→DIRECT POWER→TECHNOLOGIES, INC.

HIGHER VOLTAGE DC (HVDC) POWER SOLUTIONS FOR CRITICAL POWER ENVIRONMENTS

A PATENT PENDING SYSTEM PRESENTATION

Mark Baldwin - President

Direct Power Technologies, Inc.

David Geary, PE - VP of Engineering

Direct Power Technologies, Inc.

DIRECT POWER TECHNOLOGIES, INC.

Providing Efficient Reliability

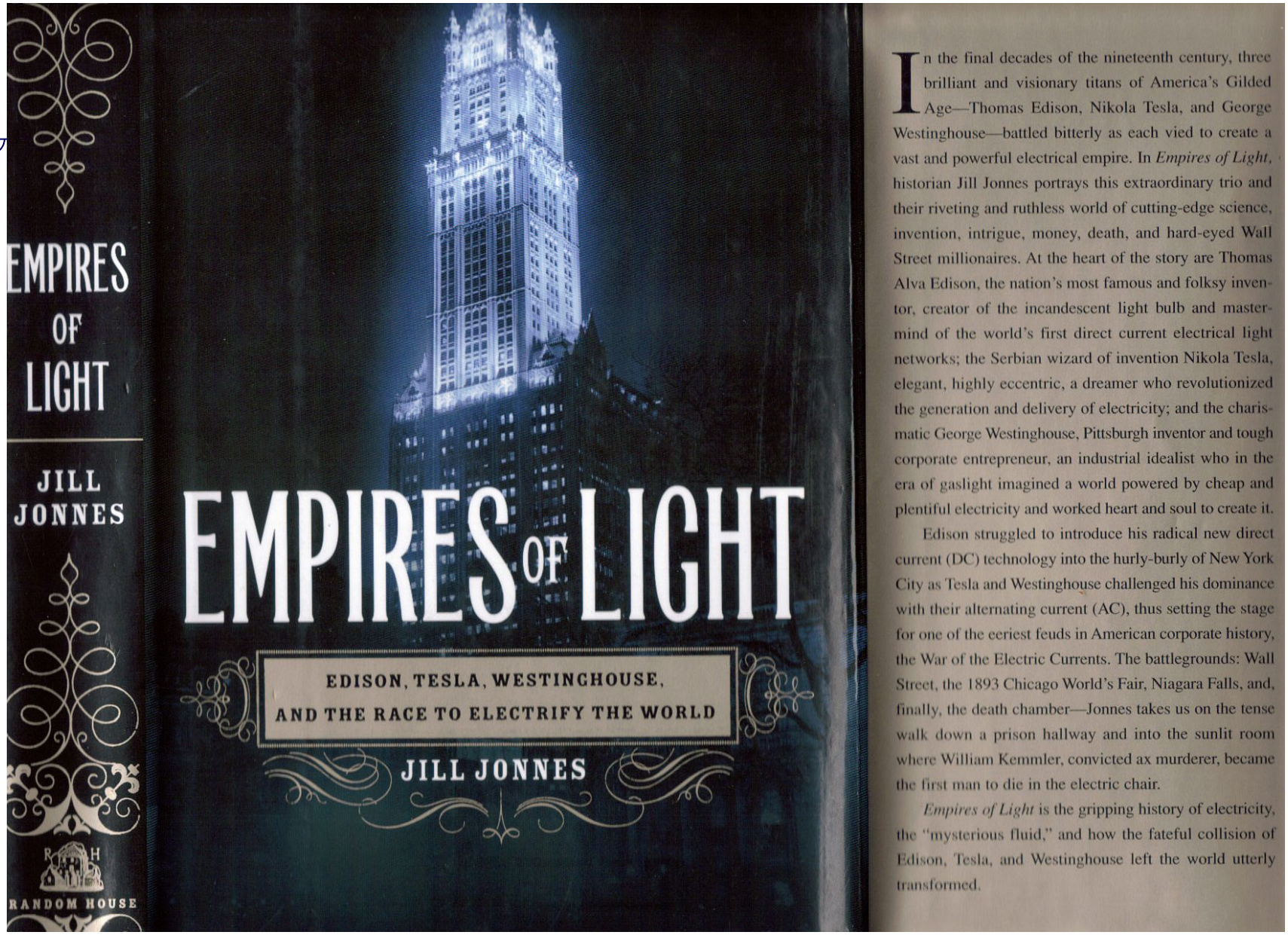
THOMAS ALVA EDISON

1889

SCIENTIFIC AMERICAN

"My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous. I can therefore see no justification for the introduction of a system which has no element of permanency and every element of danger to life and property"

NICOLA TESLA PRESENTED A LECTURE TO THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS: "A NEW SYSTEM OF ALTERNATING CURRENT MOTORS AND TRANSFORMERS". THIS WAS EDISON'S RESPONSE TO THIS NEW AC POWER CONCEPT.


EMPIRES
OF
LIGHT
JILL
JONNES
RANDOM HOUSE
EMPIRES OF LIGHT
EDISON, TESLA, WESTINGHOUSE,
AND THE RACE TO ELECTRIFY THE WORLD
JILL JONNES
In the final decades of the nineteenth century, three brilliant and visionary titans of America's Gilded Age—Thomas Edison, Nikola Tesla, and George Westinghouse—battled bitterly as each vied to create a vast and powerful electrical empire. In *Empires of Light,* historian Jill Jonnes portrays this extraordinary trio and their riveting and ruthless world of cutting-edge science, invention, intrigue, money, death, and hard-eyed Wall Street millionaires. At the heart of the story are Thomas Alva Edison, the nation's most famous and folksy inventor, creator of the incandescent light bulb and mastermind of the world's first direct current electrical light networks; the Serbian wizard of invention Nikola Tesla, elegant, highly eccentric, a dreamer who revolutionized the generation and delivery of electricity; and the charismatic George Westinghouse, Pittsburgh inventor and tough corporate entrepreneur, an industrial idealist who in the era of gaslight imagined a world powered by cheap and plentiful electricity and worked heart and soul to create it.
Edison struggled to introduce his radical new direct current (DC) technology into the hurly-burly of New York City as Tesla and Westinghouse challenged his dominance with their alternating current (AC), thus setting the stage for one of the eeriest feuds in American corporate history, the War of the Electric Currents. The battlegrounds: Wall Street, the 1893 Chicago World's Fair, Niagara Falls, and, finally, the death chamber—Jonnes takes us on the tense walk down a prison hallway and into the sunlit room where William Kemmler, convicted ax murderer, became the first man to die in the electric chair.
Empires of Light is the gripping history of electricity, the "mysterious fluid," and how the fateful collision of Edison, Tesla, and Westinghouse left the world utterly transformed.

INTRODUCTION

High density computer environments, utilizing Alternating Current (AC) power supply blade server technology, are presenting major challenges to owners and operators. Typical facility infrastructures cannot accommodate the added heat loads and reliability requirements of such installations.

Servers equipped with Direct Current (DC) power supplies, instead of AC power supplies, operate with 20-40% less heat, reduce power consumption by up to 30%, increase server reliability, offer flexibility to installations and decrease maintenance requirements.

Utilizing current off-the-shelf components, it is possible to install and operate a high reliability DC power distribution system for a DC powered server environment - without batteries or complicated AC power system drawbacks. This High Reliability DC Power Distribution System could be the next generation power system for server environments.

THE PROBLEM

The New York Times
nytimes.com

PRINTER-FRIENDLY FORMAT SPONSORED BY THE OF

September 26, 2006

Google to Push for More Electrical Efficiency in PC's

By JOHN MARKOFF

SAN FRANCISCO, Sept. 25 — Google is calling on the computer industry to create a simpler and more efficient power supply standard that it says will save billions of kilowatt-hours of energy annually.

WSJ.com THE WALL STREET JOURNAL. ONLINE

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January 29, 2007

Running Wild

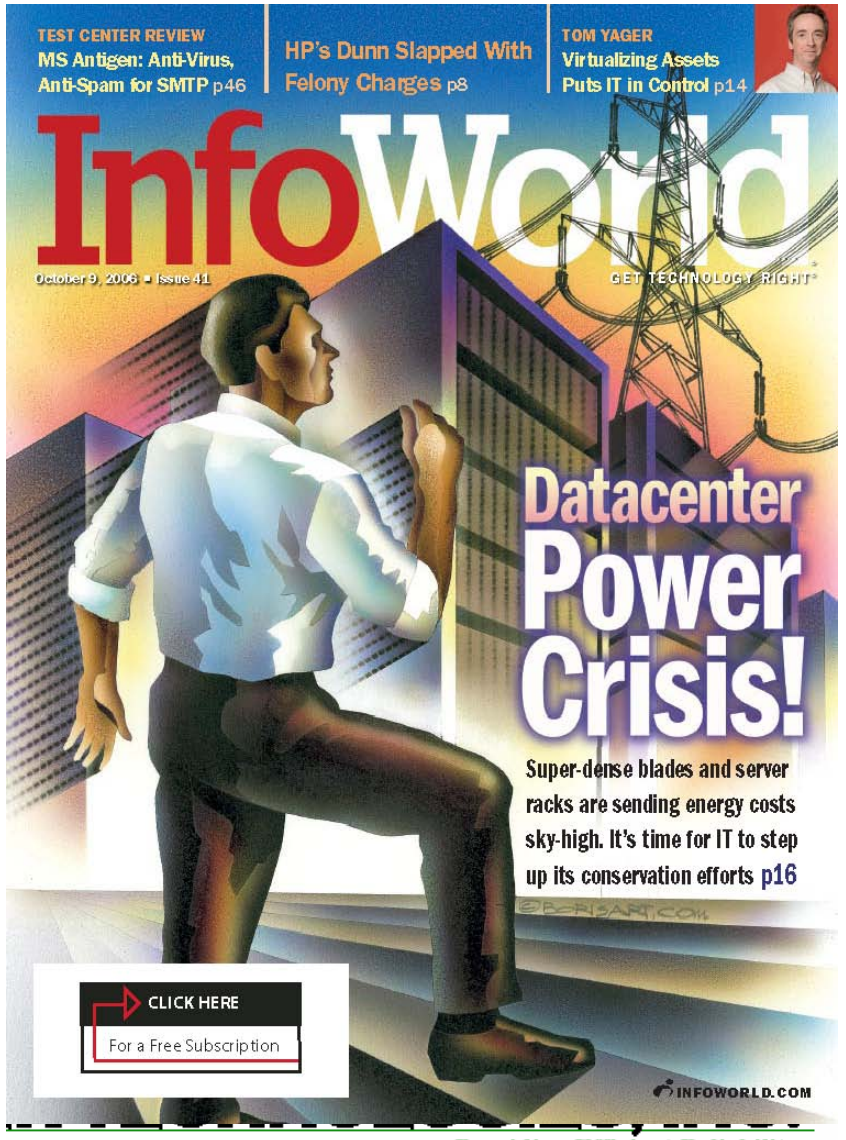
Powering and cooling computers cost more than the machines themselves. Now, new technologies are reducing those expenses.

By CHRISTOPHER LAWTON
January 29, 2007; Page R7

Servers have gotten much more powerful in recent years. But they've also gotten hungrier.

In 2006, businesses world-wide spent about $55.4 billion on new servers, according to market-research firm IDC. To power and cool those machines, they spent $29 billion, almost half the cost of the equipment itself -- and that number is rising.

With the average server system, the customer spends "more on power and cooling over its entire life cycle than what they will spend up front," says Michelle Bailey, research vice president at IDC.



Providing Efficient Reliability

THE PROBLEM

TECHNOLOGY JOURNAL.

IBM to Launch Push for Green

New Business to Address Cutting Energy Thirst Of Computer Centers

By WILLIAM M. BULKELEY

Big Blue sees green in going green.

Under an initiative it has dubbed "Project Big Green," **International Business Machines** Corp. plans to start a major business to help customers slash energy use in data centers that are running up ever larger electricity bills.

IBM has scheduled a press event for today in New York to inaugurate the business, which is part of its global-services offering. The business will help customers maximize energy efficiency of their computers and redesign the layout of their data centers to minimize cooling costs.

In addition, IBM, which says it is the world's biggest operator of data centers, will explain its own plans for reducing power consumption.

The amount of energy used by computers—both for running the machines and cooling the rooms they sit in—has increasingly raised concerns both about cost and environmental impact. Global electricity consumption by servers and ancillary equipment doubled to $7.3 billion from 2000 to 2005, Jonathan Koomey, a staff scientist at Lawrence Berkeley National Laboratory and consulting professor at Stanford University, estimated in a study released this year.

Christopher Mines, an analyst with market researcher Forrester Research, Cambridge, Mass., says it found in a recent survey of corporate computer buyers "a high degree of awareness of environmental issues surrounding computing, but a low degree of activity." He said most corporate computer managers focus on high performance and reliability for their networks and ignore electricity use. "They don't pay the bill in the vast majority of companies," he said, adding that energy bills are the province of operations managers.

IBM compares the new project with the commitment it made 10 years ago to embrace the Internet and later Linux free software, both for its own use and as a service business for corporate and governmental customers. Both plans have improved the company's internal business operations and created an opportunity for huge additional services and software revenue.

IBM is training 1,000 services experts in green technology to help clients redesign their data centers and improve their efficiency.

According to materials prepared for the press event, IBM expects to double the computing capacity of its own data centers by 2010 without using additional energy. Under that scenario, it would avoid incurring $500 million in electricity costs.

IBM's announcement today is expected to feature several technologies for reducing air-conditioning costs in data centers, where computers must be kept cool to function optimally. Among those technologies is the IBM Data Center Stored Cooling Solution, which sits outside the data center and uses a synthetic liquid solution to cool chillers that regulate air-conditioning units. The product was named the "best new energy product" by the American Society of Heating, Refrigeration and Air Conditioning Engineers.

Other aspects of IBM's green services include a software program that can analyze heat and air-conditioning use in a data center to find hot spots and suggest ways to move servers to optimize cooling capabilities.

IBM's news event today is expected to include representatives from a number of partner companies, including **General Electric** Co., **PG&E** Corp.'s Pacific Gas & Electric Co. and **Schneider Electric** SA.

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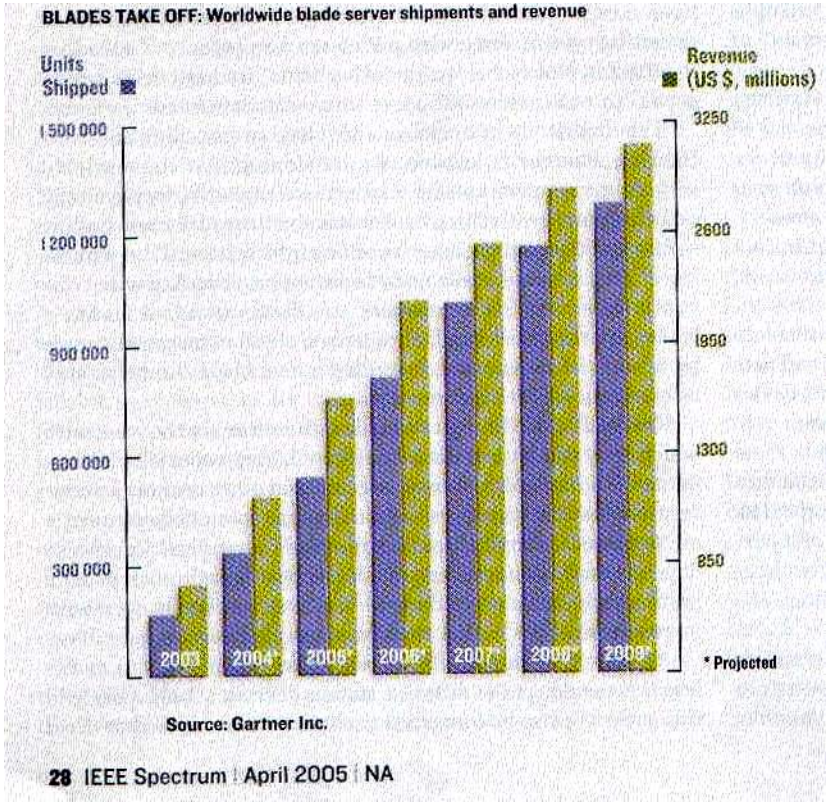
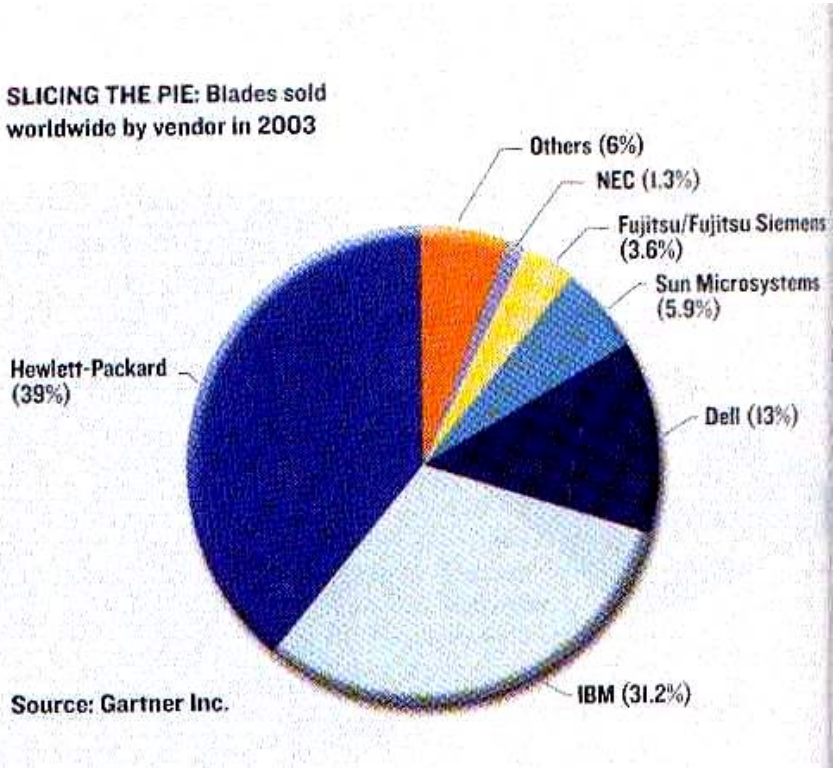
THE MARKET





APPROX. $3 BILLION BLADE SERVER REVENUE BY 2009

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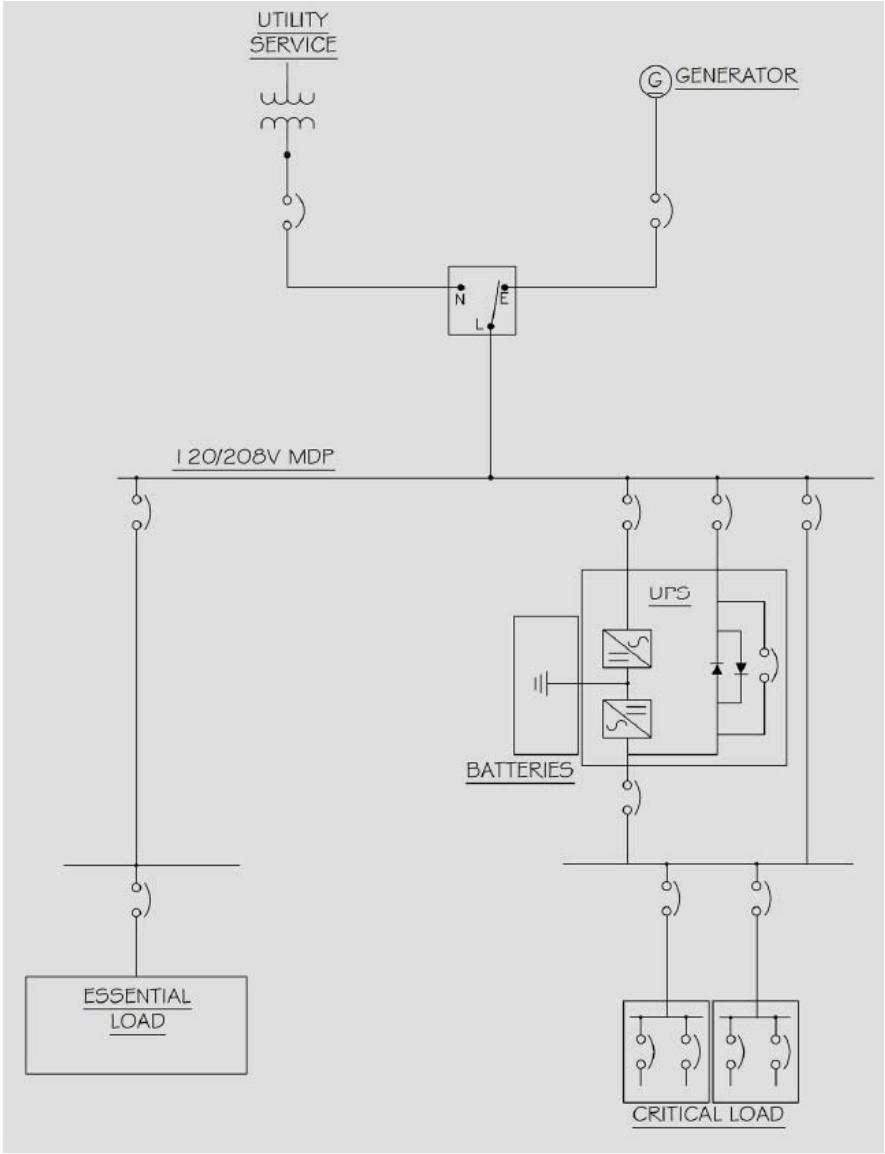
TODAY'S ENVIRONMENT

- THE ALTERNATING CURRENT (AC) WORLD
- HIGH COST - LOW EFFICIENCY/HIGH LOSS - MAINTENANCE INTENSIVE
- PARALLEL OPERATION REQUIRES HIGH COST ACTIVE PARALLELING CONTROLS
- AC POWERED BLADE SERVERS CANNOT BE ACCOMMODATED WITHIN THE TYPICAL DATA CENTER ENVIRONMENT
- MULTIPLE CONVERSIONS REQUIRED:
  - AC (UTILITY) to DC (UPS INPUT) to AC (UPS OUTPUT) to DC (WITHIN DATA PROCESSING POWER SUPPLIES)

TYPICAL SMALL AC POWER SYSTEM UP TO APPROX. 300KVA



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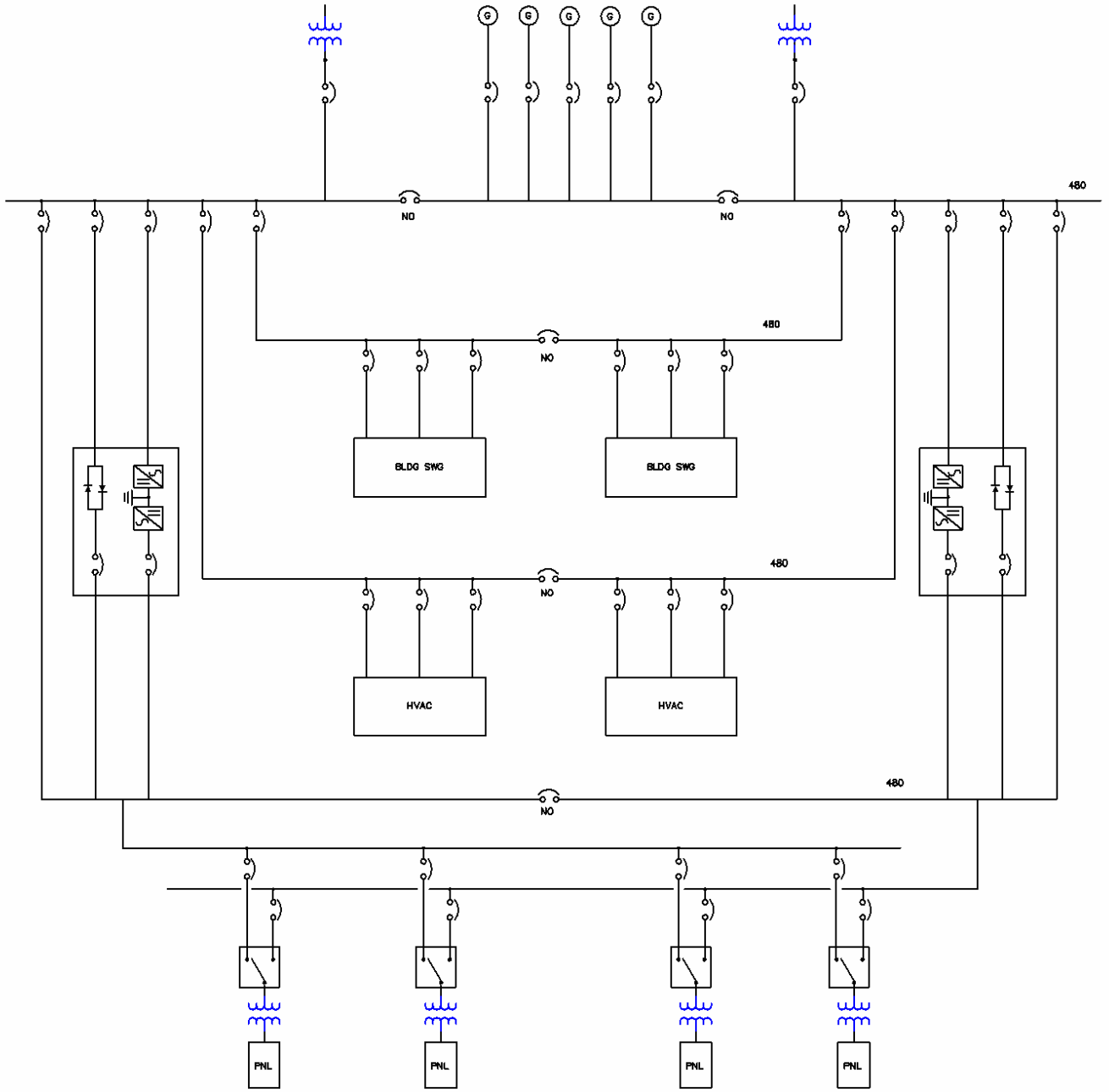
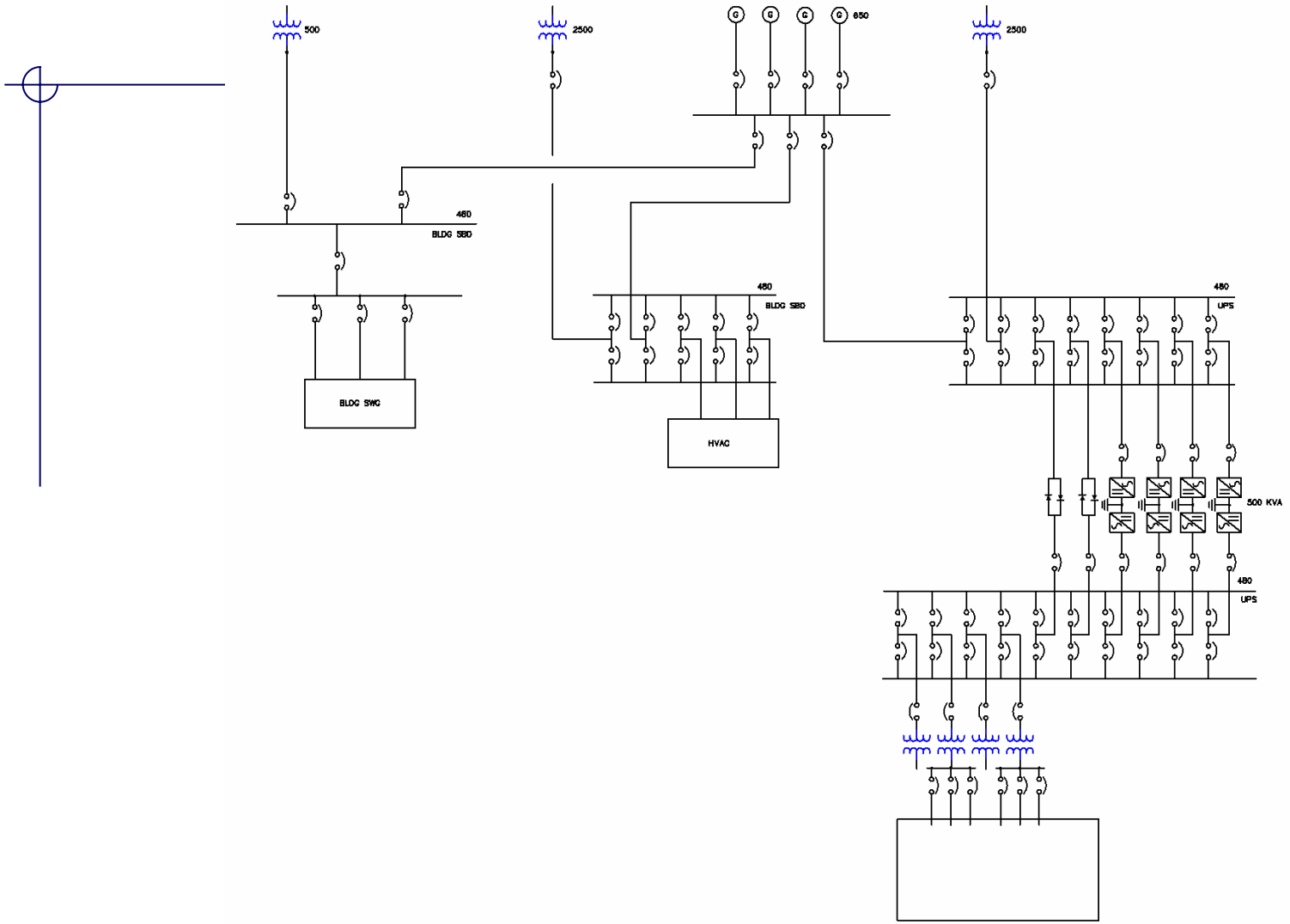
TYPICAL MEDIUM AC POWER SYSTEM UP TO APPROX. 1,000KVA



TYPICAL LARGE AC POWER SYSTEM UP TO APPROX. 2,000KVA



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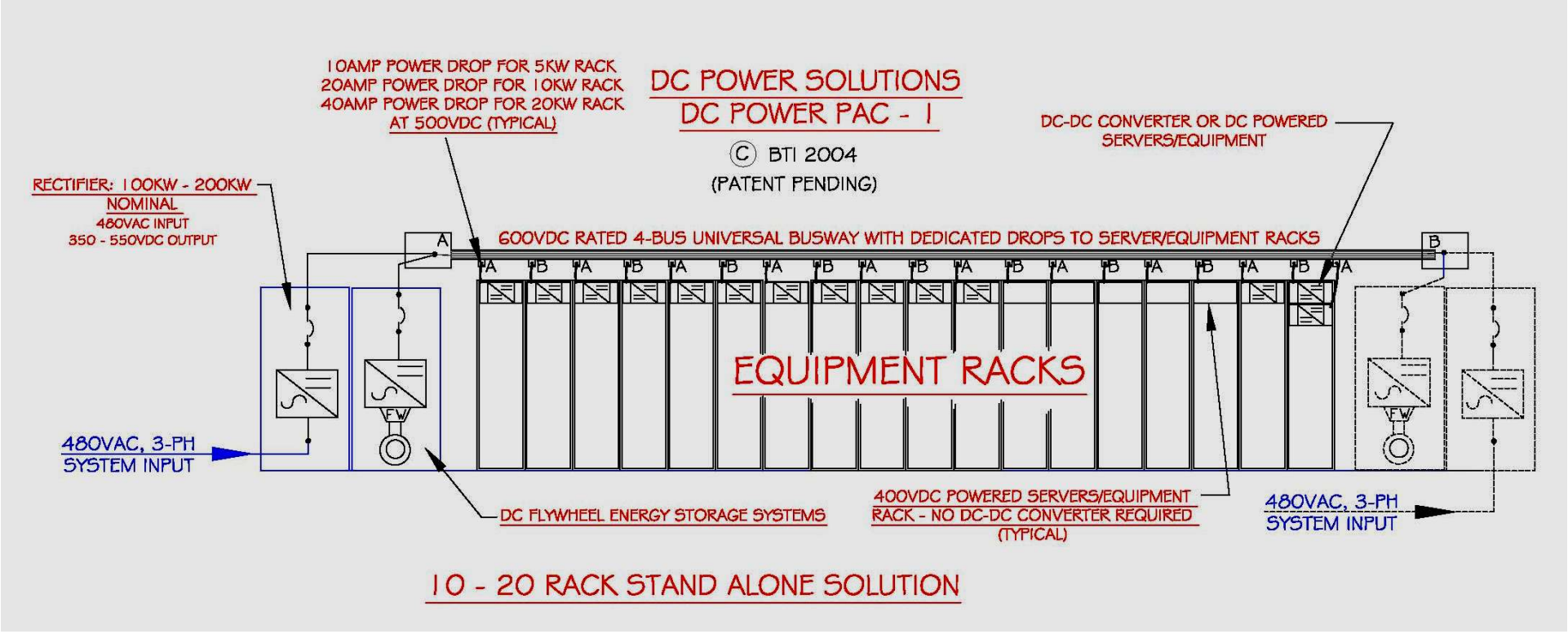
THE SOLUTION - TOMORROW'S ENVIRONMENT

- DC POWER:
  - REDUCED POWER CONVERSIONS = HIGHER EFFICIENCY
  - REDUCED POWER CONVERSIONS = HIGHER RELIABILITY
  - REDUCED POWER CONVERSIONS = LESS COMPONENTS (MAINTAINABILITY)
  - DC POWER = EASIER TO ADAPT TO ALTERNATIVE ENERGY SOLUTIONS

DC POWER SOLUTIONS
DC POWER PAC - 1 ©



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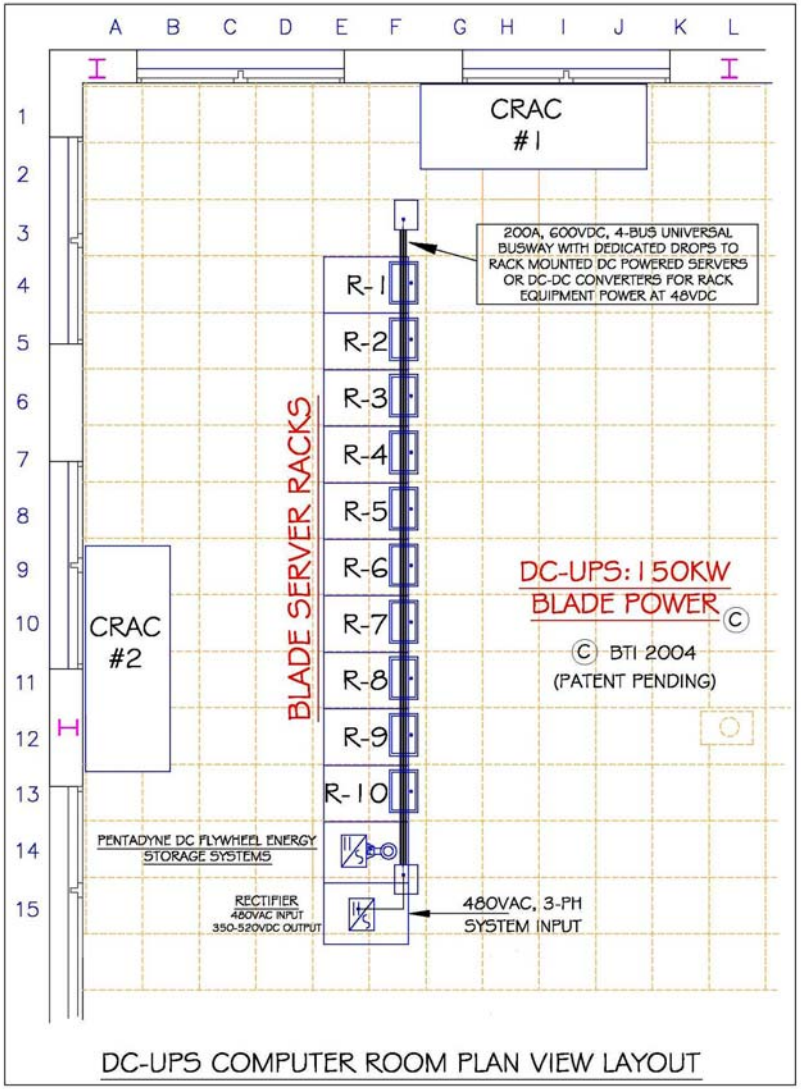
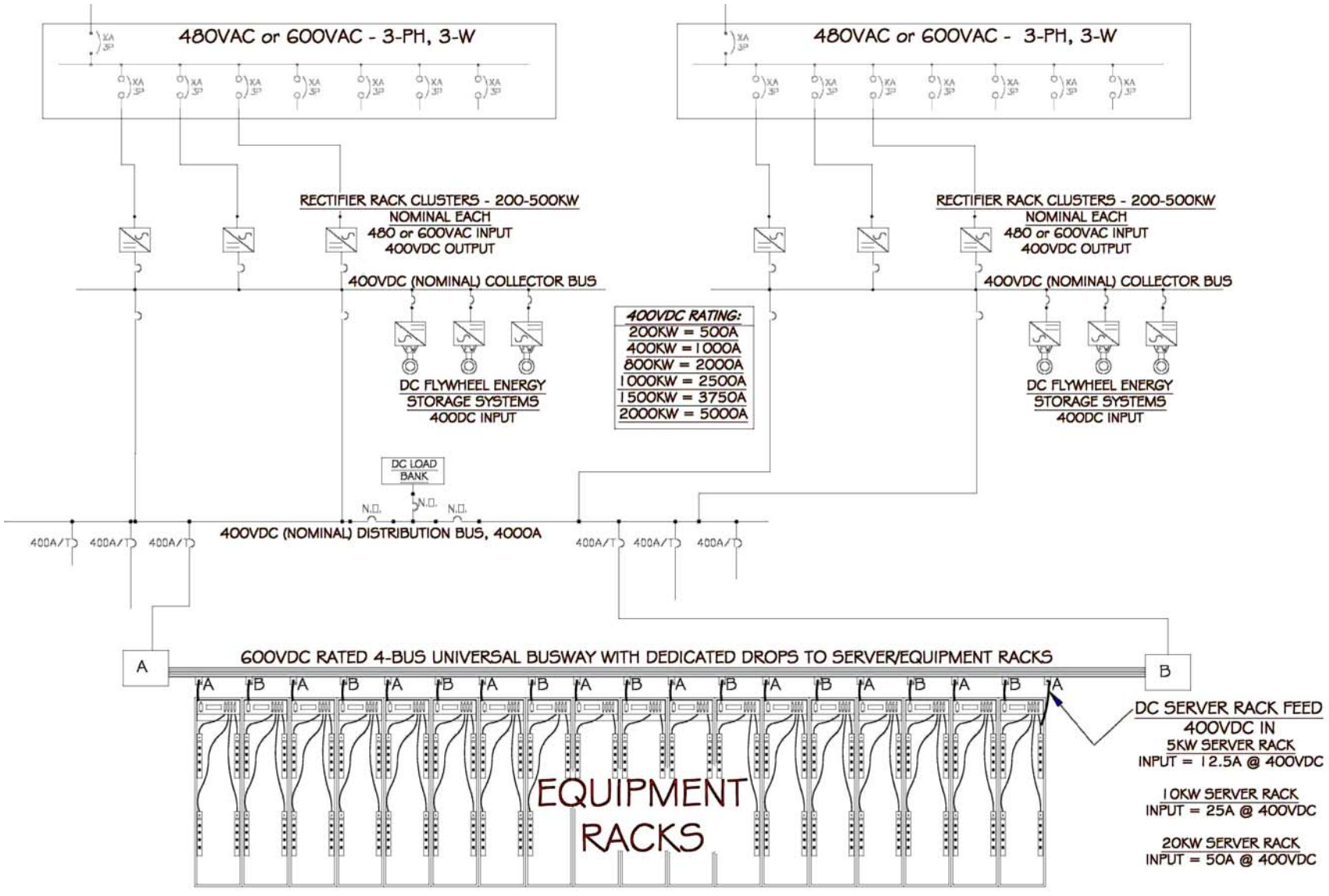
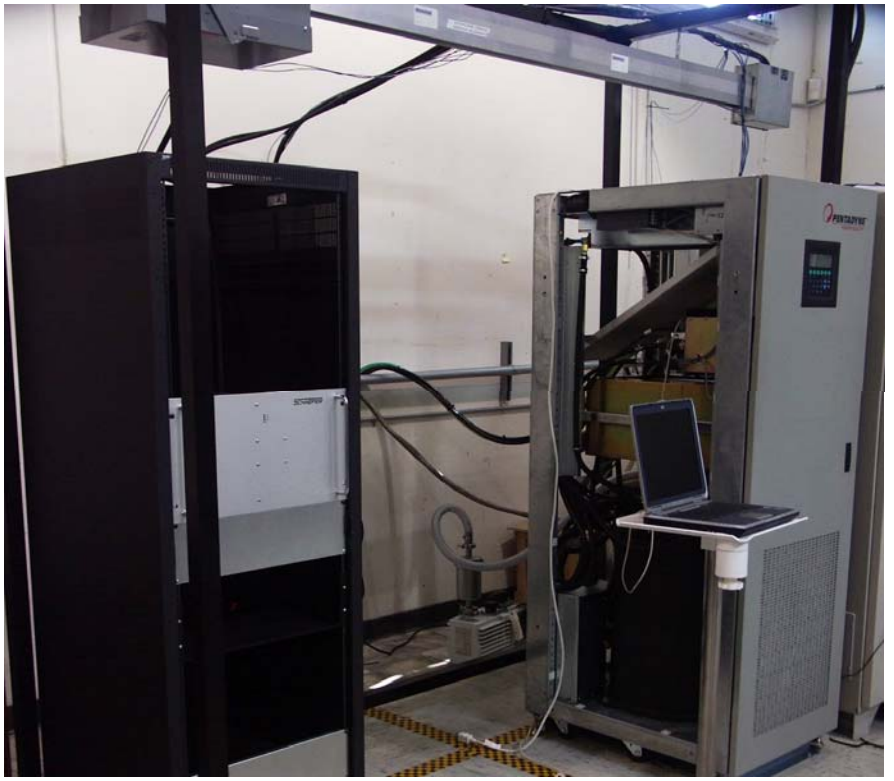


BladePower

DC POWER SOLUTIONS - DC POWER PAC - 2 ©



1ST DEMONSTRATION SYSTEM - CHATSWORTH, CA. – PENTADYNE POWER HQ – MARCH 2005



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1ST DEMONSTRATION SYSTEM - CHATSWORTH, CA. – PENTADYNE POWER HQ – MARCH 2005

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COMPONENT PARTS OF THE DC POWER DISTRIBUTION SYSTEM

- RECTIFIERS: -
  - CONVERTS UTILITY OR GENERATOR SOURCED AC POWER TO 400VDC (NOMINAL) IN ANY COMBINATION OF BUILDING BLOCK SIZING FOR CAPACITY AND/OR REDUNDANCY

- ENERGY STORAGE: -
  - PROVIDES DC POWER RIDE THROUGH WITHOUT BATTERIES. UPON LOSS OF THE AC POWER SOURCE TO THE RECTIFIERS, THE PENTADYNE FLYWHEEL TECHNOLOGY BASED SYSTEM WILL SUPPORT THE 400VDC BUS WHILE ENGINE GENERATORS ARE BROUGHT ON LINE

COMPONENT PARTS OF THE DC POWER DISTRIBUTION SYSTEM - CONT'D

- EQUIPMENT RACK DISTRIBUTION: -
  - PROVIDES UL LISTED 400VDC POWER DISTRIBUTION TO EQUIPMENT RACK LOCATIONS WITHIN A COMPACT PACKAGE WITH HOT SWAPPABLE / MOVABLE CONNECTORS. BUSWAY HAS THE CAPABILITY OF BEING FED FROM 2 SEPARATE 400VDC SOURCES FOR REDUNDANCY
- DC - DC VOLTAGE CONVERTERS: -
  - NOT REQUIRED IN THIS NEW TOPOLOGY: DISTRIBUTE AT A 380-400V DC AND CONNECT DIRECTLY INTO DC POWERED SERVER RACKS. HIGHEST EFFICIENCY CONFIGURATION!

NEXT GENERATION DC POWER ARCHITECTURE:
400VDC BLADE-POWER SERVER RACKS

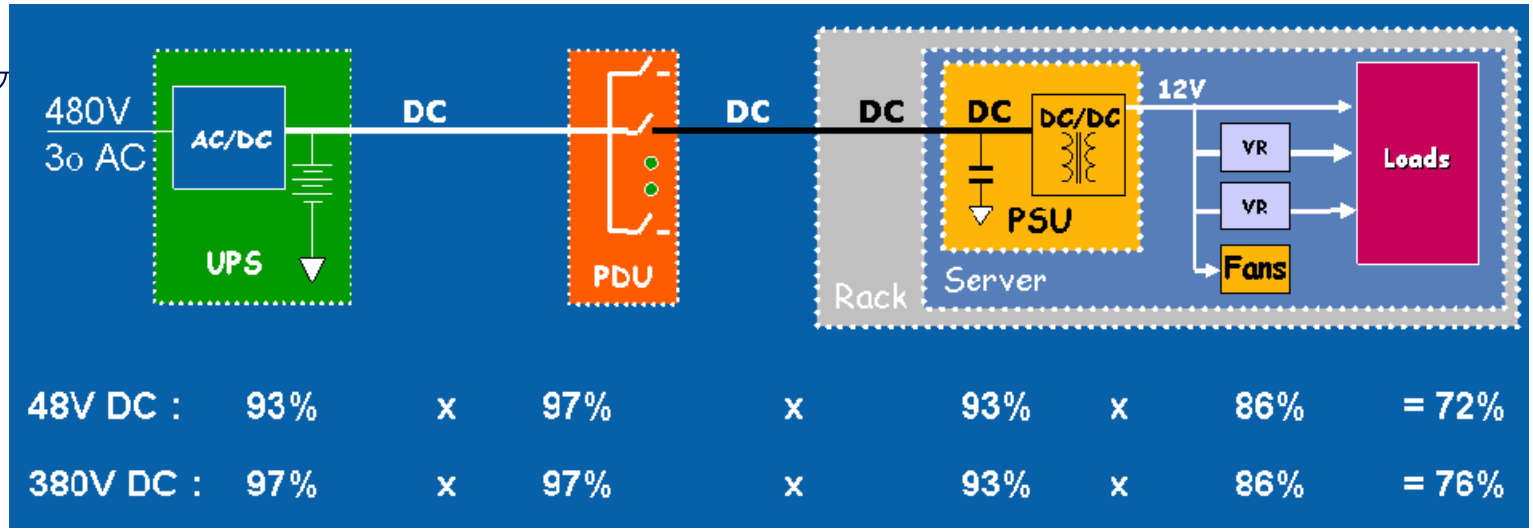
THE UNIVERSAL COMPUTER POWER SUPPLY-

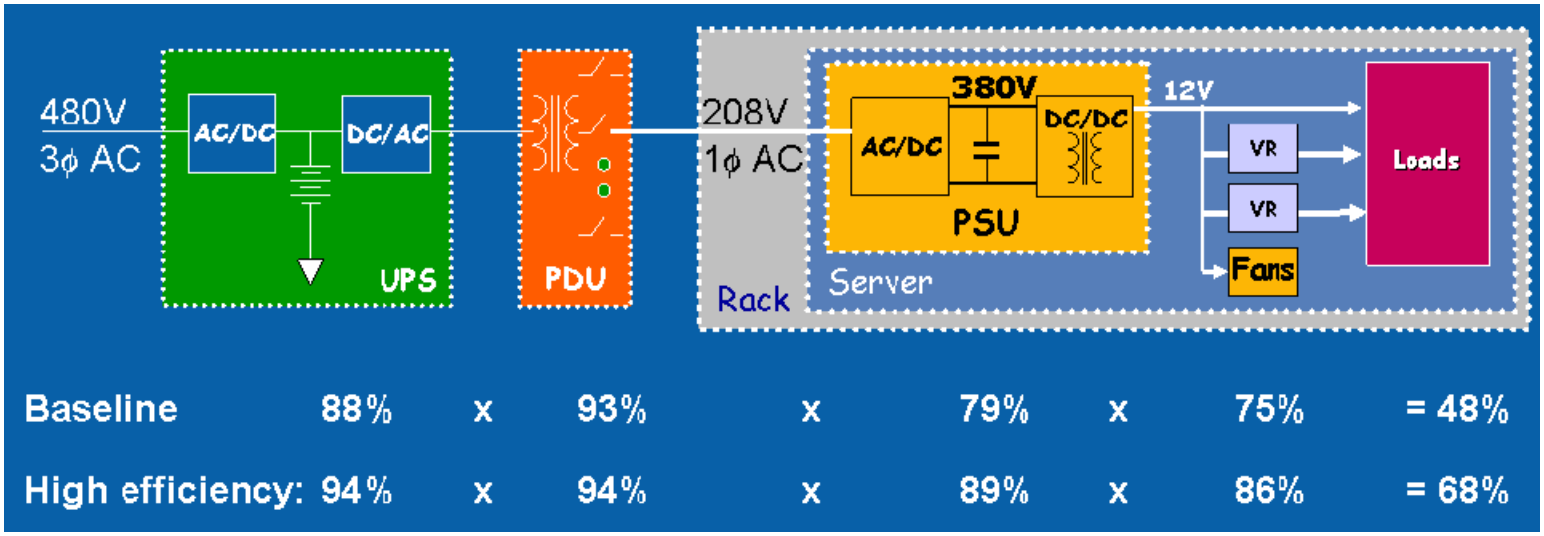
SPECIFICATIONS

AC Input Range	110/240V 47-63Hz. Limits: 85 - 264 VRMS (270V Surge), 47 to 63 Hz
DC Input Voltage Range	110 to 373V DC (380V DC surge)

- 1ST LEVEL POWER CONVERSION IN TODAY'S COMPUTERS IS A DIODE RECTIFIER THAT TAKES 85 - 264VAC AND CONVERTS TO 110 - 373V DC.
- DIODE BRIDGE RECTIFIER
  - - 264VAC X SQUARE-ROOT OF 2 = 373VDC
- A NOMINAL 400VDC DISTRIBUTION SYSTEM CAN ELIMINATE THE FIRST STAGE CONVERSION WITHIN COMPUTERS!
- STUDIES ARE UNDER WAY WITH COMPUTER MANUFACTURER'S FOR A 400VDC "DISTRIBUTION-TO-THE-RACK" ARCHITECTURE.

INTEL'S VISION





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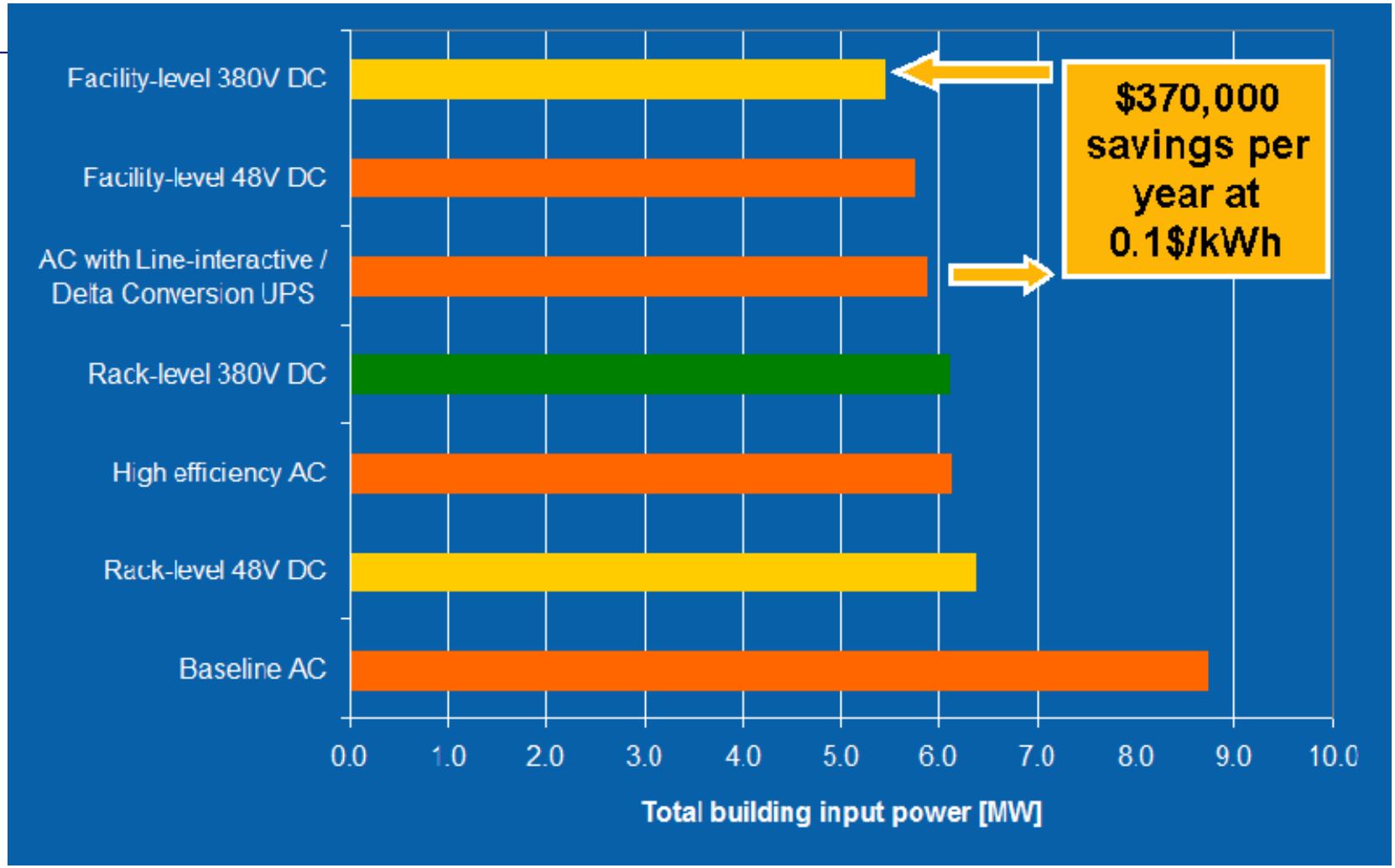
System Efficiency Impacts

For a load power of 500kW;

Architecture	System Efficiency	Input Power	Annual Energy costs @ 10 cents / kWh
	%	kW	$$ (1000's)
Baseline AC	50	1000	876
Best-in-Class AC	63	793	695
Rack Level HVDC	63	793	695
-48 V DC	70	715	625
HVDC Data Center	72	695	608

63% to 70% ⇒ $70K per annum savings
70% to 72% ⇒ Additional $17K per annum savings



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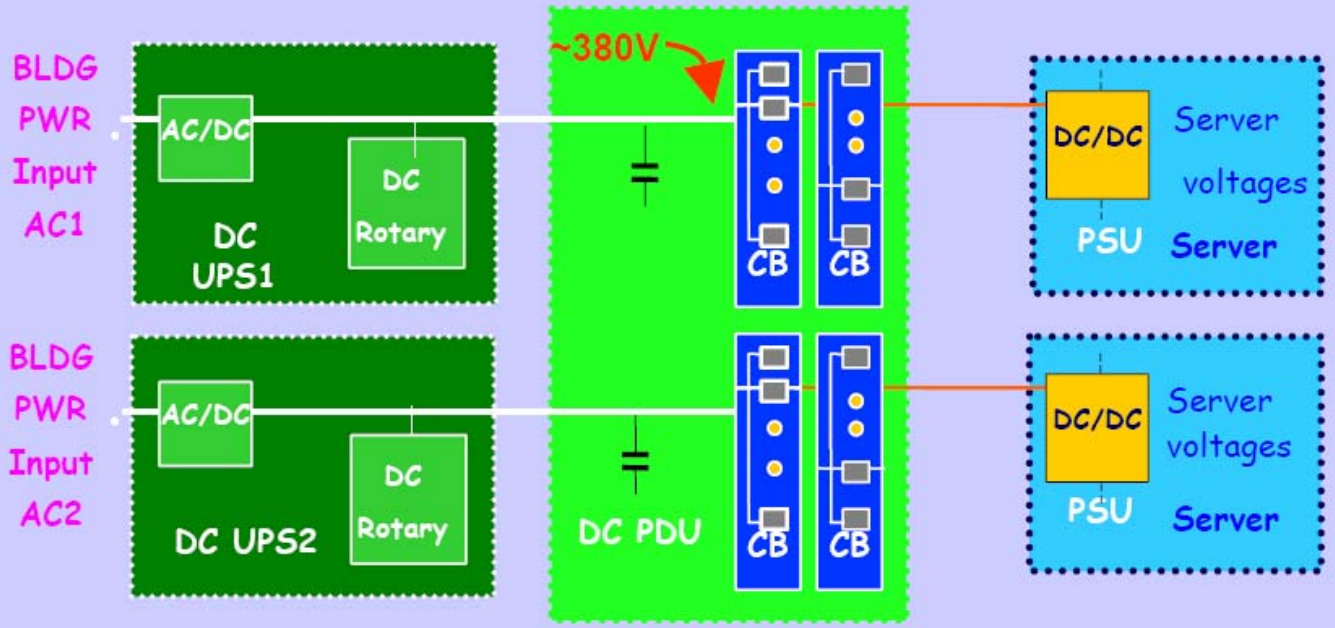
SUN MICRSYSTEMS' VISION

DC Distribution Configuration



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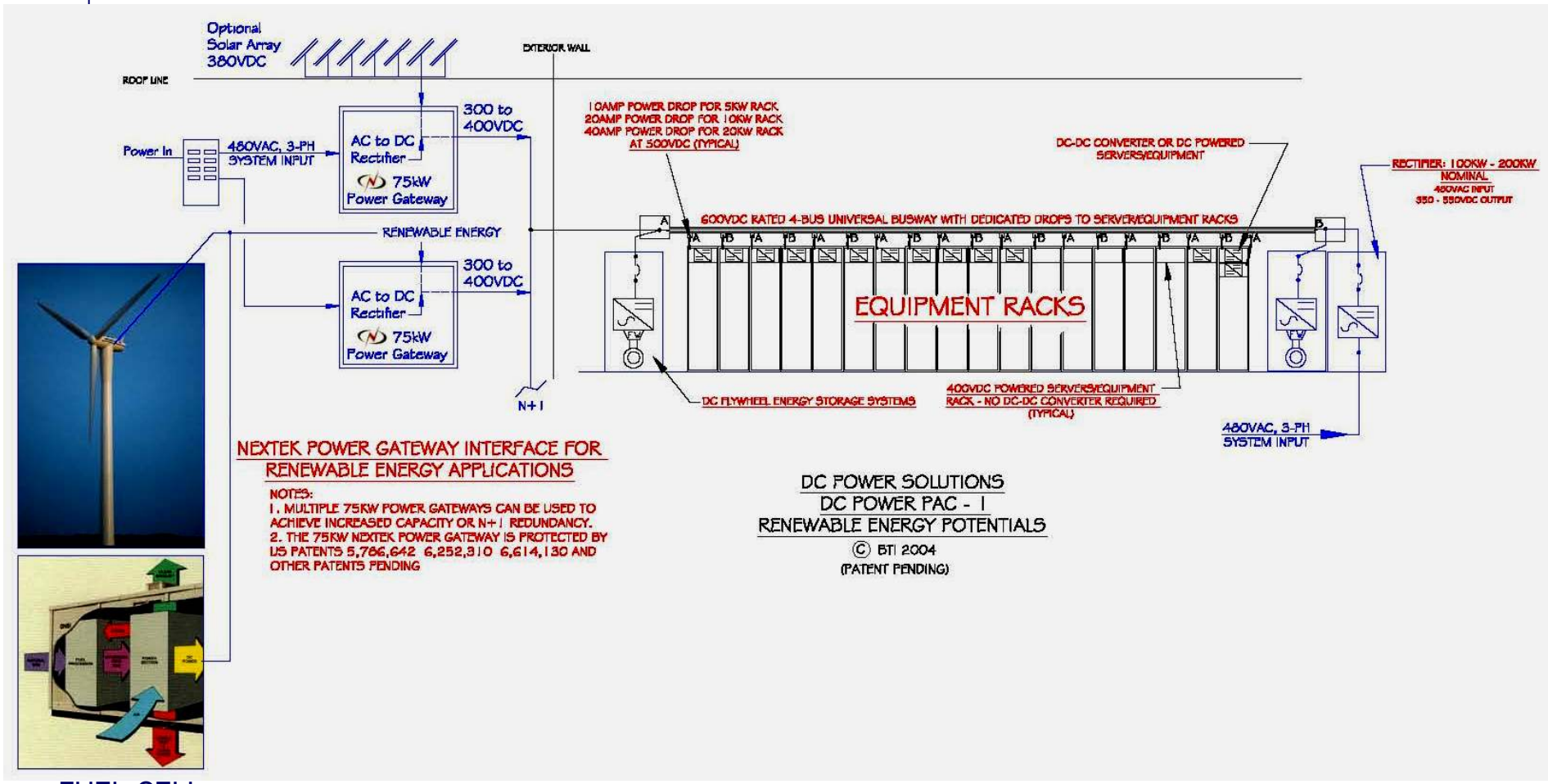
SUN MICRSYSTEMS' VISION

Summary of efficiencies

	High efficiency	Nominal efficiency
Standard data center distribution	78	65
Rack data center distribution	81	72
DC data center distribution	88	80

ALTERNATIVE / RENEWABLE ENERGY POTENTIALS WITH **DC POWER SOLUTIONS**

DC POWER SOLUTIONS
DC POWER PAC - 1 - RENEWABLE ENERGY ©



FUEL CELL

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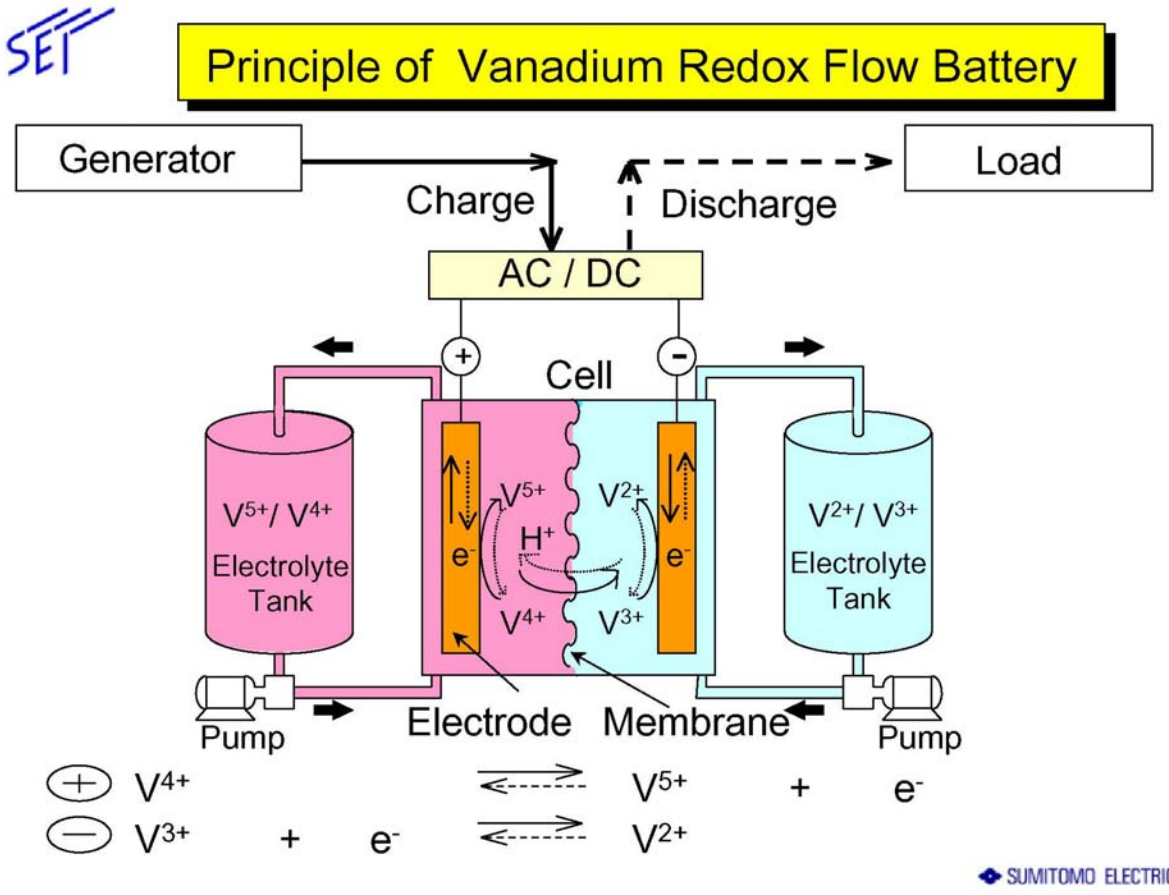
FLOW BATTERY TECHNOLOGY

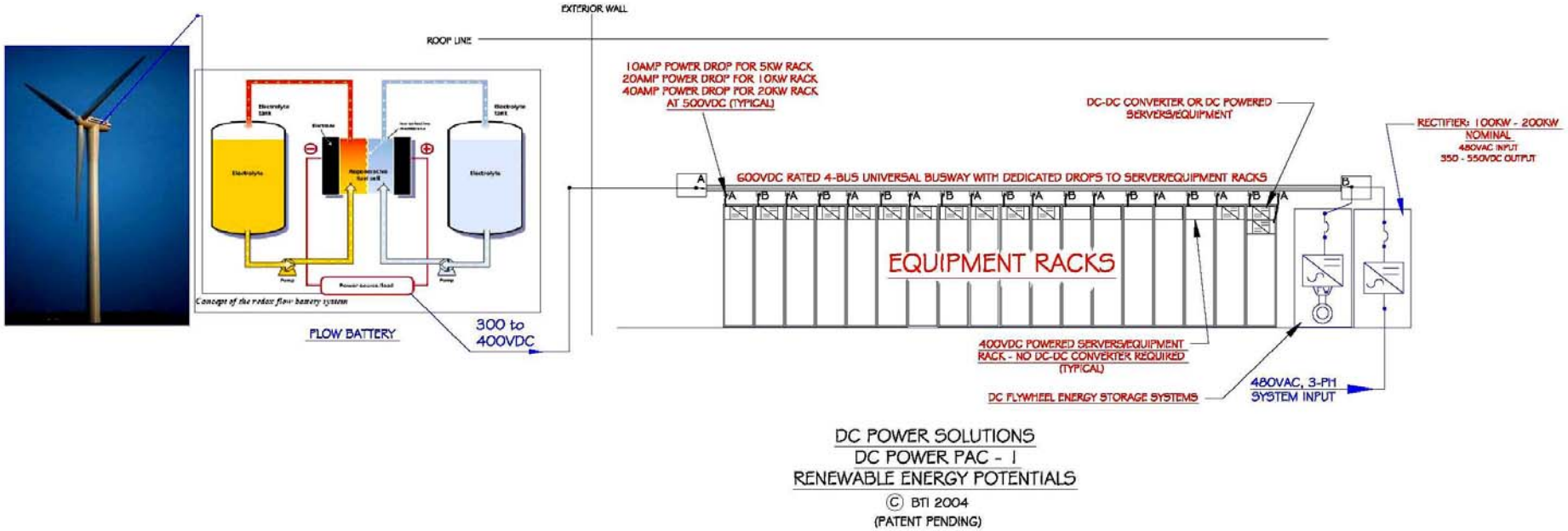
Flow batteries can turn intermittent wind power from a utility manager's headache to a green and reliable energy source.

This 30 MW wind farm in Japan is augmented by a battery system that can supply 4 MW of power for up to 90 minutes.

FLOW BATTERY TECHNOLOGY



DC POWER SOLUTIONS
DC POWER PAC - 1 - RENEWABLE ENERGY:
FLOW BATTERY ©



DC POWER SOLUTIONS
DC POWER PAC - 1
RENEWABLE ENERGY POTENTIALS
© BTI 2004
(PATENT PENDING)

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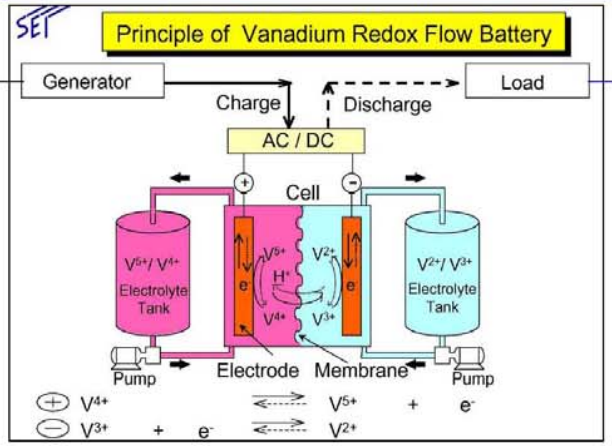
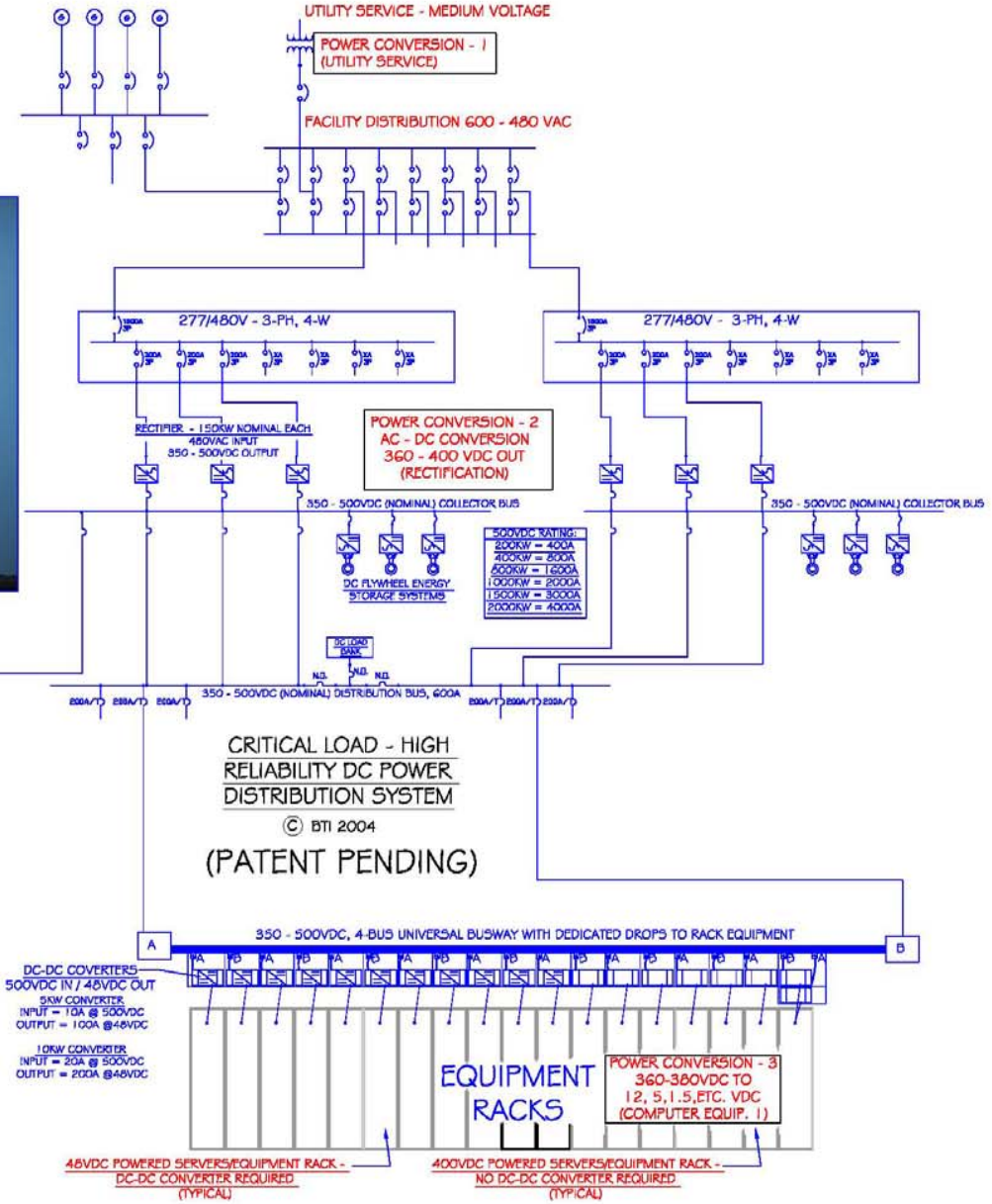
DC POWER SOLUTIONS

DC POWER PAC - 2 - RENEWABLE ENERGY: FLOW BATTERY ©





DC POWER SYSTEM BENEFITS AND STUDIES

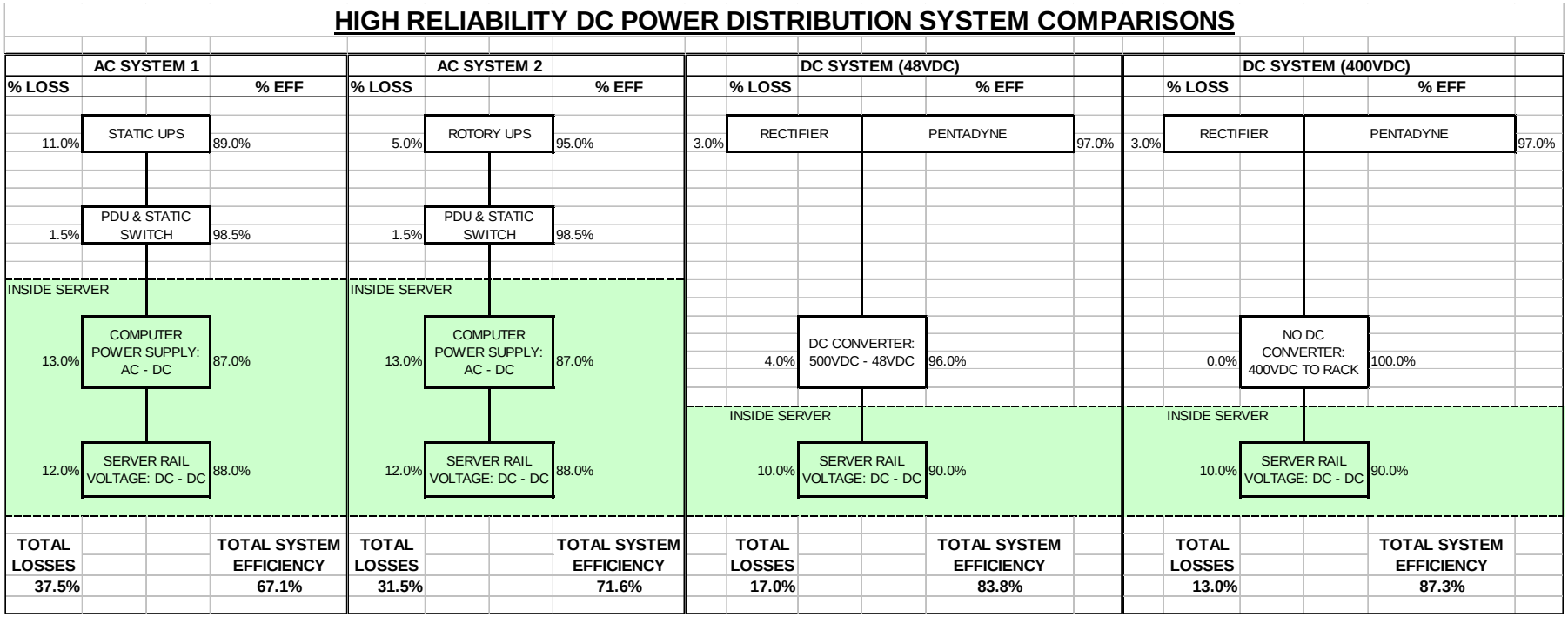
DC SYSTEM BENEFITS

- -LOWER COMPONENT COUNT = HIGHER SYSTEM EFFICIENCIES, GREATER RELIABILITY, LESS MAINTENANCE COST & LOWER TOTAL COST OWNERSHIP
- -MODULAR & FLEXIBLE: SYSTEM CAN GROW WITH LOAD REQUIREMENT
- -ENVIRONMENTALLY FLEXIBLE: SYSTEM FRONT-END COMPONENTS CAN BE LOCATED IN NON-CONDITIONED SPACES OR ON THE RAISED FLOOR NEAR LOAD
- -PENTADYNE ENERGY STORAGE ELIMINATES NEED FOR CHEMICAL BATTERIES
- -UNIVERSAL STARLINE BUSWAY PROVIDES A MODULAR “GO-AS-YOU-GROW” STRATEGY FOR DC DISTRIBUTION AS RACK POPULATION CHANGES
- -UNIVERSAL STARLINE BUSWAY PROVIDES A DOUBLE END-FEED FEATURE TO PERMIT REDUNDANT DC SOURCES AT CRITICAL LOADS
- -NO DOWN-STREAM STATIC OR TRANSFER SWITCHES ARE REQUIRED, VOLTAGE MATCHED DC SYSTEMS CAN INHERENTLY BE COUPLED TOGETHER
- - DC DISTRIBUTION ELIMINATES HARMONICS

DC SYSTEM BENEFITS - CONT'D

- -SIMPLIFIED GROUNDING: POSITIVE GROUNDING OR NEGATIVE GROUNDING
- -ALTERNATIVE ENERGY FRIENDLY – DC POWER SYSTEMS ARE MORE EASILY ADAPTED TO ALTERNATIVE ENERGY SOURCE APPLICATIONS
- -SYSTEM CONFIGURATION IS A UNIQUE APPLICATION AND PARTNERSHIP OF EXISTING, AND PROVEN "COMMERCIALLY-OFF-THE-SHELF" (COTS) EQUIPMENT
- -THIS DC SYSTEM HAS NO REQUIREMENT FOR A UPS IN ORDER TO PROVIDE HIGH SYSTEM RELIABILITY WITH UTILITY POWER OUTAGE RIDE THROUGH.
- -DC DISTRIBUTION ELIMINATES POWER FACTOR CONCERNS
- -REDUCES HEAT LOAD AT SERVER RACKS BY 20-40%
- -REDUCES POWER CONSUMPTION BY UP TO 30%
- -INCREASES SERVER RELIABILITY BY AS MUCH AS 27%

HIGH RELIABILITY DC POWER DISTRIBUTION SYSTEM COMPARISONS



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BERKELEY LABS-EPRI-ECOS CONSULTING-CA. ENERGY COMMISSION

ENERGY&POWER MANAGEMENT
Serving the commercial, industrial and institutional markets

Group Studies Dc Power in Data Centers

November 21, 2005

New power delivery infrastructure solutions are needed for the high power densities of the next generation data centers. High-density computer environments, utilizing alternating current (ac) to deliver power to blade server technology and other high-density computing devices, are presenting major challenges to owners and operators. Typical facility infrastructures cannot accommodate the added heat loads and reliability requirements of such installations.

Servers equipped with direct current (dc) power supplies, instead of ac power supplies, operate with 20-40% less heat, reduce power consumption by up to 30%, increase server reliability, offer flexibility to installations and decrease maintenance requirements.

Utilizing current off-the-shelf components, it is possible to install and operate a high-reliability, high-voltage dc power distribution system for a dc-powered server environment-without batteries or complicated ac power system drawbacks. This high-reliability dc power distribution system could be the next generation power system architecture for data centers.

An industry group is being formed to study and demonstrate the use of dc power for data center applications. This group, sponsored by the California Ener-gy Commission through Lawrence Berkeley National Laboratory, will be headed by a partnership between EPRI Solutions and Ecos Consulting. Companies represented at the initial meeting include HP, Sun Microsystems, Baldwin Technologies, Inc., Pentadyne Power Corp., SATCON, SquareD, TDI, CCG Facility Integration Inc., Nextek Power Systems, and Dranetz-BMI.

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DC Power for Data Centers of the Future

http://hightech.lbl.gov/dc-powering/

Overview

An alternative approach to conventional alternating-current (AC) power uses a direct-current (DC) power distribution scheme throughout a data center. Most data center server racks are not currently powered this way, but with the advent of servers on the market that can operate with either AC or DC, it is possible to use the DC powering approach, thus eliminating extra power conversion steps and losses. Other benefits include reduced cooling needs, higher equipment densities, and reduced heat-related failures.

Parties interested in participating in this project should contact William Tschudi, My Ton, or Brian Fortenbery.

Demonstration Goal and Objectives

A stakeholder group has been formed by industry and the California Energy Commission to investigate:

1. Whether or not DC powered server(s) and/or server racks can provide the same level of functionality and computing performance when compared to similarly configured and operating servers (and/or server racks) containing AC powered server(s), as measured with industry standard measurement devices and software tools.
2. Document any efficiency gains from the elimination of multiple conversion steps in the delivery of DC power.
3. Feasibility for both facility-level as well as rack-level DC conversion and delivery.
4. Identify issues/best practices and make recommendations for implementation.

Additional Information

- Facility-Level Overview [Download]
- Rack-Level Overview [Download]
- Frequently-asked Questions

BERKELEY LABS

DC DEMONSTRATION SYSTEM AT SUN MICROSYSTEMS, NEWARK, CA.

http://hightech.lbl.gov/

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DC DEMONSTRATION - TIMELINE

- Stakeholders first met – Fall 2005
- Kick-off meeting – April 2006
- Equipment assembly – May 2006
- Initial “Team Open House” June 7, 2006
- Public Open House events: June 21, July 12, 26; Aug 9, 16
- End date – August 16, 2006

THE RESULTS

DC Power for Improved Data Center Efficiency

January 2007

DIRECT POWER TECHNOLOGIES, INC.

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THE RESULTS

1.4 Project Results

Our results indicate that the DC approach does provide an increase in conversion efficiency. We were fortunate enough to have access to two AC distribution systems as well as two DC conversion/distribution systems, and the efficiency ratios were determined for both sets.

Table ES1

System Efficiency	UPS Efficiency	Transformer Efficiency	PS Efficiency	System Efficiency
AC System A: Measured Efficiency	90%	98%	90%	79%
AC System B: Measured Efficiency	90%	98%	90%	79%
DC System A: Measured Efficiency	94%	100%	92%	87%

Energy Consumption	Compute Load (kWh)	Input Load (kWh)	Efficiency Gain
AC System A: Measured Consumption	23.3	26.0	
AC System B: Measured Consumption	23.3	25.9	
DC System A: Measured Consumption	22.7	24.1	
% Energy Consumption Improvement vs. AC System A			7.3%
% Energy Consumption Improvement vs. AC System B			7.0%

THE RESULTS

It should be noted that both of the AC distribution system used represent the best on the market with regard to efficiency. Both of the AC UPSs are high efficiency units, and the efficiencies of the power supplies in the AC servers – at 90%, are much higher than units currently found in today's data centers. By comparison, a typical AC system in today's data center would have a UPS that was about 85% efficient, and power supplies around 73% efficient.[1] The estimated improvement of the DC system over these "typical" systems is shown in Table ES3 below.

Table ES3

System Efficiency	UPS Efficiency	Transformer Efficiency	PS Efficiency	System Efficiency
AC Typical Distribution Efficiency	85%	98%	73%	61%
DC Distribution Efficiency	92%	100%	92%	85%

Energy Consumption	Compute Load (W)	Input Load (W)	Efficiency Gain
Typical AC Distribution Efficiency	10,000	16,445	
DC Distribution Option (Optimized)	10,000	11,815	
% Energy Consumption Improvement vs. Typical AC Distribution			**28.2%**

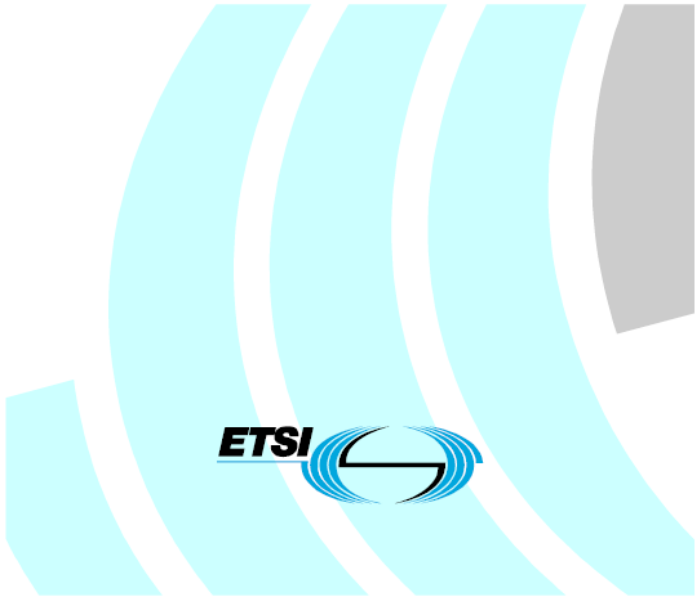
In this case, an improvement of over 28% is possible in an average data center. This means the DC distribution system, as demonstrated, will have the potential of using 28% less energy than the typical AC system found in today's data centers. Since data center HVAC loads are typically about the same as the IT load, this means that a 28% improvement in distribution and conversion also means a 28% overall facility level efficiency improvement.

OVER SEAS STANDARDS ACTIVITIES

ETSI EN 300 132-3 V1.2.1 (2003-08)

European Standard (Telecommunications series)

Environmental Engineering (EE);
Power supply interface at the input to telecommunications equipment;
Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V



DIRECT POWER TECHNOLOGIES, INC.
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DC POWER IN THE PRESS

Can DC Power Cut Data Center Costs?
March 27, 2006

By Jeffrey Burt

Gannett is revamping its Washington data center's power infrastructure, having added another string of traditional AC power supplies prompted in part by the move to bring the company's Web hosting operation in-house.

However, Gannett officials expect the media company's hosting capacity to grow and are already planning for ways to keep the 15,400-square-foot data center powered up and cooled as that occurs. One option under study is the use of DC power distribution within the data center.

RELATED LINKS

- Novell to Develop Cross-Platform Data Center Tools
- Data Centers Give Intel Static over Electric Bills
- Will Google Shed Light on Data Center?
- HP Cools Down Data Centers
- Rethinking Compute Power in the Data Center

"The question for us is, Does it make sense to go down the same [AC] road if there's an option out there that can save us money?" said Gary Gunnerson, IT architect for Gannett, in McLean, Va., and an eWEEK Corporate Partner.

Analysts said the drumbeat for DC power is likely to increase through June, when the Electric Power Research Institute will host a two-day data center conference focusing on DC power in Washington.

While many in the industry have brushed off DC power, calling it more marketing hype than reality, others—including Intel, Hewlett-Packard and Sun Microsystems—are interested. That trio is part of a project funded by the California Energy Commission in which industry players are working with Lawrence Berkeley National Laboratory, in Berkeley, Calif., to create a prototype of a DC-powered data center in Chatsworth, Calif., by September.

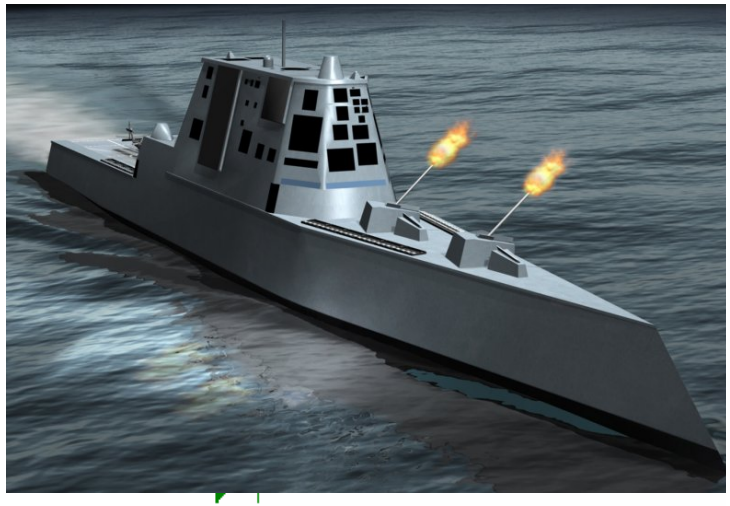
Meanwhile, there seems to be some traction for DC power in the industry. Rackable Systems officials say that 35 percent of the $83 million in revenue the company generated in the fourth quarter of last year was related to DC power deployments. Rackable offers DC solutions at the rack, row and data

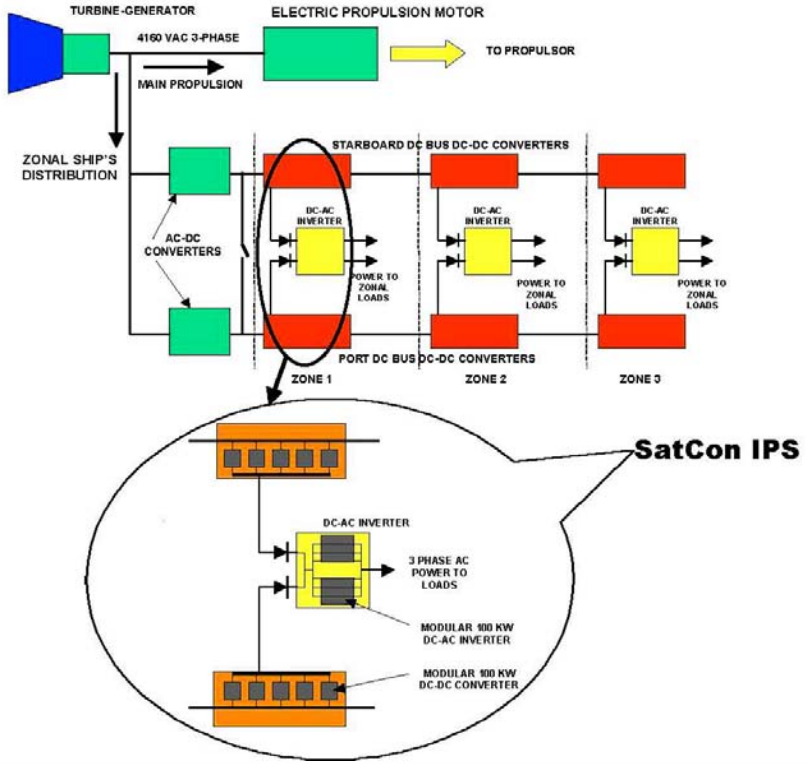
PRODUCT DEVELOPMENT IN PROCESS

RECTIFIERS & DC - DC CONVERTERS

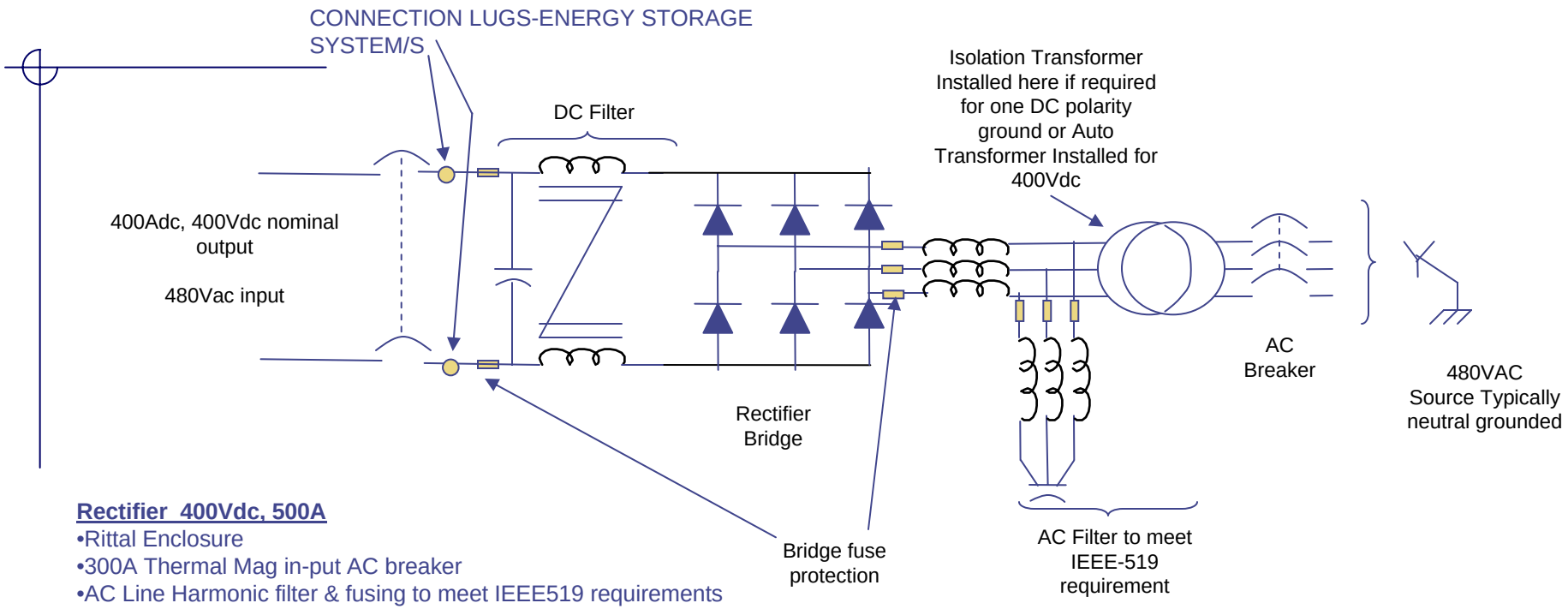
- DPTI is working with SATCON POWER SYSTEMS to develop high efficiency rectifiers and dc-dc converters specific for this system architecture application.

- SATCON is currently providing power conversion products for the Navy's new DD(X) destroyer program for a DC based Integrated Power System.





150kW Rectifier PDU



Rectifier 400Vdc, 500A

- Rittal Enclosure
- 300A Thermal Mag in-put AC breaker
- AC Line Harmonic filter & fusing to meet IEEE519 requirements
- 480/283Vac auto transformer
- 3 semiconductor line fuses with blown fuse indicators and switches
- 500Adc, 400Vac diode bridge 40°C rated with cooling provided
- DC filter for ripple reduction
- Output DC fuses 500A rated with blown fuse indicator & switches OR 500A DC OUTPUT CIRCUIT BREAKER (BREAKER PREFERRED)
- POWER QUALITY METERING – INPUT & OUTPUT VIA DRANETZ-BMI ENCORE SYSTEM

150kW PDU Rectifier Power Schematic

RECTIFIERS & DC - DC CONVERTERS

- DPDI is also working with EPRI to develop high efficiency rectifiers and dc-dc converters specific for this system architecture application.

Intelligent Universal Transformer - EPRI

Core Technologies Needed

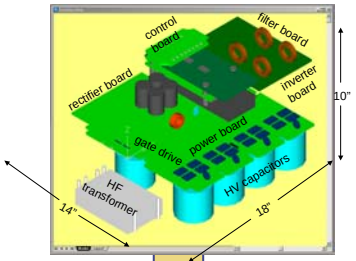
New State-of-the-Art High-voltage multilevel IUT Topology – Lab Bench Development

Demonstrated 2004-2005

New High-Voltage, Low-Current Power Semiconductor Devices

Interoperable with Open Communication Architecture

All Solid-State Replacement for Distribution Transformers



Product Spin-offs

Patent application for EHV version of IUT (substations)

Other power electronic applications

Functions and Value

Traditional voltage stepping, plus..

New service options, such as dc

Real-time voltage regulation, sag correction, system monitoring, and other operating benefits

Other benefits: standardization, size, weight, oil elimination

Cornerstone device for advanced distribution automation (ADA)

DIRECT POWER TECHNOLOGIES, INC.
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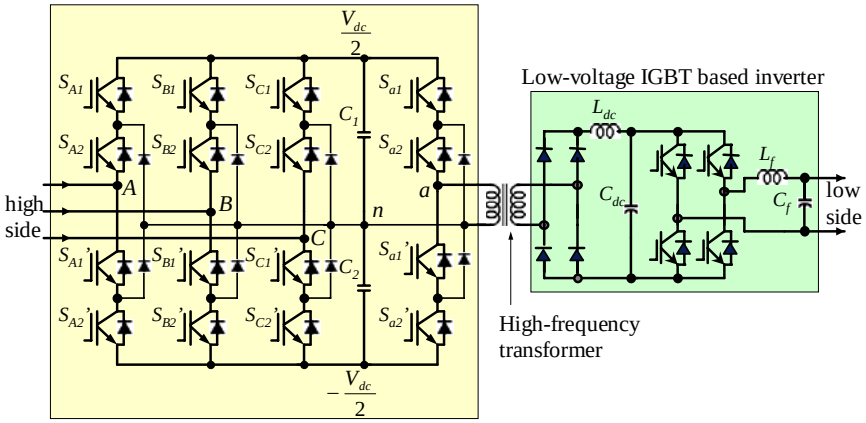
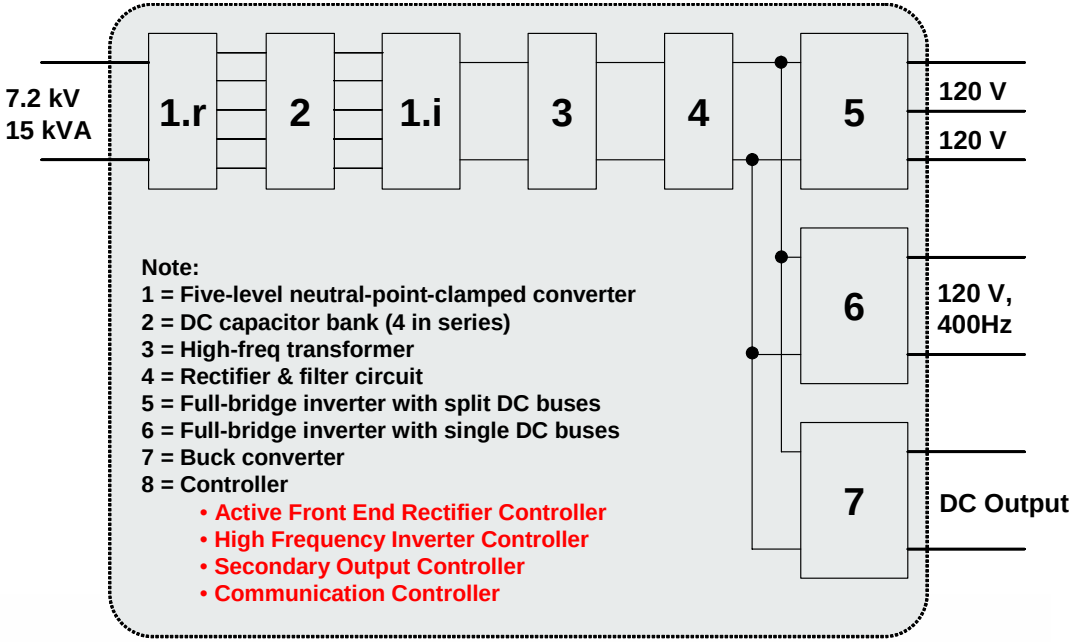
EPRI's Advanced Solid State Transformer Design using HV Power Electronics

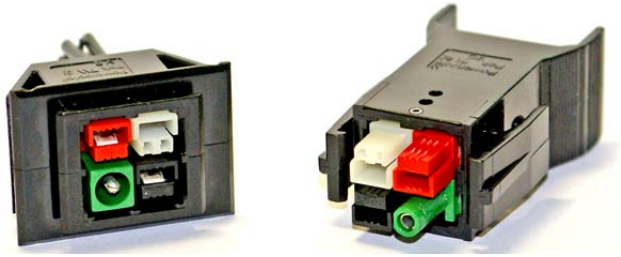
- The multi-level IUT transformer concept is based on using HV-IGBTs at the distribution voltage level.
- One major advantage in using multilevel converter approach is its effective switching frequency is multiplied, and thus the ripples are significantly reduced.
- Voltage sharing problems can be eliminated with the use of clamping circuits
- Lesser series connected modules at the input stage are required making the design to be more reliable as compared to ABB/Purdue design.





380/400VDC CONNECTORS

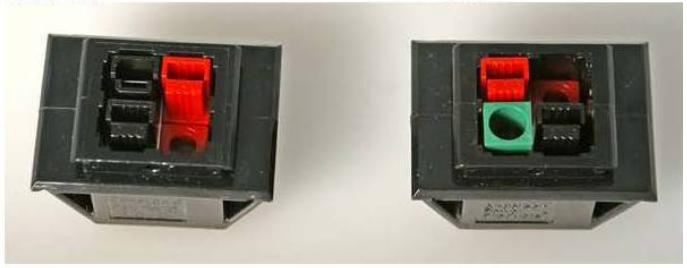
- DPTI is working with Anderson Power to develop a 380/400VDC connector



PowerPak configurations for 400 VDC

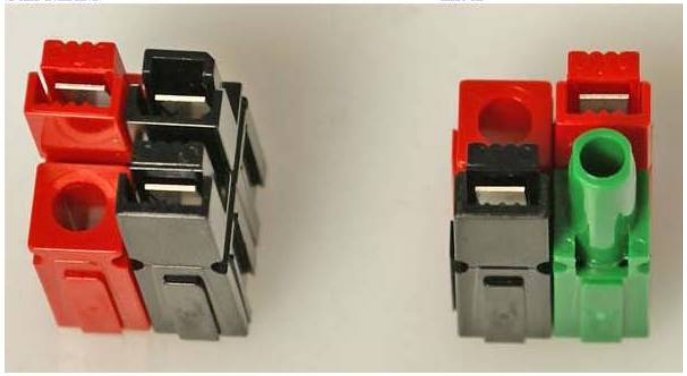
30 amp Receptacle
Sun Micro

10 Amp Receptacle
Intel

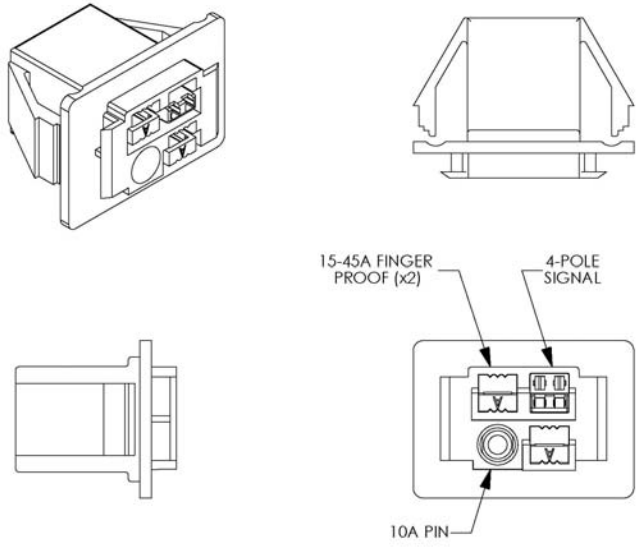


30 amp Plug w/latch
Sun Micro

10 Amp Plug w/latch
Intel



Red spacer location will be replaced by future 4 circuit signal module



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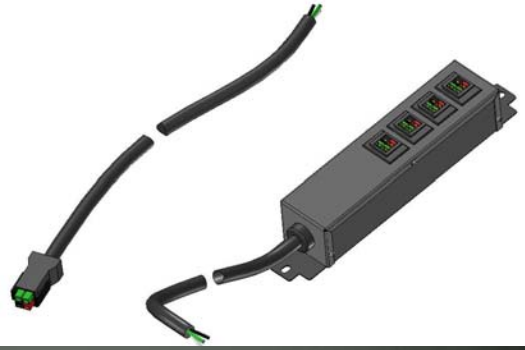
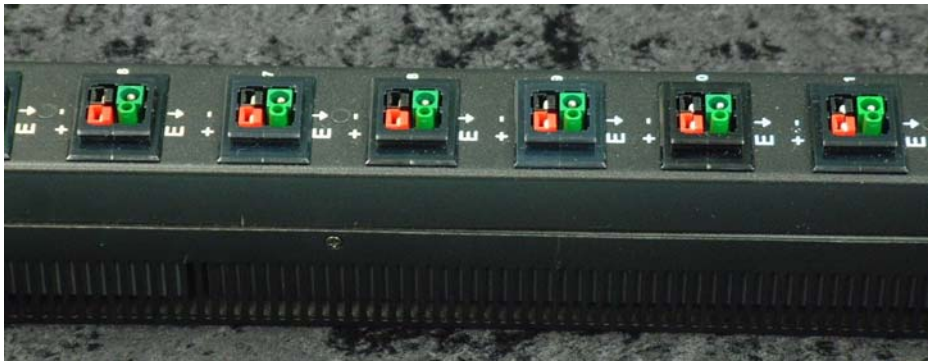
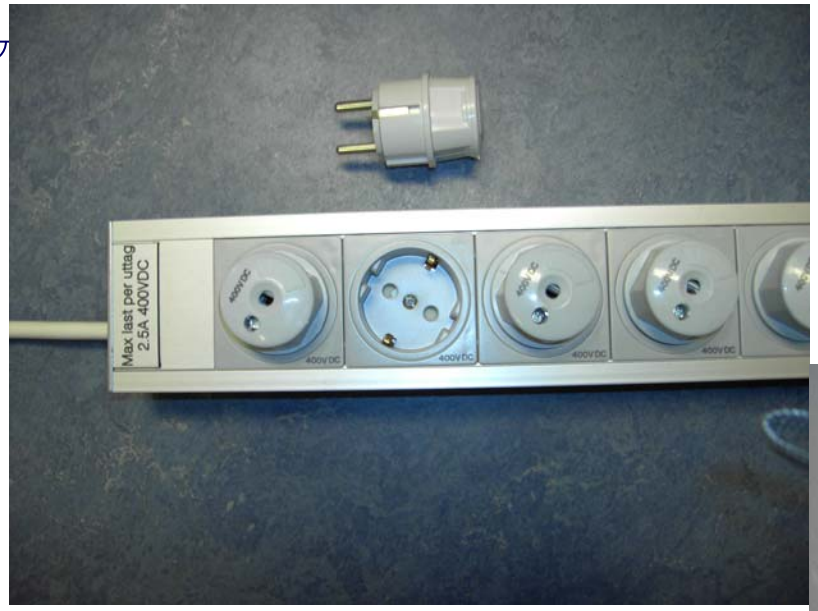
380/400VDC PLUG STRIP

- DPTI is working with multiple companies to develop a 380/400VDC plug strip





OVERSEAS DEVELOPMENT OF 400VDC CONNECTORS



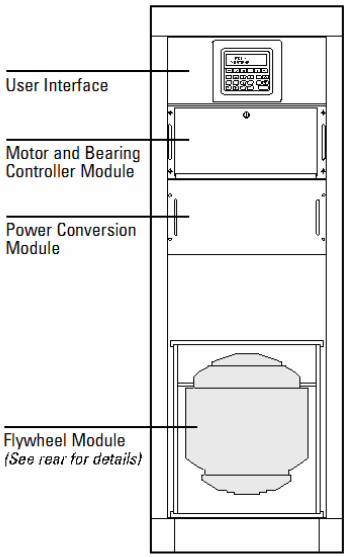
DIRECT POWER TECHNOLOGIES, INC.
Providing Efficient Reliability

ENERGY STORAGE SYSTEM

Pentadyne *Voltage Support Solution*™

The Pentadyne *Voltage Support Solution*™ provides ride-through power and voltage stabilization in a variety of areas, including:

1. **Uninterruptible Power Supply (UPS)**
2. **Adjustable Speed Drive (ASD)**
3. **Distributed Generation (DG)**
4. **Utility Premium Power**
5. **Electric Urban Rail**



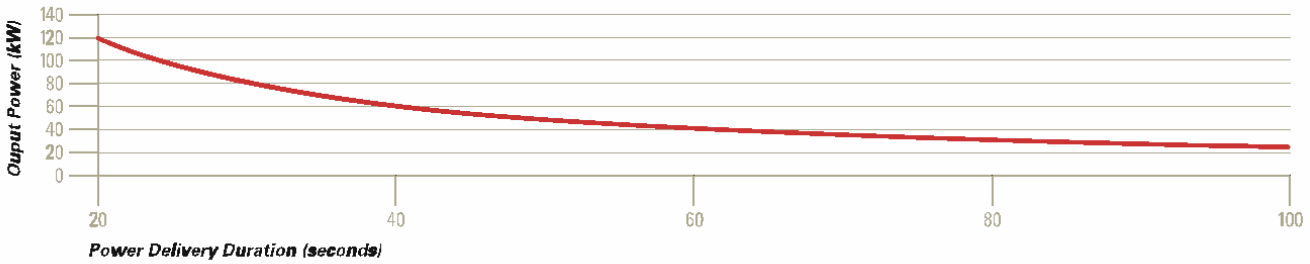
Specifications

Rated Power	120 kW
Duration at Rated Power	20 seconds
Useable Energy Storage	0.67 kW.h (2400 kW.s)
Max. Recharge Power	120 kW
Typical Idle Power Consumption	300 W
Total Weight	590 kg (1300 lb)
Dimensions (W x D x H)	63 x 83 x 180 cm (25 x 33 x 71 in.)
Operating Temperature	-20°C to 50°C (-4°F to 122°F)
Non-operating Temperature	-20°C to 80°C (-4°F to 176°F)
Output Voltage	500 to 850 VDC*
Output Voltage Regulation	+/- 5% DC
Weatherproof Enclosure	Optional
Forklift Compatible	Yes

*Parameters are set by the user through the Pentadyne system "user interface" console; for other voltages, please consult Pentadyne.

Operational Flexibility

The Pentadyne *Voltage Support Solution*™ can provide clean constant DC output (or AC output with optional hardware) for 20 seconds at 120 kW or other combinations of power and time equaling 2400 kW-seconds of energy (as shown below).



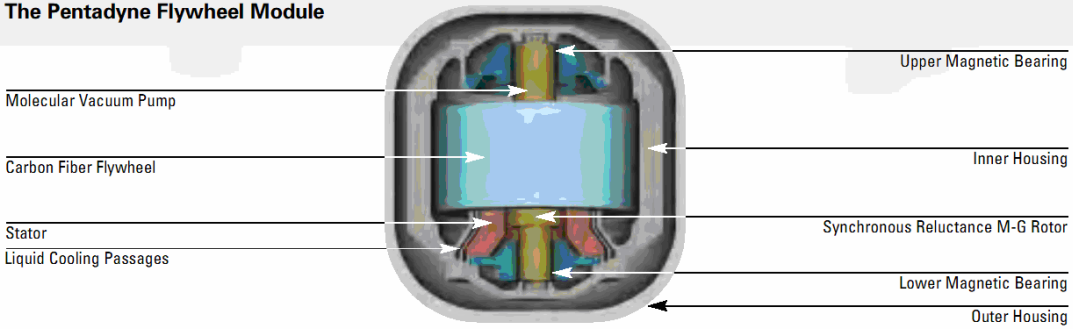
Pentadyne *Voltage Support Solution*™

Pentadyne Flywheel Technology. Unique technology features create unique economic benefits.
Superior customer economic benefits come from Pentadyne Power Corporation's choice of innovative technologies, which include:

Features	Economic Benefits
• Active magnetic bearings	• No mechanical losses
• Internal, integrated vacuum system	• Very low aerodynamic losses
• Synchronous reluctance motor-generator	• Very low standby losses
• Fiber composite flywheel	• Low cost energy storage
• Unique patented safety system	• Low installation cost

Pentadyne's flywheel technology provides precise electrical power for ride-through and voltage stabilization during electrical disturbances.

The Pentadyne Flywheel Module



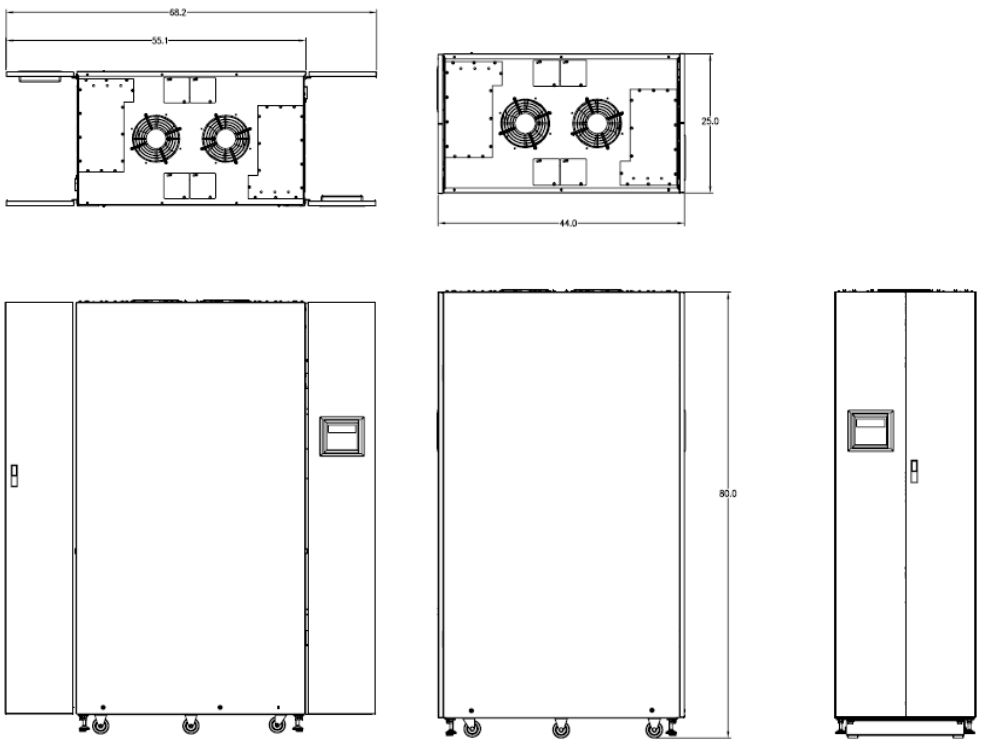
Why Choose Pentadyne Flywheels Instead of Batteries?
Pentadyne's flywheel technology provides superior performance without the high cost of ownership and the environmental impacts that batteries present. Further, due to the unique operating features such as rapid recharging and broad operating temperature range, the Pentadyne flywheel can be used where batteries have been ruled out.

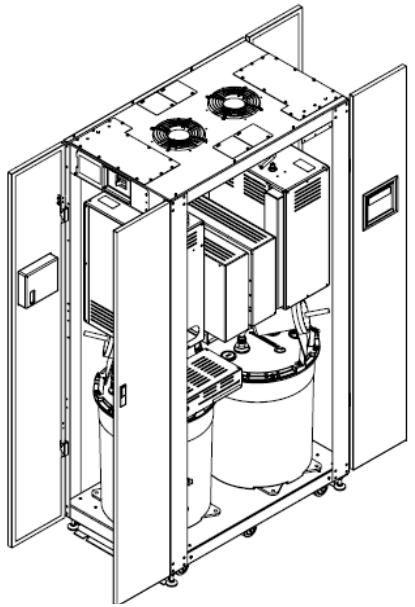
	Pentadyne Flywheel	Batteries
Lifecycle Costs	• Very low standby costs • Low maintenance costs • Low installation costs • Small footprint and light weight • Long life	• Large float and cooling costs • High maintenance costs • Air conditioned room required • Large footprint and heavy • Frequently replaced
Reliability	• Rapid recharge • Broad operating temperature range • Remotely monitored	• Slow recharge • Narrow operating temperature range • High failure rate

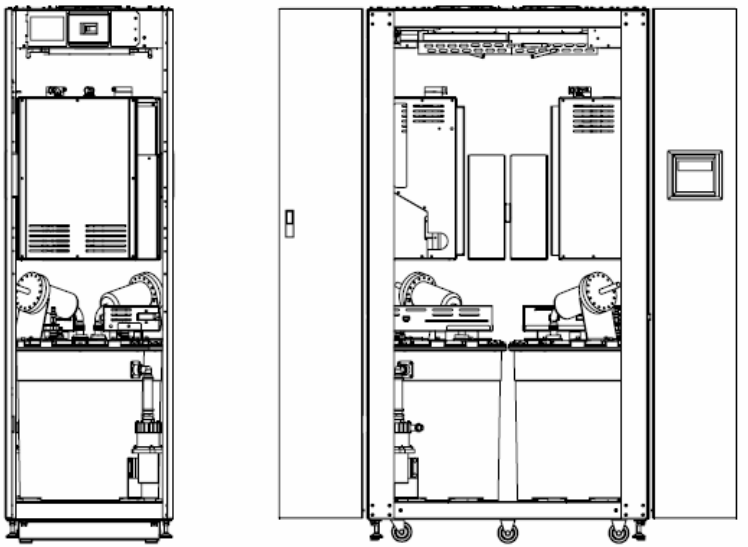
Save 50–70% of the cost of owning batteries
Over a 10 year period, considering the space conditioning energy requirements, high maintenance, and frequent cell replacements, the battery energy storage may cost 2 to 3 times as much as the Pentadyne flywheel system on a lifecycle basis.

Pentadyne's flywheel technology provides ride-through power for 20 seconds or more—which exceeds the duration of 98% of all industrial and commercial power quality problems—and provides voltage stabilization during electrical disturbances. Get the facts. Contact your Pentadyne Distributor.

FUTURE – PROTOTYPE 2 FLYWHEEL BLADE-POWER CONFIGURATION:







DIRECT POWER TECHNOLOGIES, INC.
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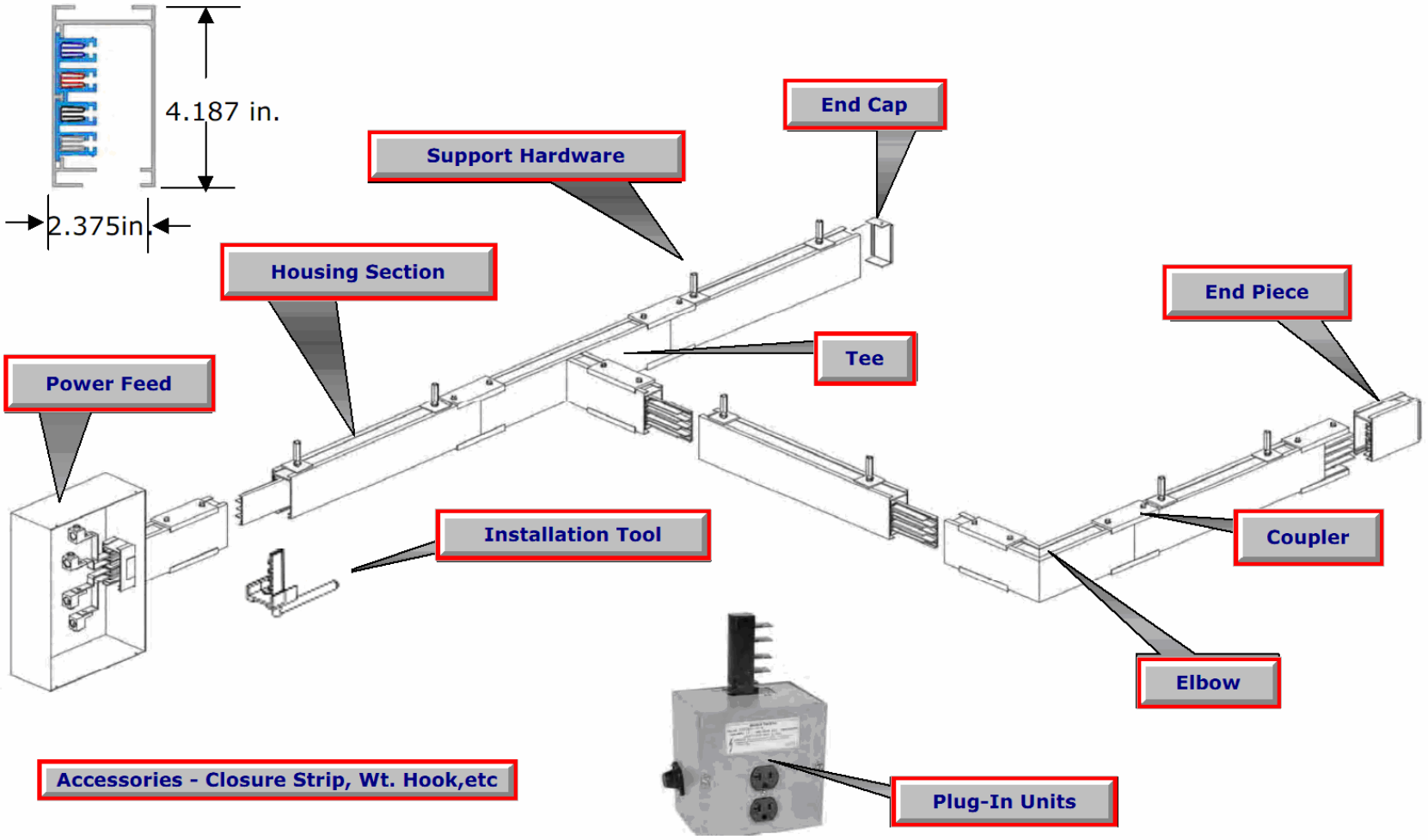
400VDC DISTRIBUTION TO EQUIPMENT RACKS

STARLINE RACK BUSWAY

Standard B225 Amp System to 600 Volts

Also B160 or 160 Amp Systems

2, 3 or 4 pole with/without Isolated ground



BUSWAY IS RATED AT 200Amps AT 600V DC

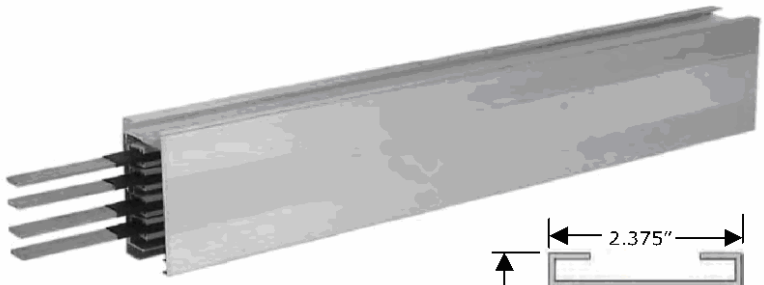
225 Amp

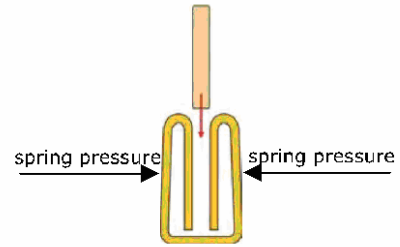
STARLINE TRACK BUSWAY

HOUSING SECTIONS

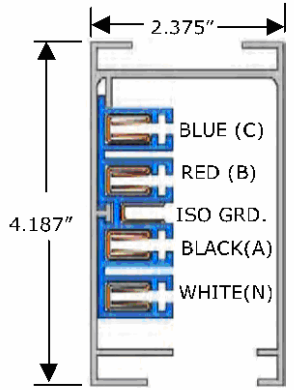
Track Busway housing section consists of an extruded aluminum shell with "spring-pressure" type copper channel busbars contained in a full length PVC insulator mounted on one side on the interior wall. The aluminum extrusion acts as a 100% ground path meeting UL 857 Standard and complies with applicable paragraphs of Section 250 of the NEC. Each housing has an open access slot over its entire length for the insertion of turn-n-lock plug-in units.. Housing configurations include 2, 3 and 4 pole varieties with 600 Volt maximum rating. Each housing section has male stabs protruding at one end which fit into the channels of the adjoining section. Installation tool is used to force the stabs into the busbar channels for a solid "spring-loaded" electrical connection.

MATERIAL: Extruded Aluminum 6005-T5 unpainted
RATINGS: 100% Ground Path 225 Amp, 600 Volt
LENGTH: 5 Ft, 10 Ft , 20 Ft.
INSULATION: PVC
VOLTAGE DROP: distributed load Single Phose 40ft (.8PF)





"Spring-pressure" channel busbar



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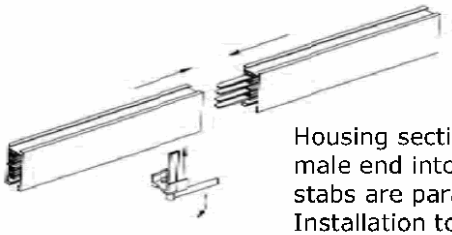
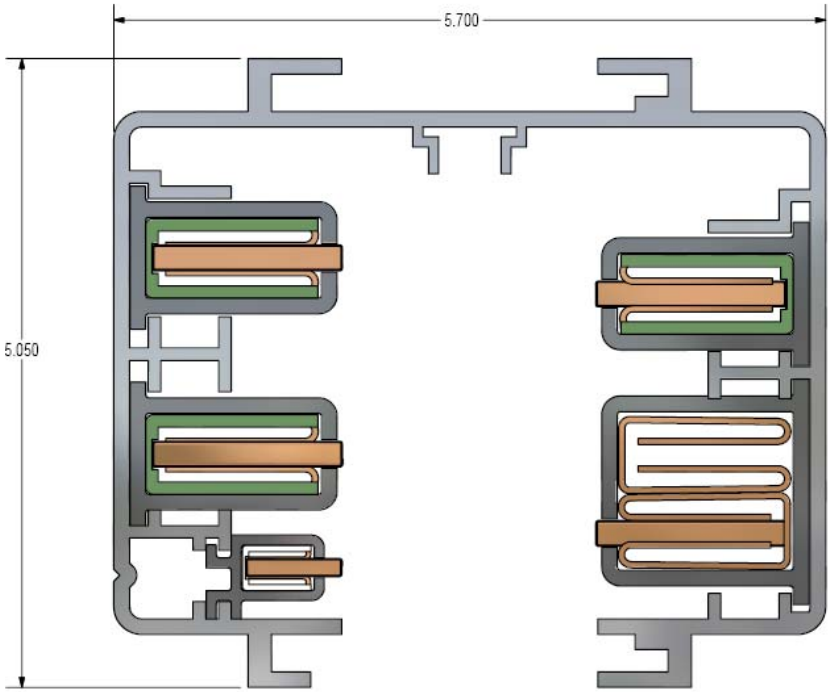
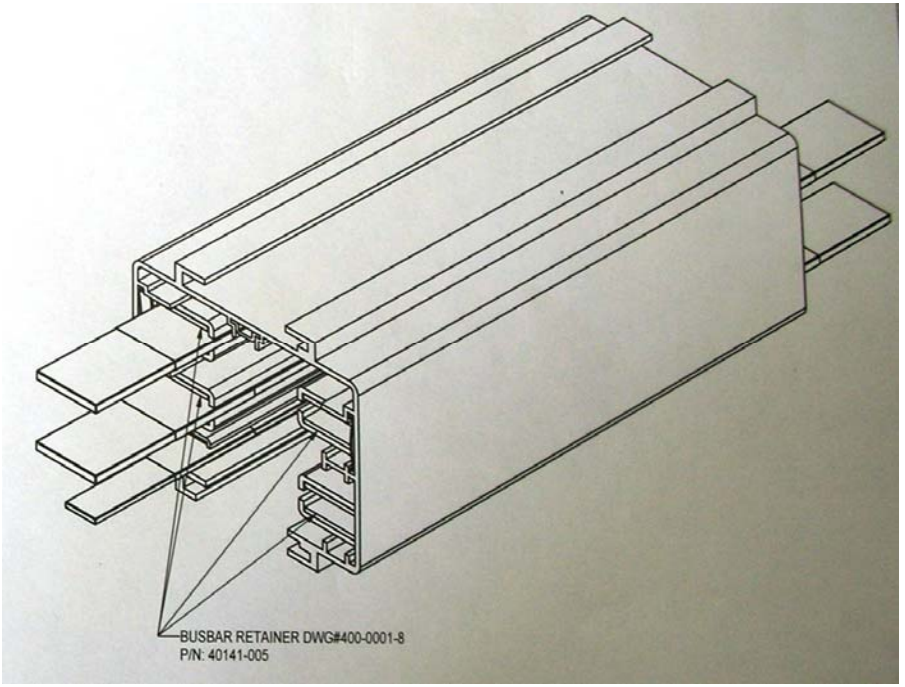


Housing sections are joined by inserting male end into open female end so that stabs are parallel to female slots. Installation tool is then rotated to force stabs into slots.

NEW BUSWAY IS RATED AT 400Amps AT 600V DC





DIRECT POWER TECHNOLOGIES, INC.
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DC RATED BUSWAY PLUG FOR HVDC POWER DROP

DIRECT POWER TECHNOLOGIES, INC.
Providing Efficient Reliability

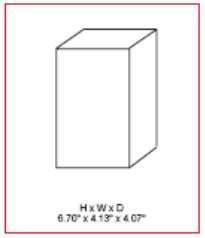
600VDC RATED BREAKER FOR POWER DROPS

S3
150/225A
Standard thermal-magnetic

Isomax MCCBs

S3B

S3N S3H S3L


H x W x D
6.70" x 4.13" x 4.07"

Standard S3 package includes complete circuit breaker and mounting hardware. Order cable lugs as a separate item, standard copper/aluminum (Cu/Al) lugs are no charge when ordered with breaker.

General
The S3 breaker family ranges from 15 through 225 amperes. The S3 trip mechanisms are non-interchangeable and use sensitive electromagnetic relays for overcurrent trip protection. Heat sensitive bimetals are used for thermal overcurrent protection. Short circuit current protection begins at 10 times the thermal rating of the breaker and uses a magnetic coil principle.

Versions
To meet all application needs, the S3 is available in various versions:
- T = Thermal-magnetic
- Q = 100% UL rated
- D = Molded case switch
- M = Magnetic only (MCP)
- G = 3X Mag (100 - 225A 3-pole only)

Performance level
Each version is also available in different maximum fault interrupting levels
- B = 240VAC
- N = Normal
- H = High
- L = Extra high

Number of poles
In UL/CSA form, the S3 is available in two pole or three pole versions, both with the same dimensions. A four pole version is also available in UL/ IEC form. For price estimate, add 35% to list price of selected version three pole breaker, contact ABB Control for details.

Accessory mounting
Internal accessories are UL/CSA approved for both factory or field installation. Accessories require control cable connectors. Shunt trips or UVR's mount in the left cavity. Auxiliary or bell alarm switches mount in the right cavity.

Reverse feeding
All versions of the S3 family are suitable for reverse feed applications.

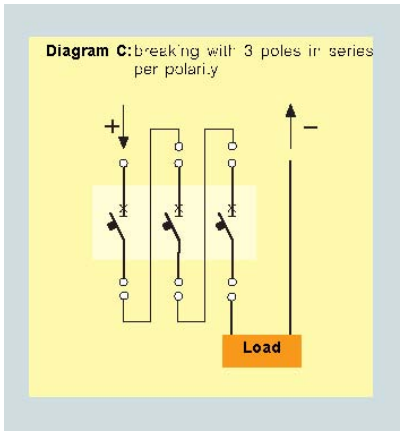
Molded case switches
UL489 switches include no overcurrent protection except for a high instantaneous trip mechanism for self protection. IEC type molded case switches with no trip protection are also available.

UL/CSA Interrupting capacity (kA RMS)
UL489 / CSA C22.2

Voltage	N	H	L
240VAC	65	100	150
480VAC	25	50	85
600VAC	14	14	25
500VDC	35	50	65
600VDC	20	35	50

IEC-947 Interrupting capacity (kA RMS)

Voltage	N	H	L
230VAC	65	100	170
380/400/415VAC	35	65	85
440VAC	30	50	65
500VAC	25	40	50
690VAC	14	18	20
500VDC	35	50	65
750VDC	20	35	50



CONNECTION DIAGRAM FOR

600VDC BREAKER APPLICATIONS

DIRECT POWER TECHNOLOGIES, INC.
Providing Efficient Reliability

OTHER DC RATED BREAKERS

Presentation

A complete DC offer from 16 to 4000 A

NS160 DC - 1P. NS160 DC - 2P. NS160 DC - 3P. NS630 DC - 4P.

NW10 DC - 3P. NW10 DC - 4P.

Merlin Gerin

SQUARE D

www.SquareD.com

For the most up-to-date information

UL Listed 500 Vdc Rated Circuit Breakers

500 Vdc Rated
UL Listed
Class 600

3

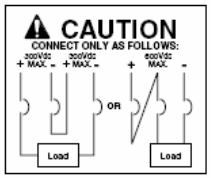
The UL Listed thermal-magnetic molded case circuit breakers shown below are specifically designed for use on ungrounded dc systems having a maximum short-circuit voltage of 500 Vdc or a maximum floating (unloaded) voltage of 600 Vdc. The circuit breakers are suitable for use only with UPS (uninterruptable power supplies) and ungrounded systems.

This two-level voltage rating allows these circuit breakers to be applied to battery sources having a short-circuit availability of 20,000 amperes for FH, KH, LH, and MH circuit breakers and 25,000 amperes for PAF circuit breakers at 500 Vdc.

FH, KH, LH and MH circuit breakers are provided with an adjustable magnetic trip that is readily accessible by means of a single adjustment on the face of the circuit breaker. PAF circuit breakers have a fixed magnetic trip range.

These circuit breakers are UL Listed for the interrupting ratings shown only if applied with three poles connected in series (series connection is external to circuit breaker). See diagram below.

Note: Due to external series connection, I-LINE® circuit breakers are not available for this application.



Source = 600 Vdc max. (floating)
500 Vdc max. (loaded)

Circuit Breaker Catalog Number	Adjustable Magnetic Trip Range—DC Amperes▲ Low	High	Interrupting Rating @ 500 Vdc	Price
FHL3609013DC	50	180	20,000 AIR	$ 905.
FHL3606014DC	75	260		905.
FHL3610016DC	150	580		1027.
KHL3615517DC	350	700	20,000 AIR	3809.
KHL3615017DC	350	700		3809.
KHL3617521DC	400	800		3809.
KHL3620022DC	500	1000		3809.
KHL3622522DC	500	1000		3809.
KHL3625025DC	625	1250		5065.
LHL3625025DC	625	1250	20,000 AIR	5065.
LHL3630026DC	750	1500		5065.
LHL3635023DC	875	1750		5065.
LHL3640030DC	1000	2000		5065.
MHL3645031DC	1125	2250	20,000 AIR	6304.
MHL3650032DC	1250	2500		6304.
MHL3660039DC	1500	3000		6304.
MHL3670035DC	1750	3500		7621.
MHL3680036DC	2000	4000		7621.
MHL3690039DC	2500	5000		9385.
MHL36100040DC	2500	5000		9385.
MHL36120040DC■	2500	5000	25,000 AIR	11172.

Circuit Breaker Catalog Number	Fixed Trip Range—DC Amperes Hold	Trip	Interrupting Rating @ 500 Vdc	Price
PAF361200DC	1200	1620	25,000 AIR	$16484.
PAF361600DC	1600	2160		16484.
PAF362000DC	2000	2700		16484.
PCF362500DC	2500	3375	25,000 AIR	26243.

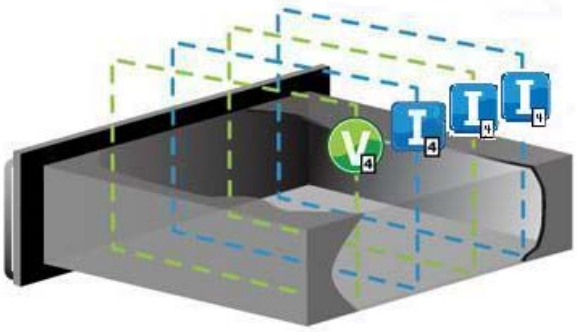
▲ Magnetic trip setting tolerances are ±20% from the nominal values shown.
■ Suitable for use only in a ventilated enclosure. Minimum enclosure dimensions are 36" h x 20" w x 7" d with a minimum of 100 square inches of ventilation near the top of the enclosure.

Product Summary –

- Revolutionary, next generation product family from Dranetz-BMI for the permanently (and semi-permanent) installed market
- Encore Series Model 61000
  - All new instrument design that builds upon the strengths of:
    - Signature System
      - Strong Power Quality capabilities
      - Web browser based interface
    - 4400/PX5
      - Power Quality compliance capabilities
      - Visualization – Bright, colorful, easy to use local user interface
    - Measuring Pad
      - Physical measurements

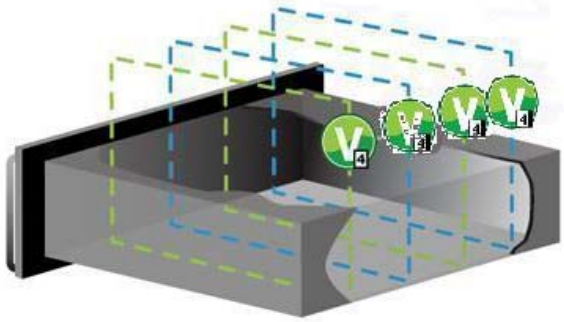
Encore Series

Possible Configurations



Utility Substation Distribution Analyzer

Three instruments in one



Multiple voltage bus/circuit monitoring

Four instruments in one

Key

- 4 Channel Voltage Module
- 4 Channel Current Module
- 4 Channel Analog Input Module
- Digital Input or Output Module

ENCORE SERIES

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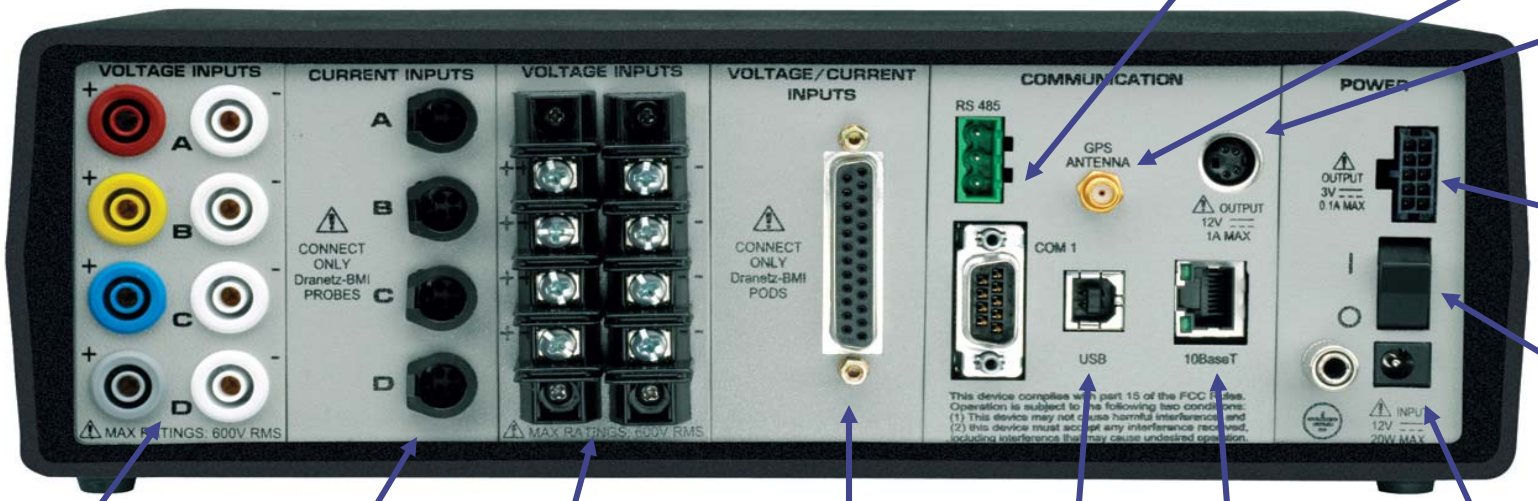
Providing Efficient Reliability

Encore Series

Sample Rear Panel

(actual instrument depends on your configuration)



RS232, RS485

GPS Antenna

Power Supply Output For GSM

Power Supply Output for Flex CT's

Power Switch

Voltage Module Safety Connectors

Current module TR Connectors

Voltage Module Screw Terminals

Voltage Module Pod interface

USB

Ethernet

12VDC Instrument Power Supply

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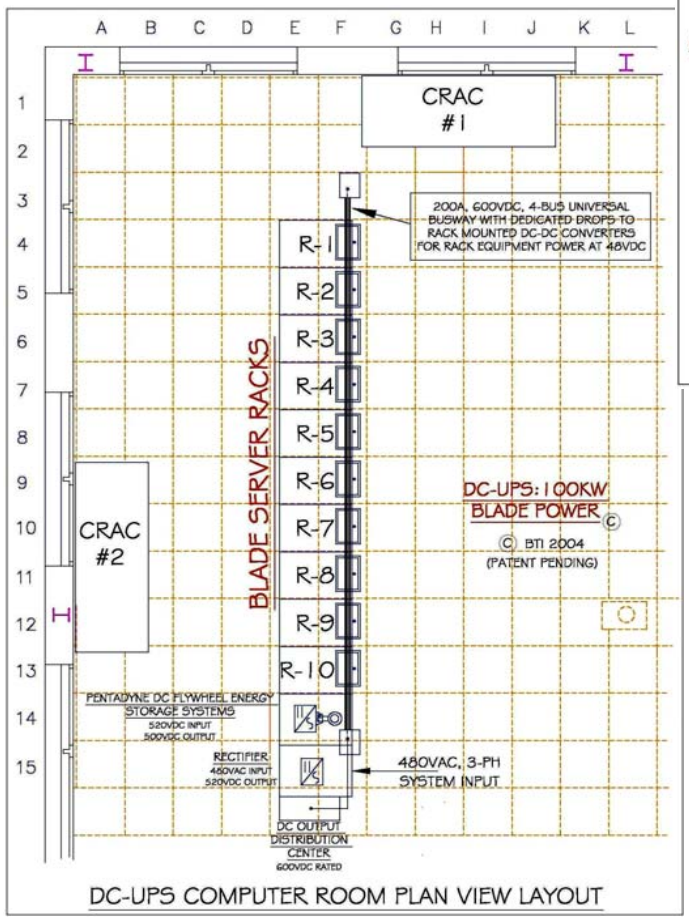
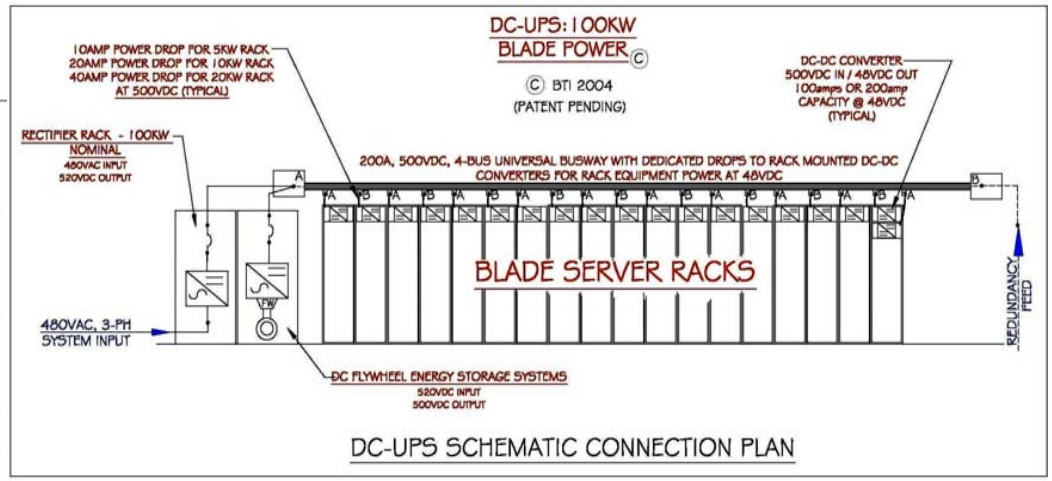
DC-UPS



DC-UPS COMPUTER ROOM PLAN VIEW LAYOUT



DC-UPS SCHEMATIC CONNECTION PLAN

BLADE POWER ©

- -ALLOWS YOU TO FIELD MORE BLADE SERVERS PER SQ. FOOT USING EXISTING AIR CONDITIONING
- -SYSTEM PROVIDES HIGHER OVERALL POWER EFFICIENCIES WITH A LOWER COMPONENT COUNT
- -DESIGNED FOR IT MANAGEMENT – CAN BE INSTALLED ON EXISTING RAISED FLOOR AND EXPANDED BY DATA CENTER STAFF AS NEW BLADE SERVERS ARE ADDED
- -PROVIDES A BATTERY-LESS UPS FEATURE AND SAVES VALUABLE RAISES FLOOR SPACE

DIRECT POWER TECHNOLOGIES, INC.
Providing Efficient Reliability

THANK YOU !

Direct Power Technologies, Inc.

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