

The decoupled control of the ac-side, dc-link and circulating current of a modular multilevel converter (MMC) can significantly improve its operation and control performances. This paper presents a new mathematical model for MMC, in which six intermediate controllable voltages (ICVs) corresponding to the ac-side currents, the dc-link current, and the circulating currents are introduced. Using the ICVs as the intermediate control variables, the MMC can be decoupled into six single phase circuits, and the current in each circuit responds to its corresponding ICV. Based on the ICV controls, the direct control of dc-link voltage and circulating current and the decoupling of dc side and ac side can be achieved. These conditions can improve the performances and stability of the MMC-based high-voltage direct current (HVDC) systems. Simulations and experiments were implemented to verify the proposed method.