US009429660B2

(12) **United States Patent**
Luo et al.

(10) **Patent No.: US 9,429,660 B2**
(45) **Date of Patent: Aug. 30, 2016**

(54) **SINGLE ANTENNA GPS MEASUREMENT OF ROLL RATE AND ROLL ANGLE OF SPINNING PLATFORM**

(75) Inventors: **Jianhui Luo**, Wayland, MA (US); **Wallace E. Vander Velde**, Winchester, MA (US); **Huan-Wan Tseng**, Westford, MA (US); **Triveni N. Upadhyay**, Concord, MA (US)

(73) Assignee: **Mayflower Communications Company, Inc.**, Bedford, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1129 days.

(21) Appl. No.: **13/374,551**

(22) Filed: **Jan. 3, 2012**

(65) **Prior Publication Data**

US 2013/0169477 A1 Jul. 4, 2013

(51) **Int. Cl.**
G01S 19/54 (2010.01)
G01S 19/53 (2010.01)

(52) **U.S. Cl.**
CPC ***G01S 19/54*** (2013.01); ***G01S 19/53*** (2013.01)

(58) **Field of Classification Search**
CPC G01S 19/54; G01S 19/53
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,520,448 B1 2/2003 Doty et al.
6,535,833 B1 * 3/2003 Syrjarinne 702/150
2009/0217286 A1 * 8/2009 Schmidbauer et al. 718/105
2010/0052981 A1 3/2010 Alexander et al.
2010/0289687 A1 * 11/2010 Vander Velde F41G 7/222 342/16

OTHER PUBLICATIONS

E. Abbott et al., Land-vehicle navigation using GPS, Proceedings of the IEEE, vol. 87(1), p. 145-162, 1999.*

J.O. Smith III, In-Phase & Quadrature Sinusoidal Components, in Mathematics of the Discrete Fourier Transform (DFT) with Audio Applications, Second Edition, http://www.dsprelated.com/freebooks/mdft/In_Phase_Quadrature_Sinusoidal.html, 2007.*

M.L. Psiaki, Attitude Sensing Using a Global-Positioning-System Antenna on a Turntable, Journal of Guidance, Control and Dynamics, vol. 24(3), p. 474-481, May-Jun. 2001.*

* cited by examiner

Primary Examiner — Gregory C Issing
Assistant Examiner — Fred H Mull
(74) *Attorney, Agent, or Firm* — Kaplesh Kumar

(57) **ABSTRACT**

System and method for determining the roll rate and roll angle of a spinning platform. The IQ amplitude and/or phase characteristics of GPS signals received at a single receiver antenna are measured using the signals output directly by a correlator that is driven at the satellite tracking frequency used for forming the navigation solution. The roll rate and roll angle are determined in real time by a Roll filter, which is preferably an Extended Kalman Filter (EKF) employing probabilistic data association, whose inputs include the measured IQ characteristics and the navigation solution. Data from non-GPS measurement sources is optionally provided to update the navigation and/or roll solution.

65 Claims, 10 Drawing Sheets