Editorial for the Special Issue on Next Generation Datacenter Power Conversion Technologies

MODERN datacenter is becoming the critical infrastructure with the rapid evolvement of emerging information technologies such as 5G communications, big data, cloud computing, blockchain, and artificial intelligence. In 2030, energy consumption in datacenters is projected to be 3000 TWh, which will account 7.6% of global energy usuage. The rising demand for data center services is accompanied by massive energy consumption, and it motivates intensive research on cost-effective, reliable, and greener electricity to optimize the utilization of electric power. In datacenter, less than half of the total energy is delivered to the terminal load, such as CPU, GPU, memory, and disk, while the rest is lost during power conversion, distribution, and cooling. This results in high costs, large cooling equipment, and inefficient power utilization. Higher energy efficiency, higher power density, better cooling, and cost reduction are the major driving forces to shape greener datacenter power management technologies. Correspondingly, we organized this Special Issue on Next Generation Datacenter Power Conversion Technologies to provide technical insights on the latest power architectures, power electronic topologies, modeling and analysis methods, and control strategies to embrace next-generation datacenter power conversion.

The call for paper of the CPSS Special Issue on Next Generation Datacenter Power Conversion Technologies was published in September 2022. We received seventeen submissions in total. Reviews were promptly organized by Guest Associate Editors both in academia and industry from the United States, Japan, United Kingdom, Denmark, and China. Reviewers are invited from all over the globe. After rigorous reviews, nine papers were accepted. These accepted papers address different challenges with innovative solutions in different perspectives of datacenter power conversion technologies, such as: optimized scheduling of datacenter and electricity retailer; voltage regulator modules in next-generation 48 V bus-based datacenter power systems; high frequency, high power density dc/dc converters and their optimized co-design; battery energy storage systems and its control in datacenter applications, high-performance ac/dc conversion systems in datacenter power supply, design of high frequency planar magnetic components in datacenter power systems, etc.

The paper by Z. Tian and his co-authors from Harbin Institute of Technology, China presents a 9:1 cascaded multi-resonant switched capacitor converter for datacenter applications and further explores ways to improve the performance of the converter. A method to reduce the intermediate decoupling capacitance is investigated. By adjusting the dead time of the control signal, the zero-voltage switch (ZVS) of most switching devices is realized, and the efficiency of the converter is improved. A 120 W, 48 V-5 V resonant converter prototype is designed to validate the concept. 330 W/in^3 power density and 98.1% peak efficiency are recorded.

The paper by D. Wu and his co-authors from Shanghai University, China, and Arizona State University, Arizona, USA proposes an isolated bridgeless PFC converter derived from active-clamped SEPIC topology. The presented converter reduces the conduction loss by removing two diodes in the line current path while preserving the advantages of active clamped SEPIC including soft-switching and active voltage clamp for high-frequency switches. The voltage stress of the output diode is inherently clamped by the center-tapped transformer configuration. A 3.3 kW rated prototype with 101 W/in^3 power density and 97.26% peak efficiency is designed to validate the concept.

The paper by Y. Tian and his co-authors from Beijing Jiaotong University, China, and NR Electric Co., Ltd, Nanjing, China presents a calculation method to analyze the fringing field of high-frequency planar magnetic components. The proposed model accurately analyzes the firing loss and determines the winding position, which facilitates the design of planar magnetic components operating at high frequency in high-density datacenter power supplies.

The paper by N. Jolly and his co-authors from Arizona State University, USA analyzes and develops a multi-variable & multi-constraint design optimization approach to minimize power losses in a 2 MHz LLC resonant converter for datacenter power supplies. A 2-MHz GaN-based 700 W rated *LLC* converter prototype is designed and tested. 95.6% peak efficiency and 6.2 W/cm^3 power density are reported.

The paper by G. Ye and his co-author from Shandong University, China presents a coordinated operation scheduling method for datacenters and electricity retailers based on cooperative game theory. A cooperative game union comprised of the data center and the electricity retailer is established to minimize the total cost. The extra income of the alliance is distributed using the Shapley value method. Simulation results illustrated that the proposed method can reduce the data center operational cost by 5%.

The paper by J. Liang and his co-authors from ShanghaiTech University, China presents a comprehensive overview of voltage regulator modules in 48 V Bus-based datacenter power systems. Existing solutions are divided into inductive and capacitive categories according to the type of passive components. The performances of the corresponding converters are briefed and compared, and some design considerations are analyzed as the case study. Opportunities and challenges in

the future data center power systems are presented to provide technical insights.

The paper by G. Li and his co-authors from Zhejiang University, Hangzhou, China, and Hangzhou EV-Tech, Hangzhou, China presents a high efficiency, high frequency, high-density SRC DCX with modular structure and different output voltage adaption for datacenter power systems. Two MHz 380 V/48 V and 380 V/12 V SRC DCX prototypes are built by only changing the connection structures. At 1800 W rated power, peak efficiency over 98.0% and 800 W/in^3 power density is reported.

The paper by J. Yang and his co-authors from Shanghai Jiao Tong University, Shanghai, China, and Ginlong Technology Co., Ltd., Zhejiang, China presents a distributed multimode control method for cascaded isolated dc/dc converters (IDC) in battery storage-based datacenter applications. The proposed control incorporates the voltage power relationship and limited voltage gain of IDC. Correspondingly, modular design with improved conversion efficiency and robustness can be achieved. The proposed control strategy is effectively validated by a down-scaled experimental prototype.

The paper by Q. Zhang and his co-authors from the Xiamen University of Technology, Xiamen, China, and Fuzhou University, Fuzhou, China presents an improved three-phase step-down Swiss rectifier for datacenter power conversion systems. The proposed rectifier is based on the harmonic-current-injection concept. A nonlinear control strategy is introduced to reduce the impact of DC inductor current ripple on the input current. An 80 kHz, 300 V/2 kW prototype with digital control is designed and tested to validate the concept. THD lower than 2% is recorded.

We appreciate the efforts from all authors who had submitted papers and we appreciate timely reviews from Guest Associate Editors and reviewers, especially at this time of difficulty. Great thanks to all Guest Associate Editors for their diligence and professional support.

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