基于 FPGA 的 MMC 实时仿真异构计算平台的设计及实现

李雄飞 1, 贺光辉 1, 项胤兴 2
（1 上海交通大学 电子信息与电气工程学院，上海 200240；2 福建省电力科学研究院，福建 福州 350007）

摘要： 基于采用替代电路的模块化多电平换流器(Modular-Multilevel-Converter, MMC)桥臂等效模型，本文提出了一种基于 FPGA 的实时仿真异构计算平台，用以对含有 MMC 的电网系统进行实时仿真计算.该系统将 MMC 电路与电网解耦，实现了电网主电路与 MMC 桥臂等效电路的并行计算.此外，针对 MMC 桥臂等效电路计算中的电压电阻多数据集合并问题，本文提出了一种改进的分组循环累加电路，实现了不同子模块串上的电压电阻值快速合并，并且提出了该 FPGA 系统的优化策略.最后，对含有 MMC 的电网系统在该异构平台上进行实时仿真计算实验，表明了该系统计算的准确度、仿真速度等都达到了令人满意的结果.

关键词： MMC；FPGA；电磁暂态仿真；异构计算
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Design and Implementation of Heterogeneous Computing Platform Based on FPGA for MMC Grid Real-time Simulation

LI Xiong-fei1，HE Guang-hui1，Xiang Yin-xing2
(1 School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University, Shanghai 200240， China;2 Fujian Electric Power Research Institute, Fuzhou 350007, China)

Abstract： Based on the alternative circuit equivalent model of MMC bridge arm, a real-time simulation heterogeneous computing platform based on FPGA to simulate real-time simulation of MMC-containing power system is proposed. The system decouples the MMC circuit from the grid, and realizes the parallel calculation of the equivalent circuits of the main circuit and MMC bridge. In addition, in order to solve the problem of multi-data set reduction of voltage and resistors in the equivalent circuit calculation of MMC bridge arm, an improved packet cyclic accumulating circuit is proposed to realize the rapid merging of voltage and resistance values from different sub-module strings. And optimization strategy of FPGA system is discussed. Finally, the real-time simulation experiment on the heterogeneous platform with MMC-based power system shows that the accuracy and simulation speed of the system have achieved satisfactory results.

Key words： MMC; FPGA; electromagnetic transient simulation; heterogeneous computation

作者简介：
李雄飞男，（1993-），硕士研究生.研究方向为电磁暂态仿真和硬件加速.E-mail:448134158@qq.com.
贺光辉男，（1980-），博士，副研究员.研究方向为通信系统、VLSI、硬件加速等.
项胤兴男，（1986-），硕士，工程师.研究方向为电力系统仿真.