one correspondences between voltages of the battery and preset compensation amounts.

5. The method according to claim 4, wherein modifying the control signal includes:

modifying, at a present time point, the control signal according to the compensation amount.

6. The method according to claim 3, wherein:

the present electrical parameter of the battery includes the present voltage of the battery; and

calculating the compensation amount of the control signal of the motor includes:

calculating in real time the compensation amount of the control signal of the motor according to the present voltage of the battery.

7. The method according to claim 6, wherein:

calculating in real time the compensation amount of the control signal includes:

calculating in real time a compensation amount of a voltage outputted to the motor according to the present voltage of the battery; and

modifying the control signal includes:

modifying an original voltage outputted to the motor according to the compensation amount of the voltage.

Textron Specialized Vehicles Inc., Exh. 1003, p. 400

8. The method according to claim 7, wherein the compensation amount of the voltage is determined according to a difference between a full voltage of the battery and the present voltage of the battery.

9. A method for controlling a motor comprising:

obtaining a present electrical parameter of a battery;

calculating a voltage compensation amount of the battery according to the present electrical parameter; and

compensating an output voltage of the battery according to the voltage compensation amount to maintain the output voltage of the battery stable.

10. The method according to claim 9, wherein the present electrical parameter of the battery includes at least one of a present charge quantity of the battery, a present voltage of the battery, a present output electrical current of the battery, or a present internal resistance of the battery.

11. The method according to claim 10, wherein:

the present electrical parameter of the battery includes the present voltage of the battery; and

calculating the voltage compensation amount of the battery includes:

calculating the voltage compensation amount of the battery according to the present voltage of the battery and a full voltage of the battery, the voltage compensation amount being equal to a difference between the full voltage and the present voltage.

Textron Specialized Vehicles Inc., Exh. 1003, p. 401

12. An apparatus for controlling a motor comprising:

one or more processors configured to:

obtain a present electrical parameter of a battery;

calculate a compensation amount of a control signal of the motor according to the present electrical parameter; and

modify the control signal according to the compensation amount.

13. The apparatus according to claim 12, further comprising:

an electrical parameter detection circuit electrically coupled to the one or more processors and configured to detect the present electrical parameter.

14. The apparatus according to claim 13, wherein the electrical parameter detection circuit includes at least one of a coulometer, a voltage detection circuit, an electrical current detection circuit, or a resistance detection circuit.

15. The apparatus according to claim 14, wherein the one or more processors are further configured to:

calculate the compensation amount of the control signal of the motor corresponding to a subsequent time point according to the present voltage of the battery and a preset voltage model including one-to-one correspondences between voltages of the battery and preset compensation amounts; and

modify, at a present time point, the control signal according to the compensation amount.

Textron Specialized Vehicles Inc., Exh. 1003, p. 402

16. The apparatus according to claim 14, wherein the one or more processors are further configured to:

calculate in real time the compensation amount of the control signal of the motor according to the present voltage of the battery.

17. The apparatus according to claim 16, wherein the one or more processors are further configured to:

calculate in real time a compensation amount of a voltage outputted to the motor according to the present voltage of the battery; and

modify an original voltage outputted to the motor according to the compensation amount of the voltage outputted to the motor.

Textron Specialized Vehicles Inc., Exh. 1003, p. 403

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

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
	Changxing		ZHOU	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Shenzhen	Country of Residence [i]	CN

Mailing Address of Inventor:

Address 1	17/F West Wing, Skyworth Semiconductor Design Bldg
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City	Shenzhen
State/Province	
Postal Code	518057
Country [i]	CN

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Qiu		LAN	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Shenzhen	Country of Residence [i]	CN

Mailing Address of Inventor:

Address 1	17/F West Wing, Skyworth Semiconductor Design Bldg
Address 2	No. 18 Gaoxin South 4th Avenue, Nanshan District
City	Shenzhen
State/Province	
Postal Code	518057
Country [i]	CN

Inventor 3 Remove

Legal Name

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jinyun		NI	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Shenzhen	Country of Residence i	CN

Mailing Address of Inventor:

Address 1	17/F West Wing, Skyworth Semiconductor Design Bldg		
Address 2	No. 18 Gaoxin South 4th Avenue, Nanshan District		
City	Shenzhen	State/Province	
Postal Code	518057	Country i	CN

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	136725		
Email Address	uspto@anovalaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM		
Attorney Docket Number	00203.3030.00US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	Suggested Figure for Publication (if any)	

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 i

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

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	136725		

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 benefit claim 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" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCT/CN2016/075097	2016-03-01

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)[i] 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).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

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. ☒

Organization Name	SZ DJI TECHNOLOGY CO., LTD.		
Mailing Address Information For Applicant:			
Address 1	17/F West Wing, Skyworth Semiconductor Design Bldg		
Address 2	No. 18 Gaoxin South 4th Avenue, Nanshan District		
City	Shenzhen	**State/Province**	
Country	CN	Postal Code	518057
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

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			

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Signature:

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NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Li Jiang/			Date (YYYY-MM-DD)	2018-08-29
First Name	Li	Last Name	Jiang	Registration Number	74191

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	00203.3030.00US
	Application Number	
Title of Invention	MOTOR CONTROL METHOD, APPARATUS, AND SYSTEM	

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ABSTRACT

A method for controlling a motor includes obtaining a present electrical parameter of a battery, calculating a compensation amount of a control signal of the motor according to the present electrical parameter, and modifying the control signal according to the compensation amount.

Textron Specialized Vehicles Inc., Exh. 1003, p. 413