What makes 400VDC to an attractive power alternative for data centers?

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Selection of 400V DC Sites

Vendor participants include: HP, IBM, EMC, Fujitsu, Hitachi, NEC
Availability in 400VDC and AC-UPS

**400VDC**
- Mains failure; battery is connected directly to the load
- 28 x 12V battery blocks
- Simple control scheme, only one parameter (DC voltage)
- Battery provides a hard source for safe & reliable fault clearing (high batt. current at short circuit = short clearing time)

**AC-UPS**
- Mains failure; Battery supplies power only if no malfunction on inverter or static switch
- 40 x 12V battery blocks
- Complex control scheme; voltage, frequency, phase, waveform
- Soft source makes fault clearing less effective (longer clearing time at short circuit due to lower inverter output current vs. batt. current)
Basic differences in DC and AC mind set and approach

**DC-UPS**

- N+1
- Battery = Safety Line
- Any unit to be replaced in on-line operation
- Availability in primary focus

**AC-UPS**

- 2N (single big system)
- Grid/Diesel = Safety Line
- By-pass to AC at fail or maintenance
- Redundancy at maintenance/failure in focus
Basic UPS Module configurations

- **AC UPS “N” System**
  (Single Module System)

- **DC UPS**
  (AC SMS N System Equivalent)

Source:  

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BICSI, Class F1 and Class F2 with DC-UPS

Class F1 – Single Power Path

Class F2 – Redundant Components

Source: the green grid®

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BICSI, Class F3 and Class F4 with DC-UPS

Class F3 – Dual Path: Concurrently Maintainable

Class F4 – Dual Path: Fault Tolerant

Source: the green grid

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Cascade Effect in Power Consumption

- **Power Consumption: 100 W System Load**

  - **Total 275 W**
    - Room cooling system 70W
    - UPS + PDU 20W
    - Server fans 15W
    - PSU 50W
    - VR 20W (12V/5V,<5V)

  - **Load 100 W**

  \[ \text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}} = \frac{275W}{185W} = 1.5 \]

  Source: Intel Corporation
End-to-end efficiency comparison

**AC**

**AC-UPS efficiency 50% load, no isolation transf.**

- Double Conversion, market average: 92-94%
- Emerson Trinergy, Double Conversion op. eff.: 95.6%

**Total distribution, average efficiency 98%**

**AC/DC efficiency, market average 90%-93%**

**End-to-end efficiency, double conversion:**

- Market Average: $0.93 \times 0.980 \times 0.915 = 83.4\%$
- Emerson Trinergy: $0.956 \times 0.980 \times 0.915 = 85.72\%$

**DC (400V)**

**DC-UPS efficiency 96.5% (50% load, mains isolated)**

**Total distribution average eff. 99%**

**DC/DC efficiency 91%-95%**

**End-to-end efficiency**

$0.965 \times 0.99 \times 0.93 = 88.85\%$

**Total saving 5% - 8% with 400VDC (cascade effect, mains isolation)**
N+1 redundancy in DC attractive alternative to 2N

- High overall availability
- Power available even if single unit (rectifier, controller, distribution c.b.) fails
- Dual power distribution path A and B
- If controller fails the rectifiers operate at their default setting
More simple site lay-out with 400VDC
StarLine DC Solutions, 400VDC Busway from Universal Electric

415V AC @ 400A = 287kVA/258kW (0.9pf)
380V DC @ 400A = 152kVA X 2 = 304kVA/Kw (1.0pf)

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400V Power Chain Infrastructure Availability

DC Power System
Abb, Eltek, Delta*

DC Load Breaker
ABB, Carling, Schneider, Siemens

Distribution Busway
Univ Elect / Starline, PDI*, Eaton*, Siemens*

Rack PDU
API Technologies, ServerTech, Echola Systems*, Delta*, Fujitsu*

Cord Connector
Anderson Power Products, Hubbel, Rong Feng / Delta, Fujitsu*

ICT Load

400V DC Ecosystem Has Progressed Significantly Over Last Year

* Pre-production products or in development

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400V DC Server Availability

- **HP**
  - HP sees 400V DC market potential and is investing in compatible products
  - HP now offers 400V DC input in their common slot power supply for rack mount devices: ProLiant (DL, ML, SL), Storage, etc; support for c7000 blade by end of 2014
  - Next generation (G9) of products will also include 400V power supplies (500, 800, and 1200W) for 45+ Server, Storage and Switch products

- **IBM**:
  - Some X and Z series available today; Flex blade center support and rack mount common slot power supplies in 2014

- **Juniper**: EX and QFX series top of rack switches with 850W common slot power available

- **Huawei**: working on complete IT portfolio

- **Cisco**: UCS platform compatibility in development

- **NEI**: catalog products available today, 1U and 2U servers

- **Supermicro**: 2 servers models available for trial

- **Dell**: early stages of 400V investigation

**Increased Availability of 400V DC Loads**
### 120kW 400V DC Power System

**Highlights:**
- 120kW base system; bulk or integrated output
- 97% peak efficiency
- 15kW hot-swappable rectifier modules
- High-Resistance Midpoint Ground configuration
- cUL/CE 60950 Listed
- Designed to meet NEBS

**Features:**
- Expand with additional 120kW modules (2nd phase)
- Available battery cabinets
- Top or bottom rack cable entry
- 2000mm x 600mm x 1100mm footprint
400V DC Summary

- 400V DC power reduces complexity and increases availability compared to traditional AC power
- Lower TCO
  - N+1 good enough vs. 2N in many cases (fault tolerant modularity)
  - No bypass/STS/paralleling equipment
  - No UPS output switchboard
- Higher overall efficiency
- 400V DC Eco-system continues to develop

400V DC Power Technology
Improves Power Architectures in Data Center & Telecom Sites