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Jin et al.

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(54) **CONTROLLER FOR HYBRID ENERGY STORAGE**

2011/0080044 A1* 4/2011 Schmiegel 307/23
2011/0148360 A1* 6/2011 Lee 320/134
2011/0163603 A1* 7/2011 Chou et al. 307/66

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FOREIGN PATENT DOCUMENTS

WO WO2007/104167 9/2007
WO WO2011/026901 3/2011

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OTHER PUBLICATIONS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 454 days.

Gyuk et al., "Flywheel-based Frequency Regulation Demonstration Projects for CEC, Nysesda, & DOE," *DOE Energy Storage Systems Research Program Annual Peer Review*, Nov. 2006.
Kirby et al., "Generator Response to Intrahour Load Fluctuations," *IEEE Transactions on Power Systems*, vol. 13 #4, PE-627-PWRS-0-12-1997, 1997, 7 pages.
Makarov et al., "Assessing the Value of Regulation Resources Based on Their Time Response Characteristics," PNNL Report, PNNL 52182, prepared for CERTS and California Energy Commission, Dec. 2007, 83 pages.
Makarov et al., "Impacts of Wind Generation on Regulation and Load Following Requirements in the California System," *Power and Energy Society General Meeting—Conversion and Delivery of Electrical Energy in the 21st Century*, Jul. 2008, 9 pages.

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USPC **307/103**; 307/60; 307/43; 700/297;
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CPC combination set(s) only.
See application file for complete search history.

(57) **ABSTRACT**

A controller is disclosed for hybrid systems providing power to an electrical power grid. The controller reduces wear on hybrid systems by having only a fast unit tuned to track fluctuations of a regulation signal in a normal mode of operation. By contrast, the slow unit does not track fluctuations in the regulation signal in the normal mode of operation, which reduces wear on the slow unit. The normal mode of operation is defined by an energy range of the fast unit. Energy band parameters associated with the energy range can be dynamically modified in order to optimize the efficiency of the hybrid system.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,929,538 A * 7/1999 O'Sullivan et al. 307/66
2005/0077881 A1 4/2005 Capp et al.
2005/0122652 A1 6/2005 Richardson et al.
2010/0090532 A1* 4/2010 Shelton et al. 307/46

18 Claims, 11 Drawing Sheets

