Extreme Efficiency 240 Vac to Load Data Center Power Delivery Topologies and Control

Motivation

Traditional Datacenter Architecture

![Traditional Topology](image1)

- Voltage rectified step-down then step-down
- Single-phase ac-dc converter (240 Vac to 48 Vac)
- Direct single-stage step-down
- Power factor correction (PFC) capability

Buck PFC FCML Overview

Benefits of FCML Topology
- Reduced switch voltage stress
- Reduced filter inductance
- Utilize energy dense capacitors

Operation of Buck FCML
- Converter enablesthrottle buck action depending on position in line cycle
- Rely on UPS to hold 48 V output when the converter is disabled
- Flying capacitor voltages vary with ac line cycle
- Prevents unique balancing challenges

DPP for Data Storage Server

Conventional Power Delivery Architecture
- Cascaded dc-dc converters of different voltage levels
- Processing full load power
- Bells and inefficiency

Series-Stacked Power Architecture
- Inherent voltage step-down through series stack
- Processing power differences (a small fraction of total power)
- Extreme efficiency and power density

Multi-Port DC-DC Converter

48 V Point-of-Load Converter

Hybrid Switched-Capacitor Converters

48-12 V Cascaded Resonant Converter

12-switch Cascaded Resonant Converter

8 to 1 Cascaded Series Parallel Topology

48-6 V Cascaded Series-Parallel Converter

80-HDD Storage Server with Full Functions

HDD Server Testbench & Experimental Results

50-HDD Storage Server with Full Functions

Comparison with Commercial Converters

- 99.0% peak system efficiency
- 100% power density
- 6% low power reduction

Future Plans

Merge FCML, DPP, and POL stages, test full system functions and efficiency

- Novel active capacitor balancing control
- Improved power factor using current compensation
- Long term reliability test
- Rigorous field tests with real server loads

References


University of California, Berkeley; °Princeton University