Stochastic Loss Model and Performance Limits for Differential Power Processing

**Motivation**

- **Power Delivery Architecture in Data Center**
  - Rack
  - 48V/400V AC
  - UPS
  - 48V
  - 48V - 1V
  - DC/DC
  - 48V - 5V
  - HDD Array
  - Communication Infrastructure
  - CPU/GPU

**Stochastic Model and Scaling Factor of Differential Power Processing for Hard Disk Drive Servers**

**A Very-Large-Scale HDD Array Supported by DPP Converter**

- Uniform voltage rating with similar power consumption
- Major power directly delivered to HDDs
- Very little differential power processed by the DPP converter
- Highly scalable to ultra-large-scale array

**MAC-DPP Prototype**

- **450 W 10-Port MAC-DPP**
  - #10
  - #9
  - #8
  - #7
  - #6
  - #5
- **Stacked PCB Planar Magnetics**
  - 10x magnetics size reduction
  - Magnetic Core (1.8 cm × 1 cm)
  - Main Power Board (Thickness: 0.4 mm)
  - Bottom Cover (Thickness: 1.2 mm)

**HDD Server Testbench & Experimental Results**

- **50-HDD Storage Server**
  - Efficiency Measurement
  - Port-to-Port Efficiency
  - System Efficiency
  - Peak efficiency: 95% @ (14 W, 5 Ports to 5 Ports)
  - Over 99% system efficiency at most of operation points
  - Transient Response
  - Hot-Swapping
  - 6 A Step Load Transient

**Performance Specifications**

- System Efficiency: >99% at most of operation points
- Volume: 0.71 in³
- Power Density: 38.6 kW/L (System Power)
  - 19.3 kW/L (Processed Power)

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