电力系统

利用改进数位演算法和经验模态分解的电力系统低频振荡信号瞬时参数的提取

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摘要：

为分析电力系统低频振荡的动态特性，需要提取低频振荡信号的瞬时参数，而电力系统低频振荡信号为非线性时变复合信号，因此参数提取前需要对其进行振荡模态分解。首先结合最小平方误差法提出了改进数位演算方法，以提高信号参数的提取精度；其次应用经验模态分解法对低频振荡信号进行模态分解，确定有效振荡模态；最后根据提取参数可分析电力系统低频振荡的动态特性。算例结果验证了该方法的有效性。

关键词：

An Improved Prototype Algorithm Based on Empirical Mode Decomposition and Its Application in Extracting Instantaneous Parameters of Low Frequency Oscillation

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Abstract:

To analyze dynamic characteristics of low frequency oscillations occurred in power systems, it is necessary to extract instantaneous parameters of low frequency oscillation, however the signal of low frequency oscillation is a nonlinear time-varying compound signal, so the empirical mode decomposition (EMD) of low frequency oscillation should be performed before the extraction of parameters. Firstly, combining with least square error an improved prototype algorithm is proposed to improve the extraction accuracy; then by use of EMD the mode decomposition of low frequency oscillation signal is carried out to determine effective oscillation model; finally, according to the extracted parameters the dynamic characteristics of low frequency oscillation occurred in power system can be analyzed. The effectiveness of the proposed method is verified by simulation results.

Keywords:

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参考文献：

[1] 余贻鑫，李鹏．大区电网弱互联对互联系统阻尼和动态稳定性的影响[J]．中国电机工程学报，2005，25(11)：7-10． Yu Yixin，Li Peng．The impact of weak interconnection of bulk power grids to dampling and dynaimic stability of power system[J]．Proceedings of the CSEE，2005，25(11)：7-10(in Chinese)． [2] 朱方，汤涌，张东霞，等．我国交流互联电网动态稳定性的研究及解决策略[J]．电网技术，2004，28(15)：1-5． Zhu Fang，Tang Yong，Zhang Dongxia，et al．Study on dynamic stability problems of AC interconnected area power grids in China and their solutions[J]．Power System Technology，2004，28(15)：1-5(in Chinese)． [3] 李大虎，曹一家．基于SCADA/PMU混合量测的广域动态实时状态估计方法[J]．电网技术，2007，31(6)：72-78． Li Dahu，Cao Yijia．Wide-area real-time dynamic state estimation method based on hybrid SCADA/PMU measurements[J]．Power System

Technology，2007，31(6)：72-78(in Chinese)． [4] 赵静波，雷金勇，甘德强．电池储能装置在抑制电力系统低频振荡中的应用[J]．电网技术，2008，32(6)：93-99． Zhao Jingbo，Lei Jinyong，Gan Deqiang．Application of battery energy storage devices in suppressing low-frequency oscillation of power system [J]．Power System Technology，2008，32(6)：93-99(in Chinese)． [5] Kamwa I，Beland J，Trudel G，et al．Wide-area monitoring and control at Hydro-Quebec：Past，present and future [C]//Proceedings of IEEE Power Engineering Society General Meeting．Montreal，Canada：IEEE，2006：1-2． [6] 王铁强，贺仁睦，徐东杰，等．电力系统低频振荡机理的研究[J]．中国电机工程学报，2002，22(2)：21-25． Wang Tieqiang，He Renmu，Xu Dongjie，et al．The mechanism study of low frequency oscillation in power system[J]．Proceedings of the CSEE，2002，22(2)：21-25(in Chinese)． [7] 邓集祥，刘洪波．多机电力系统非线性振荡的研究[J]．中国电机工程学报，2002，22(10)：67-70． Deng Jixiang，Liu Hongbo．Study on nonlinear oscillation in multimachine in power system[J]．Proceedings of the CSEE，2002，22(10)：67-70(in Chinese)． [8] Poon K P，Lee K C．Analysis of transient stability swings in large interconnected power systems by Fourier transformation[J]．IEEE Trans on Power Systems，1988，3(4)：1573-1581． [9] Korba P，Larsson M，Rehtanz C．Detection of oscillations in power systems using Kalman filtering techniques[C]//Proceedings of IEEE Control Applications Conference．Istanbul，Turkey：IEEE，2003：183–188． [10] 张鹏飞，薛禹胜，张启平．电力系统时变振荡特性的小波脊分析[J]．电力系统自动化，2004，28(6)：32-35． Zhang Pengfei，Xue Yusheng，Zhang Qiping．Power system time-varying osciullation analysis with wavelet ridge algorithm [J]．Automation of Electric Power Systems，2004，28(6)：32-35(in Chinese)． [11] 肖晋宇，谢小荣，胡志祥．电力系统低频振荡在线辨识的改进Prony算法[J]．清华大学学报，2004，44(7)：883-887． Xiao Jinyu，Xie Xiaorong，Hu Zhixiang．Improved Prony method for online identification of low-frequency oscillations in power systems [J]．Journal of Tsinghua University，2004，44(7)：883-887(in Chinese)． [12] 竺炜，唐颖杰，周有庆，等．基于改进Prony算法的电力系统低频振荡模式识别[J]．电网技术，2009，33(5)：44-47． Zhu Wei，Tang Yingjie，Zhou Youqing，et al．Identification of power system low frequency oscillation mode based on improved Prony algorithm[J]．Power System Technology，2009，33(5)：44-47(in Chinese)． [13] 王铁强，贺仁睦，徐东杰．Prony 算法分析低频振荡的有效性研究[J]．中国电力，2001，34(11)：38-41． Wang Tieqiang，He Renmu，Xu Dongjie，et al．The validity study of Prony analysis for low frequency oscillation in power system[J]．Electric Power，2001，34(11)：38-41 (in Chinese)． [14] 王宇静，于继来．电力系统振荡模态的矩阵束辨识法[J]．中国电机工程学报，2007，27(19)：12-17． Wang Yujing，Yu Jilai．Matrix pencil mathod of oscillation modes identification in power system[J]．Proceedings of the CSEE，2007，27(19)：12-17(in Chinese)． [15] Huang N E，Shen Z，Long S R．The empirical mode decomposition and the Hilbert spectrum for nonlinear non-stationary time series analysis[J]．Proceedings of the Royal Society of London，Series A： Mathematical，Physical and Engineering Sciences，1998，(454)：903-995． [16] 李天云，高磊，赵妍．基于HHT的电力系统低频振荡分析[J]．中国电机工程学报，2006，26(14)：24-29． Li Tianyun，Gao Lei，Zhao Yan．Analysis of low frequency oscillations using HHT method[J]．Proceedings of the CSEE，2006，26(14)：24-29(in Chinese)． [17] 韩松，何利铨，孙斌，等．基于希尔伯特－黄变换的电力系统低频振荡的非线性非平稳分析及其应用[J]．电网技术，2008，32(4)：56-60． Han Song，He Liquan，Sun Bin，et al．Hilbert-Huang transform based nonlinear and non-stationary amalysis of power system low frequency oscillation and its applicaion[J]．Power System Technology，2008，32(4)：56-60(in Chinese)． [18] Messina A R．Inter-area oscillationsin power systems-a nonlinear and nonstationary perspective[M]．Berlin：Springer，2009：37-60． [19] 史坤鹏．基于信号能量分析的电力系统低频振荡模式识别[D]．吉林：东北电力大学，2008． [20] 李天云，高磊．基于HHT 的同步电极参数辨识[J]．中国电机工程学报，2006，26(8)：153-158． Li Tianyun，Gao Lei．Parameter identification of synchronous machine based on Hilbert-Huang transform[J]．Proceedings of the CSEE，2006，26(8)：153-158(in Chinese)． [21] 毛炜，金荣洪，耿军平，等．一种基于改进Hilbert-Huang 变换的非平稳信号时频分析法及其应用[J]．上海交通大学学报，2006，40(5)：724-728． Mao Wei，Jin Ronghong，Geng Junping，et al．A time-frequency on improved analysis method for non-stationary signals based Hilbert-Huang transform and its application [J]．Journal of Shanghai Jiaotong University，2006，40(5)：724-728 (in Chinese)． [22] Yang J Z，Liu C W，Wu W G．A hybird method for the estimation of power system low-frequency oscillation parameter[J]．IEEE Trans on Power Systems，2007，22(4)：2115-2123． [23] Sim Power Systems 5.2.1．Performance of three PSS for interarea oscillations[EB/OL]．[2010-02-10]. http://www.mathworks.com/ products/simpower/demos.html?file=/products/demos/shipping/powersys/power_PSS.html． [24] 李大虎．基于广域测量的电力系统在线安全分析若干关键问题的研究[D]．武汉：华中科技大学，2006.

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