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交流电网强度对模块化多电平换流器HVDC运行特性的影响

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摘要：

模块化多电平电压源换流器高压直流输电(modular multilevel converter high voltage direct current，MMC-HVDC) 技术是一种新型的电压源换流器直流输电技术。计及交流系统与换流站交换功率的数学关系，应用图解法分析了交流电网强度对MMC-HVDC系统稳态特性的影响，同时分析了接入强、弱交流电网的直流系统在不同控制方式下设定值改变时的暂态特性。结果表明功率圆的大小及其相对位置可以直观地反映交流电网的强弱，以及控制方式对MMC-HVDC系统运行特性的影响。最后PSCAD电磁暂态仿真验证了上述结论的正确性。

关键词：

Influence of AC System Strength on Operating Characteristics of MMC-HVDC System

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Abstract:

High voltage DC (HVDC) transmission based on modular multilevel converter (MMC) is a new type of HVDC transmission technology based on voltage source converter (VSC). Taking mathematical relationship of the exchanged power between the AC system and the converter station into account, the influence of AC system strength on steady state characteristics of MMC-HVDC is analyzed by graphic method, meanwhile the transient characteristics of HVDC system connected to strong/weak AC system are analyzed while the setting values of the different converter control modes are changed. Analysis results show that the strength of AC system as well as the influence of converter control modes on operating characteristics of MMC-HVDC system can be reflected by the size of power circle and its relative position visually. The correctness of above-mentioned conclusion is verified by the results of the simulation based on PSCAD electromagnetic transient model.

Keywords:

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参考文献：

[1] CIGRE B4-37 Working Group．DC transmission using voltage sourced converters[R]．Paris，France：International Council on Large Electric Systems，2004． [2] 汤广福，贺之渊，腾乐天，等．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． Tang Guangfu，He Zhiyuan，Teng Letian，et al．New progress on HVDC technology based on voltage source converter [J]．Power System Technology，2008，32(22)：39-44(in Chinese)． [3] Flourentzou N，Agelidis V G，Demetriades G D．VSC-based HVDC power transmission systems：an overview[J]．IEEE Trans on Power Electronics，2009，24(3)：592-602． [4] 张桂斌，徐政，王广柱．基于VSC的直流输电系统的稳态建模及其非线性控制[J]．中国电机工程学报，2002，22(1)：17-22． Zhang Guibin，Xu Zheng，Wang

Guangzhu. Steady state model and its nonlinear control of MMC-HVDC system[J]. Proceedings of the CSEE，2002，22(1)：17-22(in Chinese). [5] 宋瑞华. 新型直流输电建模仿真与控制策略研究[D]. 北京：中国电力科学研究院，2007. [6] 郑超，周孝信，李若梅，等. MMC-HVDC稳态特性与潮流算法的研究[J]. 中国电机工程学报，2005，25(6)：1-5. Zheng Chao，Zhou Xiaoxin，Li Ruomei，et al. Study on the steady characteristic and algorithm of power flow for MMC-HVDC[J]. Proceedings of the CSEE，2005，25(6)：1-5(in Chinese). [7] Du Cuiqing. The control of MMC-HVDC and its use for large industrial power systems[D]. Goteborg，Sweden：Charmers University of Technology，2003. [8] 魏晓光. 电压源换流器高压直流输电控制策略及其在风电场并网中的应用研究[D]. 北京：中国电力科学研究院，2007. [9] Dorn J，Huang H，Retzmann D. A new multilevel voltage-sourced converter topology for HVDC applications[C]//CIGRE Session. Paris，France：International Council on Large Electric Systems，2008：1-8. [10] 丁冠军，汤广福，丁明，等. 新型多电平VSC子模块电容参数与均压策略[J]. 中国电机工程学报，2009，29(30)：1-6. Ding Guanjun，Tang Guangfu，Ding Ming，et al. Submodule capacitance parameter and voltage balancing scheme of a new multilevel VSC modular[J]. Proceedings of the CSEE，2009，29(30)：1-6(in Chinese). [11] 丁冠军，汤广福，丁明，等. 新型多电平电压源换流器模块的拓扑机制与调制策略[J]. 中国电机工程学报，2009，29(36)：1-8. Ding Guanjun，Tang Guangfu，Ding Ming，et al. Topology mechanism and modulation scheme of a new multilevel voltage source converter modular[J]. Proceedings of the CSEE，2009，29(36)：1-8(in Chinese). [12] Ingars S，Leonids Ribickis. Voltage monitoring on capacitor of modular multilevel converter[J]. Scientific Journal of Riga Technical University，2009，25(25)：145-150. [13] Antonopoulos A，Angquist L，Nee H-P. On dynamics and voltage control of the modular multilevel converter[C]//European Power Electronics and Applications Conference(EPE). Barcelona Spain：Institute of Electrical and Electronics Engineers，2009：1-10. [14] Rohner S，Bernet S，Hiller M，etc. Pulse width modulation scheme for the Modular Multilevel Converter[C]//European Power Electronics and Applications Conference(EPE). Barcelona Spain：Institute of Electrical and Electronics Engineers，2009：1-10. [15] Rohner S，Bernet S，Hiller M，etc. Analysis and Simulation of a 6 kV，6 MVA Modular Multilevel Converter[C]//35th Annual Conference of IEEE on Industrial Electronics. Porto Portugal：Institute of Electrical and Electronics Engineers，2009：225-230. [16] Grain P，Adam O，Anaya-Lara G，etc. Comparison between Two VSC-HVDC Transmission Systems Technologies：Modular and Neutral Point Clamped Multilevel Converter[C]//35th Annual Conference of IEEE on Industrial Electronics. Porto Portugal：Institute of Electrical and Electronics Engineers，2009. [17] Ingars S，Leonids Ribickis. Voltage monitoring on capacitor of modular multilevel converter[J]. Scientific Journal of Riga Technical University，2009，25(25)：145-150. [18] Siemaszko D，Antonopoulos A，Ilves K，et al. Evaluation of control and modulation methods for modular multilevel converters [C]//International Power Electronics Conference (IPEC). Sapporo Japan：Institute of Electrical and Electronics Engineers，2010：746-753. [19] Angquist L，Antonopoulos A，Siemaszko D，et al. Inner control of modular multilevel converters：an approach using open-loop estimation of stored energy[C]//International Power Electronics Conference (IPEC). Sapporo Japan：Institute of Electrical and Electronics Engineers，2010：1579-1585. [20] Marquardt R. Modular multilevel converter：an universal concept for HVDC-networks and extended DC-bus-applications[C]//International Power Electronics Conference (IPEC). Sapporo Japan：Institute of Electrical and Electronics Engineers，2010：502-507. [21] Rohner S，Bernet S，Hiller M，et al. Modelling，simulation and analysis of a Modular Multilevel Converter for medium voltage applications [C]//IEEE International Conference on Industrial Technology (ICIT). Vi?a del Mar Chile：Institute of Electrical and Electronics Engineers，2010：775-782. [22] Perez M.A，Fuentes E，Rodriguez J. Predictive current control of AC-AC modular multilevel converters[C]//IEEE International Conference on Industrial Technology (ICIT). Vi?a del Mar Chile：Institute of Electrical and Electronics Engineers，2010：1289-1294. [23] Hagiwara M，Nishimura K，Akagi H. A medium-voltage motor drive with a modular multilevel PWM inverter[J]. IEEE Trans on Industrial Electronics，2010，25(7)：1786-1799. [24] Rohner S，Bernet S，Hiller M，et al. Modulation, losses, and semiconductor requirements of modular multilevel converters[J]. IEEE Trans on Industrial Electronics，2010，57(8)：2633-2642. [25] 管敏渊，徐政，屠卿瑞，等. 模块化多电平换流器型直流输电的调制策略[J]. 电力系统自动化，2010，34(2)：48-52. Guan Minyuan，Xu Zheng，Tu Qingrui，et al. Nearest level modulation for modular multilevel converters in HVDC transmission[J]. Automation of Electric Power Systems，2010，34(2)：48-52(in Chinese). [26] 屠卿瑞，徐政，郑翔，等. 模块化多电平换流器型直流输电内部环流机理分析[J]. 高电压技术，2010，36(2)：547-552. Tu Qingrui，Xu Zheng，Zhen Xiang，et al. Mechanism analysis on the circulating current in modular multilevel converter based HVDC [J]. High Voltage Engineering，2010，36(2)：547-552(in Chinese). [27] 刘钟淇，宋强，刘文华. 基于模块化多电平变流器的轻型直流输电系统[J]. 电力系统自动化，2010，34(2)：53-58. Liu Zhongqi，Song Qiang，Liu Wenhua. MMC-HVDC system based on modular multilevel converters[J]. Automation of Electric Power Systems，2010，34(2)：53-58(in Chinese). [28] 王姗姗，周孝信，汤广福，等. 模块化多电平HVDC输电系统子模块电容值的选取和计算[J]. 电网技术，2011，35(1)：26-32. Wang Shanshan，Zhou Xiaoxin，Tang Guangfu，et al. Selection and calculation for sub-module capacitance in modular multi-level converter HVDC power transmission system[J]. Power System Technology，2011，35(1)：26-32(in Chinese).

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