Abstract

Efficient, compact, and reliable power conversion systems are the cornerstone of modern industrial, transportation, and renewable energy applications. Multi-motor and multiphase drive systems have gained significant attention in medium to high power applications. Traditional solutions relying on individual converters for each load suffer from high component count, increased cost, and complex control. To address these challenges, this thesis presents the development of novel multilevel multi-output converter topologies and their associated control strategies, offering enhanced performance, flexibility, and cost-effectiveness. The research begins with the formulation of a graphical framework to visualize and analyze the operational boundaries of dual-output converters (DOCs), enabling clear identification of permissible modulation indices and phase shifts. Building upon this foundation, three converter architectures are proposed and investigated.

First, a three-level dual-output active neutral-point clamped (TLDO-ANPC) converter is introduced, which supports independent control of two three-phase loads or a six-phase machine using in-phase disposition PWM (IPD-PWM), with a reduced switch count and extended operating region. Second, a five-level stacked dual-output (FLSDO) converter is designed to minimize the number of switches while enabling independent dual-output control with different frequencies and modulation indices via a hybrid sinusoidal PWM method. Next, a five-level dual-output ANPC (5LDO-ANPC) converter is proposed, further reducing the number of switches and complexity for high-performance applications such as all-terrain electric vehicles (ATEVs) and all-wheel-drive (AWD) systems. A finite control set model predictive control (FCS-MPC) is employed for output tracking and capacitor voltage balancing. Lastly, a unique multi-drive system based on the TLDO-ANPC topology is developed to simultaneously control two different motor types, an induction motor (IM) and a permanent magnet synchronous motor (PMSM) from a single converter platform. Comprehensive theoretical analysis, simulation studies, and experimental validation demonstrate the feasibility, efficiency, and robustness of the proposed topologies and control strategies. This work lays a strong foundation for next-generation multilevel multi-output converter systems, promoting scalable and economical solutions for future electric mobility, industrial automation, and renewable energy integration.