

## 电力系统

### 伊冯/呼辽交直流系统的次同步振荡阻尼特性分析

郑葵, 肖湘宁, 郭春林, 高本锋

电力系统保护与动态安全监控教育部重点实验室(华北电力大学), 北京市 昌平区 102206

#### 摘要:

建立了基于伊冯/呼辽交直流系统的电磁暂态模型, 采用基于时域仿真实现的复转矩系数法——测试信号法, 对机组施加了一系列不同频率的测试信号。计算了不同连接方式下机组在次同步频率范围内的电气阻尼特性, 并考察了可控串联补偿装置对该阻尼特性的影响。最后结合时域仿真验证了测试信号法分析结果的有效性。理论分析和仿真结果表明, 在交直流系统中采用联网运行带可控串补的方式, 有利于抑制高压直流输电系统和交流输电线路中串补装置引起的次同步振荡问题。

**关键词:** 测试信号法 交直流系统 高压直流输电 可控串联补偿 次同步振荡

### Analysis on Damping Characteristic of Subsynchronous Oscillation in AC/DC Power Grid Consisting of 500kV AC Power Transmission From Yimin to Fengtun and $\pm 500$ kV DC Power Transmission from Hulun Buir to Liaoning

ZHENG Rui, XIAO Xiangning, GUO Chunlin, GAO Benfeng

Key Laboratory of Power System Protection and Dynamic Security Monitoring and Control (North China Electric Power University), Ministry of Education, Changping District, Beijing 102206, China

#### Abstract:

An electromagnetic transient model for AC/DC power grid consisting of 500 kV AC power transmission from Yimin to Fengtun and  $\pm 500$  kV DC power transmission from Hulun Buir to Liaoning is built, and adopting the complex torque coefficient method-test signal method that is implemented by time-domain simulation a series of testing signals with different frequencies are applied to generation units. Generation units' electrical damping characteristics within the frequency range of subsynchronous oscillation (SSO) under different wiring patterns are calculated, and the influence of TCSC on the damping characteristics is observed. Based on time-domain simulation, the effectiveness of analysis results by test signal method is verified. Both results from theoretical analysis and experimental verification show that in AC/DC power grid the connected operation of DC power system with AC power system is favorable to mitigate SSO caused by HVDC power transmission system and serial compensation equipments in AC power transmission system.

**Keywords:** test signal method; AC/DC power grid HVDC power transmission thyristor controlled series compensation (TCSC) subsynchronous oscillation (SSO)

收稿日期 2010-09-14 修回日期 2010-09-20 网络版发布日期 2011-10-12

DOI:

#### 基金项目:

“十一五”国家科技支撑计划重大项目(2007BAA12B03)。

通讯作者: 郑葵

#### 作者简介:

作者Email: 179379153@qq.com

#### 参考文献:

- [1] 徐政, 罗惠群, 祝瑞金. 电力系统次同步振荡问题的分析方法概述[J]. 电网技术, 1999, 23(6): 36-39. Xu Zheng, Luo Huiqun, Zhu Ruijin. Review on methods of analysis for subsynchronous oscillations of power systems[J]. Power System Technology, 1999, 23(6): 36-39(in Chinese). [2] 倪以信, 陈寿孙, 张宝霖. 动态电力系统的理论和分析[M]. 北京: 清华大学出版社, 2002: 292, 323-327. [3] 刘敏, 周孝信, 田芳, 等. 抑制次同步振荡的可控串补附加阻尼控制[J]. 电网技术, 2010, 34(10): 65-70. Liu Min, Zhou Xiaoxin, Tian Fang, et al. Supplementary damping control of TCSC for subsynchronous

## 扩展功能

### 本文信息

- ▶ Supporting info
- ▶ PDF(274KB)
- ▶ [HTML全文]
- ▶ 参考文献[PDF]
- ▶ 参考文献

### 服务与反馈

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ 引用本文
- ▶ Email Alert
- ▶ 文章反馈
- ▶ 浏览反馈信息

### 本文关键词相关文章

- ▶ 测试信号法
- ▶ 交直流系统
- ▶ 高压直流输电
- ▶ 可控串联补偿
- ▶ 次同步振荡

### 本文作者相关文章

PubMed

oscillation suppression[J]. Power System Technology, 2010, 34(10): 65-70(in Chinese). [4] 田旭, 姜齐荣, 谢小荣. 电力系统次同步谐振抑制措施综述[J]. 电网技术, 2010, 34(12): 74-79. Tian Xu, Jiang Qirong, Xie Xiaorong. Review of measures to mitigate subsynchronous resonance in power systems [J]. Power System Technology, 2010, 34(12): 74-79(in Chinese). [5] 周长春. 高压直流输电系统次同步振荡阻尼特性研究[D]. 杭州: 浙江大学, 2004. [6] 徐政. 复转矩系数法的适用性分析及其时域仿真实现[J]. 中国电机工程学报, 2000, 20(6): 1-4. Xu Zheng. The complex torque coefficient approach's applicability analysis and its realization by time domain simulation[J]. Proceedings of the CSEE, 2000, 20(6): 1-4(in Chinese). [7] 周孝信, 郭剑波, 林集明, 等. 电力系统可控串联电容补偿[M]. 北京: 科学出版社, 2009: 266-273. [8] 陈陈, 杨煜. 几种次同步振荡分析方法和工具的阐述[J]. 电网技术, 1998, 22(8): 10-13. Chen Chen, Yang Yu. Discussion of several analytical tolls about subsynchronous resonance (SSR)[J]. Power System Technology, 1998, 22(8): 10-13(in Chinese). [9] 张帆, 徐政. 直流输电次同步阻尼控制器的设计[J]. 电网技术, 2008, 32(11): 13-17. Zhang Fan, Xu Zheng. A method to design a subsynchronous damping controller for HVDC transmission system[J]. Power System Technology, 2008, 32(11): 13-17(in Chinese). [10] 杨秀, 陈陈, 王西田. HVDC控制系统对汽轮发电机组次同步振荡的影响[J]. 电网技术, 2004, 28(5): 5-8. Yang Xiu, Chen Chen, Wang Xitian. Impact of HVDC control on subsynchronous oscillation of turbine-generator set[J]. Power System Technology, 2004, 28(5): 5-8(in Chinese). [11] Walker D N, Bowler C E J, Jackson R L, et al. Results of subsynchronous resonance test at Mohave Power[J]. Apparatus and Systems, 1975, 94(5): 1878-1889. [12] 郑蕤, 肖湘宁, 李伟, 等. 复杂交直流系统SSO模态辨识及仿真验证[J]. 高电压技术, 2010, 36(12): 3035-3040. Zheng Rui, Xiao Xiangning, Li Wei, et al. Subsynchronous oscillation mode analysis of AC/DC system based on Prony and time-domain method[J]. High Voltage Engineering, 2010, 36(12): 3035-3040(in Chinese). [13] Wasynczuk O. Damping subsynchronous resonance using reactive power control[J]. IEEE T-PAS, 1981, 100(3): 1096-1104. [14] Daneshpoooy A, Gole A M. Frequency response of the thyristor controlled series capacitor[J]. IEEE Trans on Power Delivery, 2001, 16(1): 53-58. [15] IEEE Std 1534-2002 IEEE recommended practice for specifying thyristor-controlled series capacitors[S].

#### 本刊中的类似文章

1. 赵成勇 胡冬良 李广凯 龙文.多端VSC-HVDC用于风电场联网时的控制策略[J]. 电网技术, 2009,33(17): 135-140
2. 常 浩, 樊纪超.特高压直流输电工程成套设计及其国产化[J]. 电网技术, 2006,30(16): 1-5
3. 丁冠军<sup>1</sup>, 丁明<sup>1</sup>, 汤广福<sup>2</sup>, 贺之渊<sup>2</sup>, 温家良<sup>2</sup>.应用于VSC-HVDC输电系统中的新型混合脉宽调制技术[J]. 电网技术, 2009,33(7): 7-13
4. 梁海峰 王松 李庚银 赵成勇.VSC-HVDC系统H<sub>∞</sub>控制器设计[J]. 电网技术, 2009,33(9): 35-39
5. 陈颖|陈葛松|袁荣湘 .可变频变压器数学模型及仿真分析[J]. 电网技术, 2008,32(17): 73-77
6. 丁中民|李光范|李鹏|周文俊 .极性反转时典型油纸复合绝缘的电场特性[J]. 电网技术, 2008,32(23): 82-85
7. 孙景强|郭小江|张健|陈志刚|卜广全|陈家荣 .多馈入直流输电系统受端电网动态特性[J]. 电网技术, 2009,33(4): 57-60
8. 陈汉雄|胡劲松 .金沙江一期送端特高压直流输电系统协调控制[J]. 电网技术, 2008,32(8): 10-14
9. 吕 虎|朱艺颖|杨 铭 .多个特高压直流系统送端共用接地极的内过电压研究[J]. 电网技术, 2008,32(10): 5-10
10. 潘淑杰|马平|蔡兴国|韩冬 .用于提高输电能力的TCSC选址和定容方案[J]. 电网技术, 2009,33(4): 65-70
11. 吴杰康 胡文霞 秦砺寒 罗涛 .计及TCSC的电压稳定性灵敏度指标计算[J]. 电网技术, 2008,32(17): 12-16
12. 李 季|罗隆福|许加柱|李 勇|张 杰|刘福生 .HVDC滤波换相换流器的阻抗频率特性[J]. 电网技术, 2008,32(12): 45-50
13. 林伟芳 汤涌 卜广全 .多馈入交直流系统电压稳定性研究[J]. 电网技术, 2008,32(11): 7-12
14. 张 帆|徐 政 .直流输电次同步阻尼控制器的设计[J]. 电网技术, 2008,32(11): 13-17
15. 汤广福|贺之渊|滕乐天|易荣|何维国 .电压源换流器高压直流输电技术最新研究进展[J]. 电网技术, 2008,32(22): 39-44