Overcoming Chip Power Walls with Series Voltage Domains

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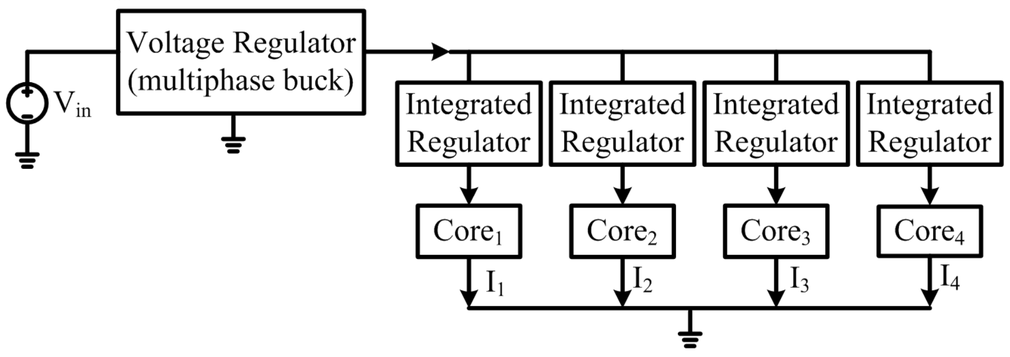
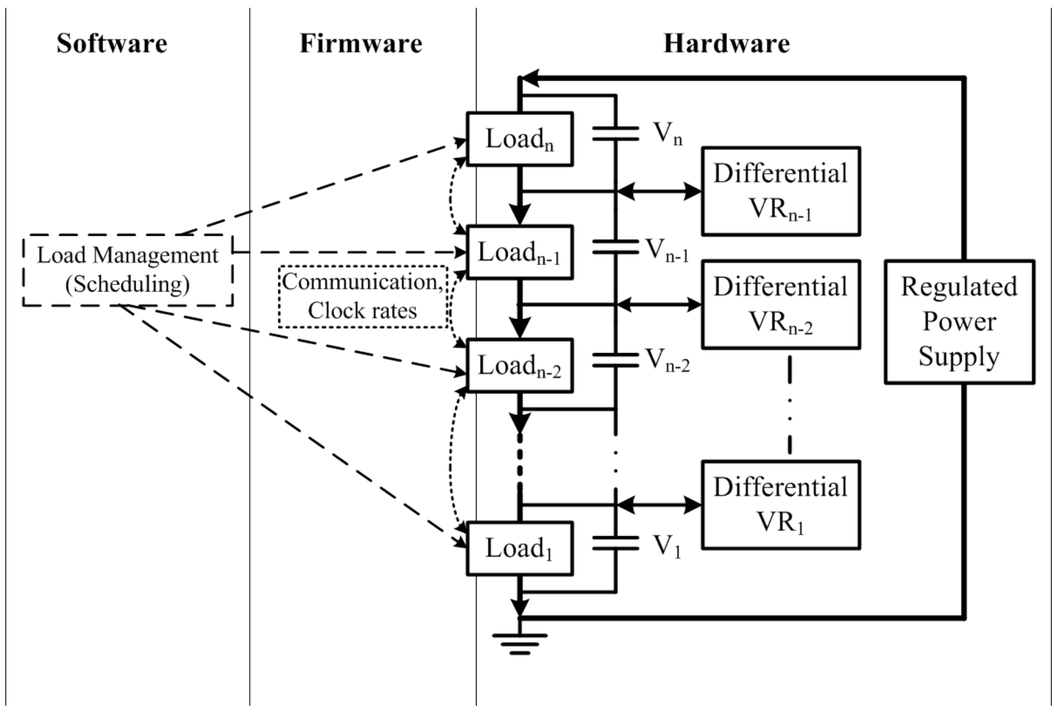
Background

- On-chip dc-dc converters enable independent voltage domains which can reduce energy consumption in digital circuits.
- A cascaded energy conversion stage reduces power delivery efficiency and reliability.



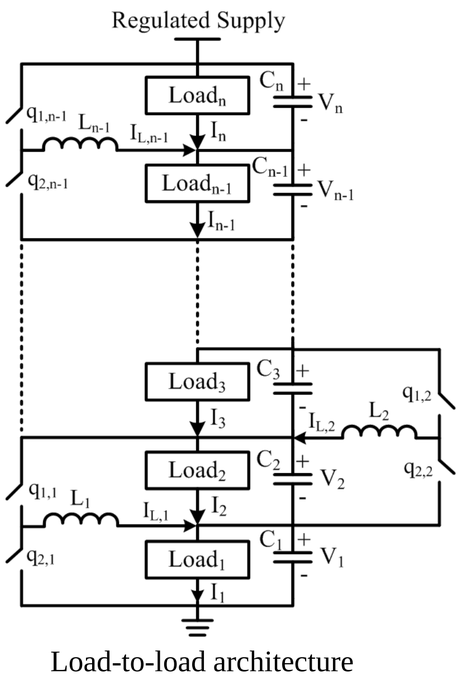
Power delivery with cascaded, on-chip dc-dc converters

Series Voltage Domains

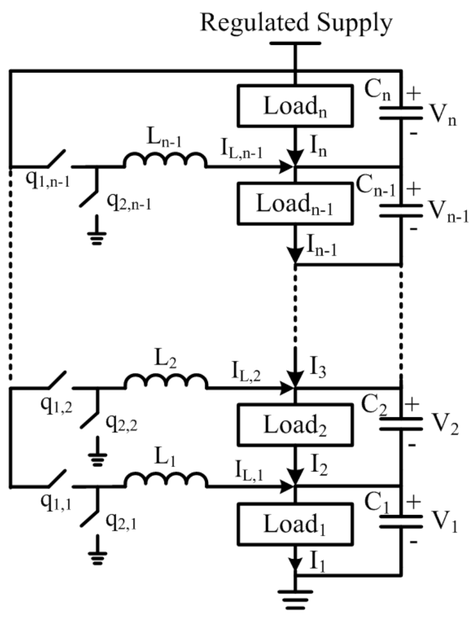


- Bulk energy flows directly to the loads.
- Voltage regulation can be accomplished in software, firmware, or hardware. Various architectures & topologies are feasible.
- Differential converters process only a small fraction of load power and enable independent voltage domains.
- Applies at various levels of abstraction (i.e., scales well).

Differential Power Delivery



Load-to-load architecture



Bus-to-load architecture

- Converter architectures derived from battery balancing circuits.

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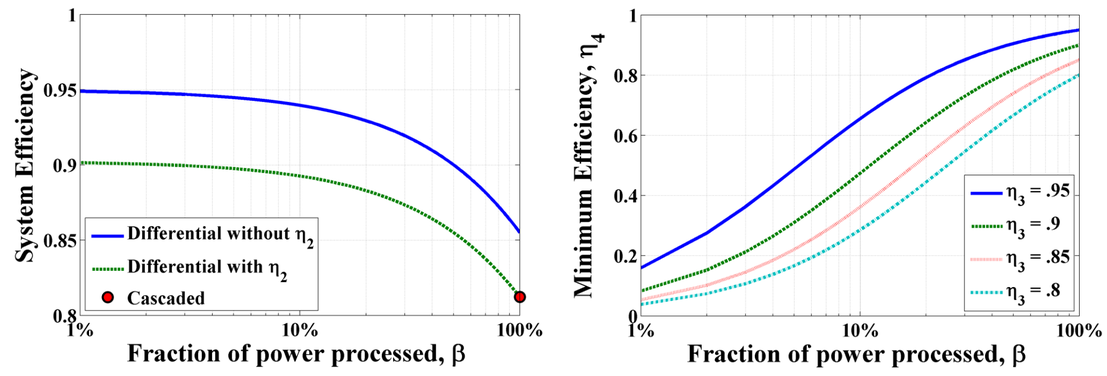
Efficiency Analysis



- Increased system efficiency due to reduction in the fraction of load power processed.
- Less efficient converters can achieve the same total efficiency.

Experimental Results

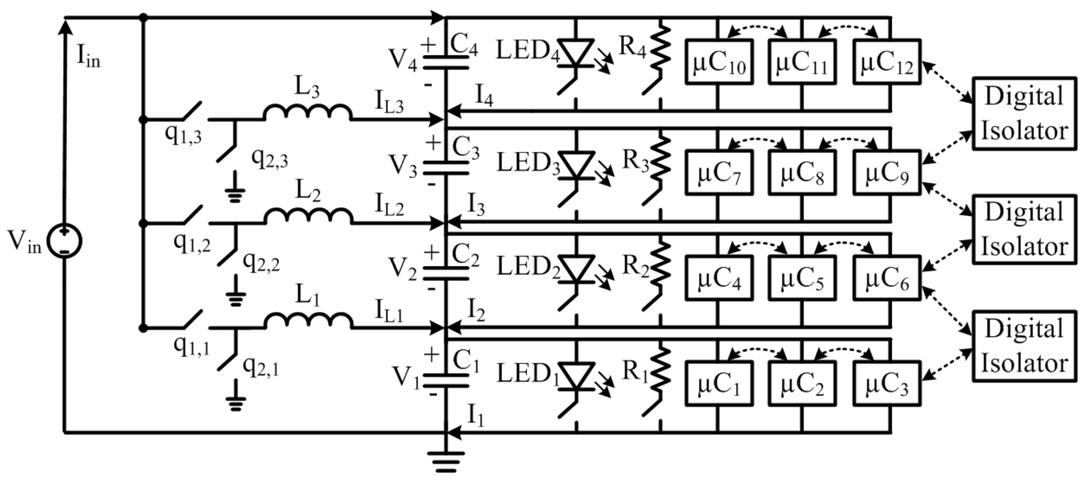
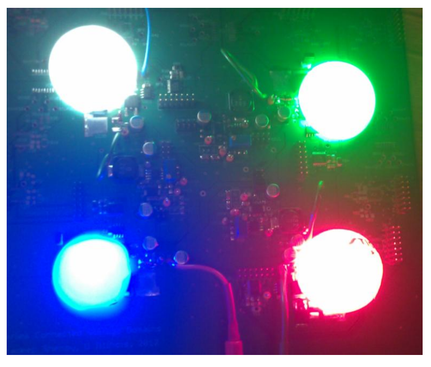
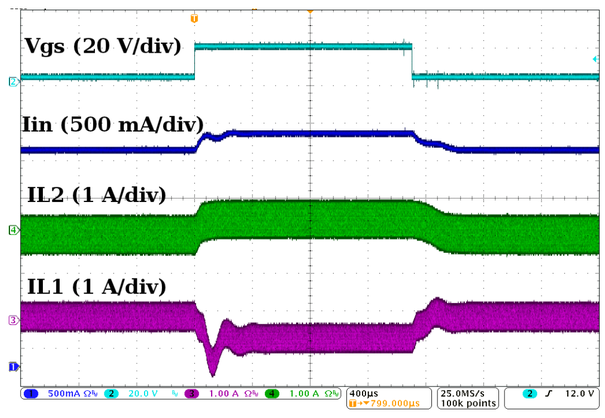


Diagram of experimental prototype with four series voltage domains



Experimental prototype in operation.



Load step response on voltage domain two.

COMPARISON OF POWER DELIVERY APPROACHES

Load Case	Cascaded Architecture		Differential Architecture		Decrease in P_{in} (%)	Decrease in Power Loss (%)
	P_{in} (W)	Conversion Efficiency (%)	P_{in} (W)	Conversion Efficiency (%)		
1	14.79	84.91	13.82	90.89	7.04	43.6
2	13.83	83.99	12.76	91.03	8.37	48.3
3	14.17	84.20	13.17	90.57	7.56	44.5
4	14.82	84.77	13.77	91.21	7.59	46.3

- Effective regulation of differential voltage domains.
- Reduced power consumption and conversion loss.
- Potential for integration due to relatively small size and cost.

Selected References

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