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(71) Applicant: **ALLEGRO MICROSYSTEMS, LLC** [US/US]; 115 Northeast Cutoff, Worcester, Massachusetts 01606 (US).

(72) Inventors: **BURDETTE, Eric**; 16276 NW 100th Avenue Road, Reddick, Florida 32686 (US). **DAVID, Paul, A.**; 10 Risingwood Drive, Bow, New Hampshire 03304 (US). **GRAHAM, Christine, M.**; 13 Stoney Brook Road, Bow, New Hampshire 03304 (US). **PRENTICE, Seth**; 5 Benjamin Way, Epping, New Hampshire 03042 (US).

(74) Agent: **ROBINSON, Kermit** et al.; Daly, Crowley, Mofford & Durkee, LLP, Suite 301A, 354A Turnpike Street, Canton, MA 02021 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,

(54) Title: MAGNETIC FIELD SENSORS AND OUTPUT SIGNAL FORMATS FOR A MAGNETIC FIELD SENSOR

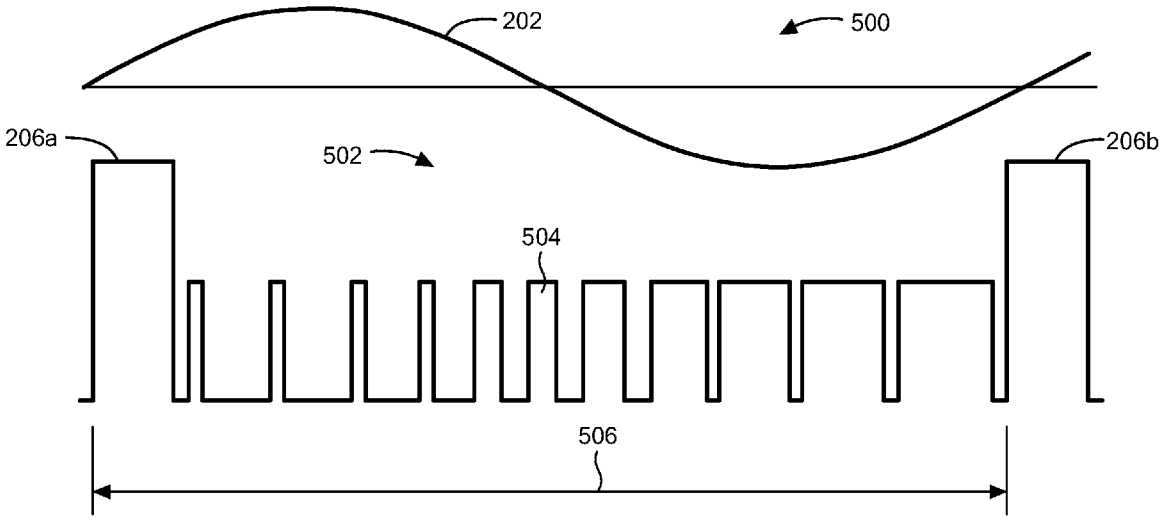

FIG. 5

(57) Abstract: An apparatus and a method provide an output signal indicative of a speed of rotation and/or a direction of movement of a ferromagnetic object having ferromagnetic features and capable of moving. A variety of signal formats of the output signal are described, each of which have pulses at a rate faster than the ferromagnetic features pass by the magnetic field sensor. The output signal can comprise PWM pulses having pulse widths changing in relation to the current amplitude of the field signal. The output signal can comprise PWM pulses having a width linearly increasing or decreasing within a period of the field signal. The output signal can comprise a predetermined number of pulses within each period of the signal. The field signal from two channels can be converted to a phase value using a CORDIC module generating an arctan signal. This arctan signal can be subsequently compared with a number of thresholds. The output signal can comprise pulses having a fixed frequency independent of the speed, within each period of the field signal.

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[Continued on next page]

PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/032840

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

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

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

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

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

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

see additional sheet

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

2. ☐ As all searchable claims could be searched without effort justifying 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.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/032840

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01P3/489 G01P13/04
ADD.

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)
G01P

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/116664 A1 (SHIBATA KIYOTAKE [JP]) 10 May 2012 (2012-05-10)	1,9-11, 19-21, 29,30
Y	paragraphs [0005], [0013], [0014], [0025], [0032] - [0036], [0078] - [0083], [0110], [0111]; figures 2,8,9-11,16	1-30

X	US 5 019 773 A (SUGIURA YASUYUKI [JP] ET AL) 28 May 1991 (1991-05-28)	1-3, 9-13, 19-23, 29,30
Y	column 2, line 41 - column 5, line 56; claims 1,3; figures 7,13 column 8, line 1 - column 8, line 42	1-30

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[X] Further documents are listed in the continuation of Box C.

[X] 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
23 October 2017	07/11/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Felicetti, Christoph

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/032840

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 1 600 741 A2 (BEI SENSORS & SYSTEMS CO [US]) 30 November 2005 (2005-11-30) paragraphs [0003] - [0007], [0014] - [0019], [0027], [0033] - [0036]	4,5,14, 15,24,25 4,5,14, 15,24,25
Y	US 2006/136171 A1 (KASTER ROBERT [US] ET AL) 22 June 2006 (2006-06-22) abstract paragraphs [0038] - [0041]	4,5,14, 15,24,25
Y	US 6 788 221 B1 (ELY DAVID T [GB] ET AL) 7 September 2004 (2004-09-07) column 1, line 24 - column 1, line 54 column 28, line 37 - column 29, line 7; figures 56a,56b	4,5,14, 15,24,25
X Y	GB 2 018 538 A (HAWKER SIDDELEY DYNAMICS ENG) 17 October 1979 (1979-10-17) page 1, line 10 - page 1, line 65	6,16,26 6,16,26
Y	US 5 138 640 A (FLECK ROD [DE] ET AL) 11 August 1992 (1992-08-11) column 1, line 9 - column 2, line 2 column 3, line 17 - column 4, line 66	6,16,26
X Y	US 5 442 313 A (SANTOS A JOHN [US] ET AL) 15 August 1995 (1995-08-15) column 1, line 5 - column 2, line 61; figure 2 column 5, line 6 - column 5, line 40	7,17,27 7,17,27
X Y	DE 35 35 842 A1 (BOSCH GMBH ROBERT [DE]) 9 April 1987 (1987-04-09) column 1, line 65 - column 2, line 50 column 3; figures 1,2	7,17,27 7,17,27
Y	US 2015/263659 A1 (CHI MIN HUN [KR]) 17 September 2015 (2015-09-17) paragraphs [0022] - [0031]; figures 1,2	8,18,28

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/032840

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-3, 9-13, 19-23, 29, 30

   Magnetic field sensor outputting a signal having at least four state transitions or two pulses for each period of the magnetic field signal, representative of at least a rate of movement of a ferromagnetic object, and corresponding method of generating an output signal.
   Dependent claims 2,3,12,13,22,23 relating to a design alternative using a plurality of PWM pulses having pulse widths changing in relation to an amplitude of the magnetic field signal.
   Dependent claims 9,19,29 relating to a switching to a different output signal at high speed.

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2. claims: 4, 5, 14, 15, 24, 25

   Magnetic field sensor outputting a signal having at least four state transitions or two pulses for each period of the magnetic field signal, representative of at least a rate of movement of a ferromagnetic object, and corresponding method of generating an output signal.
   Dependent claims 4,5,14,15,24,25 relating to a design alternative using PWM pulses having pulse widths changing linearly within each magnetic field signal period.

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3. claims: 6, 16, 26

   Magnetic field sensor outputting a signal having at least four state transitions or two pulses for each period of the magnetic field signal, representative of at least a rate of movement of a ferromagnetic object, and corresponding method of generating an output signal.
   Dependent claims 6,16,26 relating to a design alternative having a predetermined number of pulses within each period of the magnetic field signal, which need not be PWM pulses.

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4. claims: 7, 17, 27

   Magnetic field sensor outputting a signal having at least four state transitions or two pulses for each period of the magnetic field signal, representative of at least a rate of movement of a ferromagnetic object, and corresponding method of generating an output signal.
   Dependent claims 7,17,27 relating to a design alternative having a plurality of threshold pulses, each pulse occurring proximate to a time when the magnetic field signal crosses a respective threshold.

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5. claims: 8, 18, 28

Magnetic field sensor outputting a signal having at least four state transitions or two pulses for each period of the magnetic field signal, representative of at least a rate of movement of a ferromagnetic object, and corresponding method of generating an output signal.
Dependent claims 8,18,28 relating to a design alternative having a plurality of pulses equidistant from each other in time within a period of the magnetic field signal, their number varying in accordance with the speed of movement.
