Title: BACK-EMF DETECTION FOR MOTOR CONTROL

Abstract: Systems, methods, and other embodiments associated with back-EMF detection for motor control are described. In an embodiment, an apparatus includes a drive circuit configured to apply excitation signals to respective inputs of a motor, a signal inhibit circuit configured to convey a signal to inhibit application of the excitation signals during an interval, and a measuring circuit configured to measure a back-electromotive force (EMF) signal crossing a reference signal during the interval.

Figure 1
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(88) Date of publication of the international search report: 28 March 2013

Published:
— with international search report (Art. 21(3))
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02P6/18

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)

H02P

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)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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* 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

"Z" document member of the same patent family

Date of the actual completion of the international search

17 January 2013

Date of mailing of the international search report

28/01/2013

Name and mailing address of the ISA

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Authorized officer

Schurle, Patrick

Form PCT/ISA/210 (second sheet) (April 2005)
<table>
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### Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

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

2. [x] Claims Nos.: 9-19  
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:  
   see FURTHER INFORMATION sheet PCT/ISA/210

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

### Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

1. [x] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

#### Remark on Protest

- [ ] The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.
- [ ] The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- [ ] No protest accompanied the payment of additional search fees.
Continuation of Box 11.2

Claims Nos.: 9-19

Present claims 9-19 relate to a method, wherein a motor control ler inhibits the excitation outputs to a motor for all phases at a random point of time (fig. 3.4,5; [0036],[0040]), which leads to an exponential decay of the back-EMF (fig. 3.4,5; [0037],[0039]), and a determination of a time between the beginning of the inhibited and crossing of the back-EMF voltage with a reference voltage (fig. 3.4,5; [0037],[0040]). However, the description does not provide support and disclosure in the sense of Article 6 and 5 PCT for any such method having the said property or effect and there is no common general knowledge of this kind available to the person skilled in the art. This non-compliance with the substantive provisions is to such an extent, that the search was performed taking into consideration the non-compliance in determining the extent of the search of the claim (PCT Guidelines 9.19 and 9.20). For the following reasons, the extent of the search was consequently limited to claims 1-8. The description discloses an exponential decay of the back-EMF (fig. 3.4,5; [0037],[0039]) between time intervals 0 and 1 for all phases, when the driving voltage of the phases is in a high impedance state, which is an open-circuit state. First of all, it is not clear how the disclosed back-EMF curve could occur, because the back-EMF signal is essentially sinusoidal for each phase and for a three-phase motor, as disclosed, additional, the back-EMF signal s are shifted for 120 electrical degrees. Furthermore, the disclosed exponential characteristics of the current decay, which is not disclosed in the application, and which would be superimposed by the sinusoidal back-EMF signal anyway. As a result, the disclosure of the application does not meet the requirements of Article 6 PCT, because it is not clear how such an exponential and simultaneous characteristics of the back-EMF signal s could occur. Even though, the disclosed back-EMF signal characteristics of the current would occur, the time interval 0-1 between the beginning of the inhibited and crossing of the back-EMF voltage with a reference voltage, namely the star point voltage, does not indicate any angular displacement, as disclosed in the application ([0036]), because the inhibited at time 0 is no defined point of the driving voltage signal (fig. 2) and therefore randomly chosen. An angular displacement could only be detected when the driving voltage signal and the back-EMF signal for the same phase are shifted in relation to a defined point in the sinusoidal period, e.g., zero crossing. Even if the above mentioned time interval 0-1 would be an indication of an angular displacement, the application does not disclose how to calculate an angular displacement dependent on the time interval 0-1. Additionally, the application discloses a determination of a time interval 0-1 between the beginning of the inhibited and crossing of the back-EMF voltage with a reference voltage simultaneously for all three phases, which does not allow a defined determination of a displacement for one phase. Hence, the disclosure of the application does not meet the requirements of Article 6 PCT, because it is not clear how the disclosed determination of the time interval 0-1 could be an indication of an angular displacement. Even if, the disclosure in the application would exist, contrary to the arguments in paragraphs [link to #id] and [link to #id2], the application does not
disclose how to "modify the excitation signal so as to align with the angular displacement of the rotor within the motor" ([0037]). The description only discloses to restart "the excitation signal [...] as a result of determining the time between the beginning of the interval and the crossing of the excitation signal " ([0040]), but it is not disclosed at which sample of table 1 (p.9) the excitation signal is restarted or how the excitation signal is modified, in order to correct the angular displacement. Hence, the disclosure of the application does not meet the requirements of Article 17(2) PCT, because it is not disclosed how to carry out the correction of the detected angular displacement.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EP0 policy when acting as an International Preliminary Examination Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EP0, the applicant is reminded that a search may be carried out during examination before the EP0 (see EP0 Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.