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Efficiency Analysis of Rack Power Architectures

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Analysis considers from rack input to server components

100 – 277VAC

PSU
Power Supply Unit(s)

12 or 48 VDC

VRM
Voltage Regulator Module(s)

PSU + VRM loads
1 VDC
3.3 VDC
5 VDC
12 VDC

12 VDC
The 3 rack architectures

Are centralized rack PSUs more efficient?

Conventional

12V Centralized

48V Centralized

Is 48VDC much more efficient than 12VDC?
Conventional server PSUs are oversized by design

- Typical 2N design
- Engineered by the manufacturer assuming worst case chassis configuration & loading

![Conventional rack diagram](image)
Centralized PSUs minimize oversizing

- Can be configured N+1
- Scaled while in the field, better matching actual loading
12 & 48VDC rack distribution looks similar

We looked at the 2 major components

AC $\rightarrow$ 12 or 48VDC PSUs

12 or 48VDC $\rightarrow$ PoL Voltage Regulator Modules
48VDC PSU can edge out 12VDC efficiency

- Both 12VDC and 48VDC PSUs can achieve Titanium (96%) efficiency.
- Due to $I^2R$ losses, 48VDC is less costly to achieve higher efficiencies for the same power level and density.
New 48VDC VRMs bring density and some efficiency

- In the past several years, 48VDC commercially available Voltage Regulator Modules (VRMs) have come to market.

- 48VDC → PoL VRs can provide slightly higher efficiencies depending on configuration. 2% efficiency gain is possible.
Increasing chip performance is driven by three main levers:
- Increase the number of cores
- Increase transistor count (density)
- Increase frequency / clock speed

The need to increase frequency and the use of GPUs is driving chips from 150watts to up to 300 watts.

Chip packages with VRs allow for use of 48VDC on the board and higher power densities.
Putting the numbers together – Efficiency Calculator

Tool Demonstration
Analysis Take Away

- Consolidating power supplies provide the most dramatic energy improvement 33% lower losses.
- 48VDC rack distributions major advantage is delivering high rack densities, but can provide up to 7% lower energy losses over 12VDC.

Rack-level architectures do show significant improvement in efficiency over conventional servers, primarily due to the reduction in oversizing of the PSUs (both from less redundancy “overhead” and consolidation of server PSUs).

48V direct current is a likely bet for the future, not for the incremental efficiency improvement over 12V direct current, but because of the need for increased compute and density.