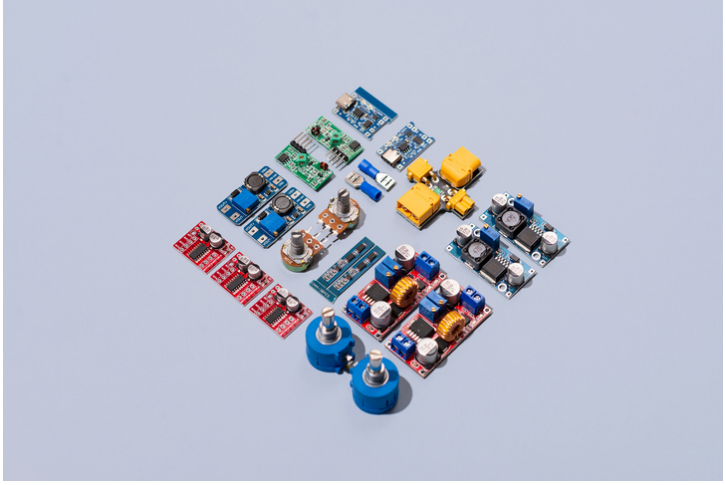
INNOVATION PARTNERSHIPS
UNIVERSITY OF MICHIGAN

High Speed Digital Control of Variable Frequency Multi-Phase Buck Converter

TECHNOLOGY NUMBER: 2022-413



Technology ID

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Category

Hardware

Engineering & Physical Sciences

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OVERVIEW

High-speed digital control for variable frequency, multi-phase buck converters

- Enhances transient response and settles quickly against disturbances
- Power management in CPUs, GPUs, telecoms, and server equipment

BACKGROUND

Voltage regulator modules (VRMs) are essential for efficiently distributing power in high-performance computing devices, such as GPUs and CPUs. Historically, fixed-frequency multi-phase buck converters with average current-mode control have been used given their ability to share current across phases efficiently. However, these come with several drawbacks, such as limited linear settling times due to prolonged average control schemes, and vulnerability to high-frequency noise. Additionally, while there are mixed-signal solutions integrating both analog and digital controls, these systems face challenges like common-mode rejection at high frequencies, complicating design and implementation. Hence, there has been an ongoing demand for VRMs offering excellent transient response and fast settling times to satisfy the energy demands of modern electronics. The industry recognizes the necessity for digitally-controlled VRMs that overcome the limitations of existing analog and mixed-signal approaches, offering flexibility, programmability, and enhanced performance.

INNOVATION

Researchers at the University of Michigan have developed a novel digital control method for multi-phase buck converters operating at MHz switching frequencies. The switching-synchronized, sampled-state space (5S) framework facilitates cycle-by-cycle digital control of both voltage and current, providing rapid transient response and stabilization from disturbances. A standout capability of this design lies in its robust cycle-by-cycle averaging method, impervious to fast disturbances and switching transients. IoT applications explore potential real-world uses in efficient power management for devices like GPUs and CPUs that demand rapid, reliable voltage regulation. It presents simpler design and implementation processes, advantageous for widespread use in server power management and telecommunications systems. Comprehensive proof-of-concept through simulation and ongoing hardware demonstration further emphasizes its potential to revolutionize digital power control technologies.

ADDITIONAL INFORMATION

REFERENCES

X. Cui, V. Contreras, W. Xu and A. -T. Avestruz, "High-Speed Digital Control in a Switching-Synchronized Sampled-State Space for Variable Frequency Multi-Phase Buck Converters," 2022 IEEE 23rd Workshop on Control and Modeling for Power Electronics (COMPEL), Tel Aviv, Israel, 2022, pp. 1-7, doi: 10.1109/COMPEL53829.2022.9829985

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