Differential Power Processing for Ultra-Efficient Rack Level Power Conversion

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Motivation

- Rack power density is rapidly increasing, necessitating advancements to power architecture design.
- Efficiency is highly valuable, but limited by power density requirements.
- AI applications demand high peak transient power, burdening PSUs.
- Significant changes to power architecture - namely $\pm$ 400V DC distribution - are on the horizon, and it may be an appropriate time for integration of novel approaches.

Differential Power Processing

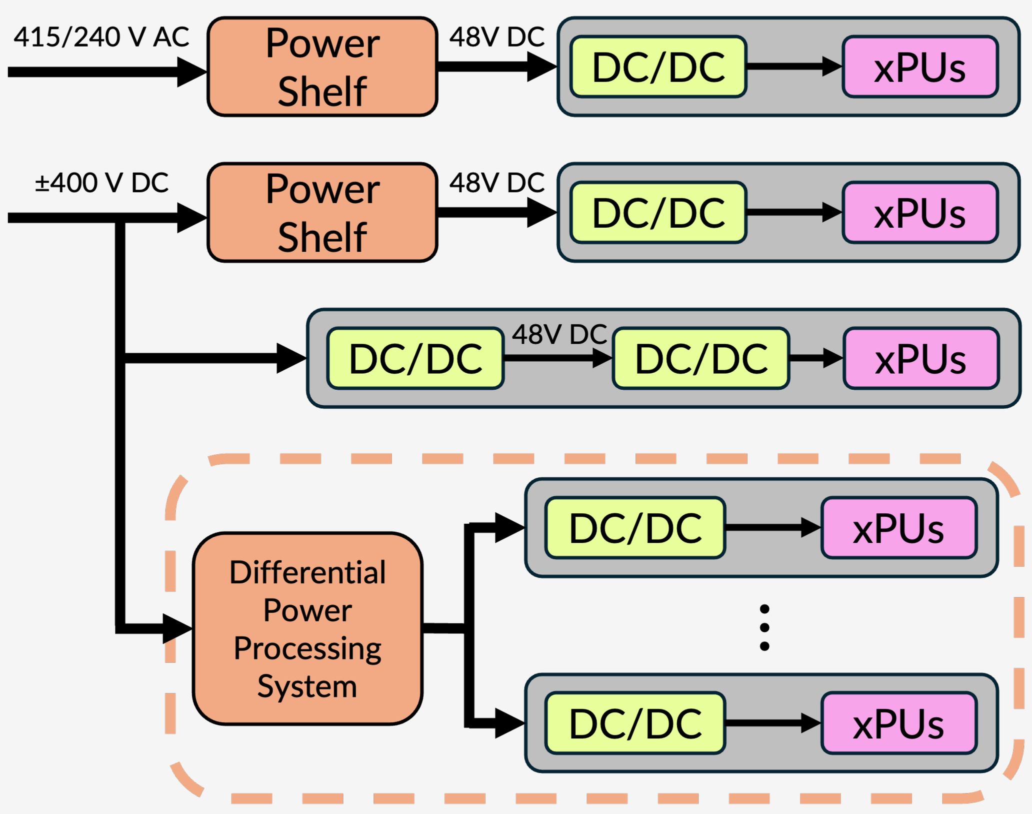

Figure 1. Comparison of status quo and potential future rack-level power distribution architectures.

Palanquin Power is developing a novel rack-level power delivery system, capable of achieving **99+% efficiency at high power densities**. We utilize a differential power processing (DPP) architecture, described below. This approach is unique in that it decouples system efficiency from converter efficiency.

In our system, servers are connected in series and current is fed directly to the stack from the rack level bus. Power can thus be delivered to loads with no losses from intermediate converters. Each load interfaces with an isolated, bidirectional converter that regulates its voltage. Critically, converters only process the difference in power between servers. This means system efficiency can be extremely high in cases where loads are well-matched, such as AI training and other high utilization tasks.

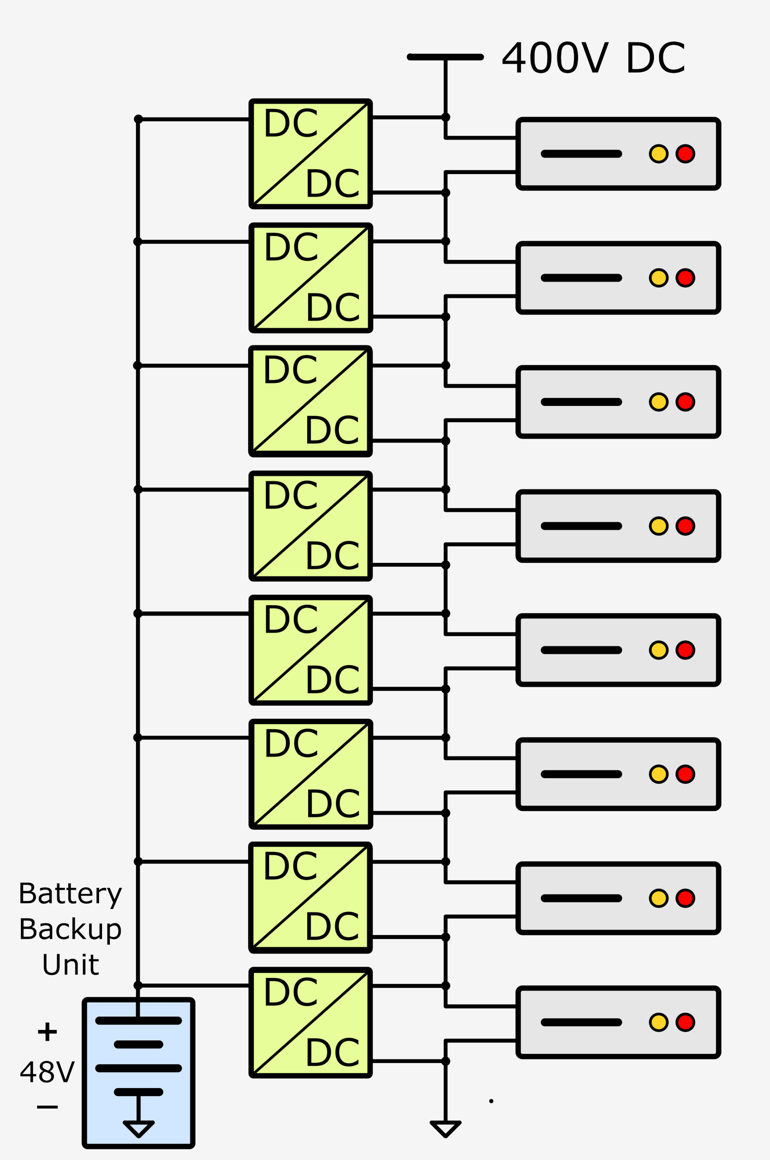

Figure 2. Diagram of a differential power processing system for server rack applications. Note that individual PSUs must be isolated & bidirectional.

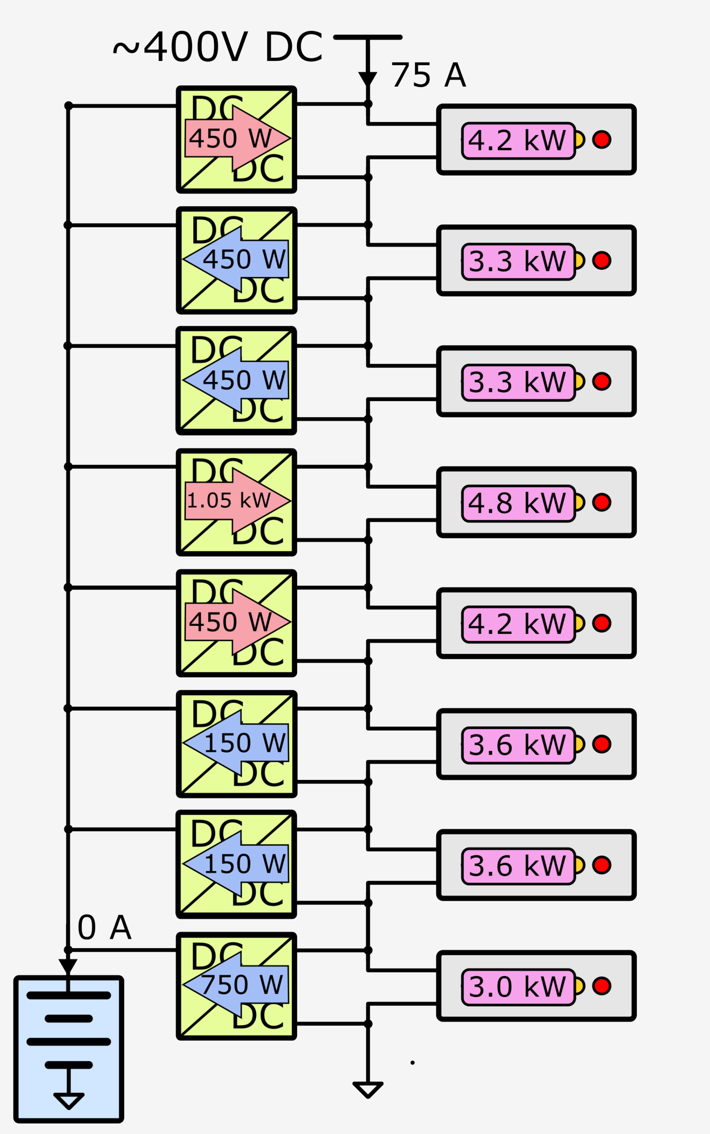

Figure 3. Diagram showing power flow in a DPP system. Note that the power processed by converters is significantly smaller than the power delivered to the servers.

Verification

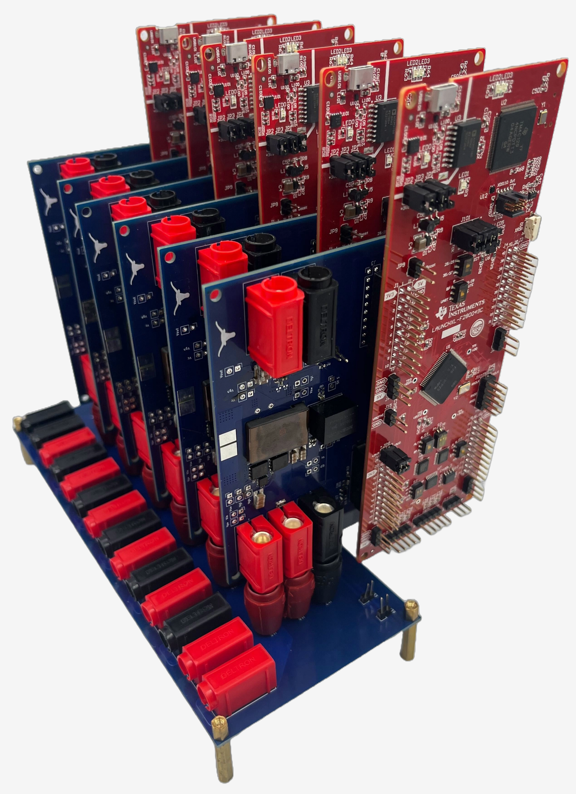

Figure 4. Experimental six-module DPP setup built for PV applications built during Dr. Solomentsev's PhD.

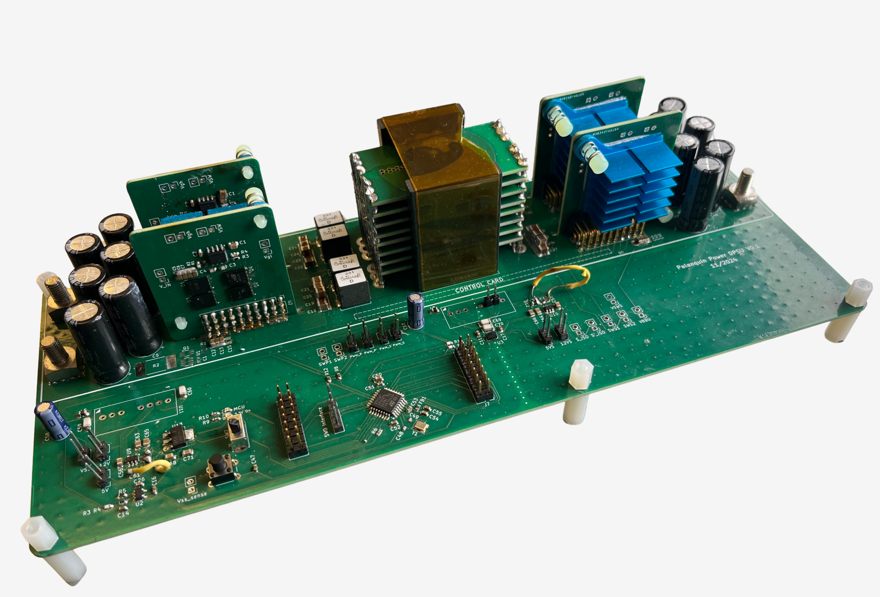

Figure 5. Prototype of a 4 kW isolated bidirectional converter under development for integration into a 32 kW DPP demonstration system.

Academic work has demonstrated 99.8+% efficiency in low-power systems at well-matched conditions. This approach has never been developed for high-power & high numbers of loads. Palanquin is currently building a first of its kind 32 kW differential power processing system.

Simulation & Monte Carlo modeling indicate that the DPP approach can result in availability rates competitive with or better than conventional architectures, since the average power processed by (and thus failure rates of) individual converters is substantially reduced.

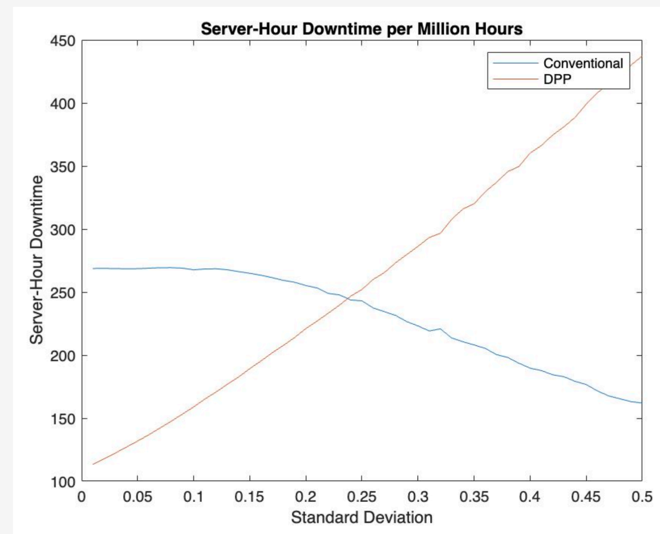

Figure 6. Simulation results showing availability as a function of load distribution.

Status

Palanquin has made patented core advancements to the DPP architecture. It is a spin-out from the University of Texas at Austin, and is embedded within the U.S. National Renewable Energy Lab via a Department of Energy award. Palanquin is developing a full-power demonstration unit to prove high-efficiency and reliability to potential customers.

TEXAS The University of Texas at Austin   NREL

Those interested in collaboration, pilot opportunities, or learning more can contact michael@palanquinpower.com.

Selected References

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