



Turnkey Power Solutions – Engineering, Converters and Systems



# WHO IS PRINCETON POWER?

Princeton Power Systems designs and builds high-performance power electronic converters for military and commercial distributed generation applications, and designs and installs complete photovoltaic systems.

Our Distributed Generation Systems, including solar systems, include energy storage, critical load control, backup power, and other advanced features.

Competitive advantages come from patented technologies, and system engineering expertise.

## CLEAN POWER, MADE SIMPLE.

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# COMPANY TIMELINE

- **2001:** Princeton University spin-out
- **2005:** Named NJTC “Early Stage Company of the Year”
- **2007:** PPS installs first photovoltaic array at Princeton University, under a New Jersey Commission on Science and Technology program
- **2008:** Hybrid (wind, solar, battery) systems installed in Bermuda, Virginia, California, New Jersey, awarded BEIP Grant from EDA for job creation
- **2009:** Commercial Inverter UL 1741 listing, “Green Product of the Year” Award, Demand Response Inverter Development begins, \$3.3M NJ Clean Energy Manufacturers loan/grant
- **2010:** 18-unit shipment for Gerald Ford Aircraft Carrier, prototype tests completed for Demand Response Inverter, solar systems strategic initiative



# THE PRINCETON POWER TEAM

## Management Team

### **Dr. Marshall Cohen**

President & CEO

- Ph.D. Physics
- 35 years experience in solar and optoelectronics
- Co-founder and last CEO of Sensors Unlimited

### **Darren Hammell**

Co-founder, EVP Business Development

- BSE Computer Science, Princeton University
- CEO of PPS 2001–2009
- NJBiz 40-under-40 Business Leaders

### **Erik Limpaecher**

Co-founder, CTO

- BSE Electrical Engineering, Princeton University

### **Cynthia Rosen, MBA**

Director of Finance & Administration

- BA in Economics, Rutgers
- MBA in Accounting, Seton Hall

## Board of Directors

### **Dr. Ed Zschau (Chairman)**

- Congressman, California's 12<sup>th</sup> District (Silicon Valley)
- Former CEO Systems Industries, General Manager IBM
- Professor of Entrepreneurship at Princeton University

### **Dr. Greg Olsen**

- Co-founder and CEO of Sensors Unlimited, Epitaxx
- 3<sup>rd</sup> private astronaut

### **Stephen Morgan**

- Former President, CEO, and Chairman of the Board of Jersey Central Power and Light
- More than 30 years industry experience in all aspects of energy generation and delivery

### **Dr. Joseph Stach**

- Former Executive Director of Massachusetts Technology Collaborative
- CEO of RF Power in Voorhees, NJ

### **Dr. Rudy Limpaecher**

- PhD Plasma Physics, 30+ years experienced in power

### **Dr. Chris Dries**

- Princeton PhD in Electronics
- President & CEO of United Silicon Carbide

**Talent. Experience. Commitment.**





# NAVY SHIPBOARD MOTOR DRIVES



## 10hp MIL-STD Motor Controller

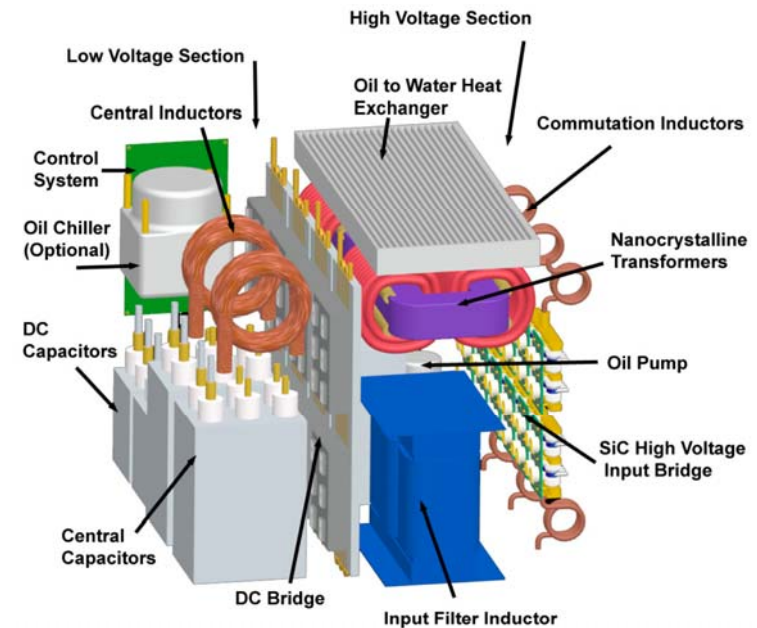
- Certified to MIL-STD 901, 461, 1399
- Pump/fan motor control capability
- Front-panel and web-based interfaces
- FIRST APPLICATION: Commissioned for the CVN-78 (USS Gerald R. Ford) FlexLab ventilation system

- Distribution agreement with Earl Industries, largest privately-held U.S. Navy contractor
- Additional models under development (25 hp, 50 hp)
- Applications for fire pumps, power distribution, propulsion



# NAVY ELECTRICAL SYSTEMS and COMPONENTS

- 1.5 MW AC-link Converter
- 3.0 MW/m<sup>3</sup> Density
- 98.0% Efficiency
  
- PCM-1A and PCM 4
- Silicon Carbide (SiC), and
- Silicon switch stacks



# GTIB 480-100 GRID-TIED INVERTER

3-phase 100kW DC-AC inverter for grid-tied and backup power applications



96.5% High-efficiency | High-reliability  
Microgrid and Backup Power capable

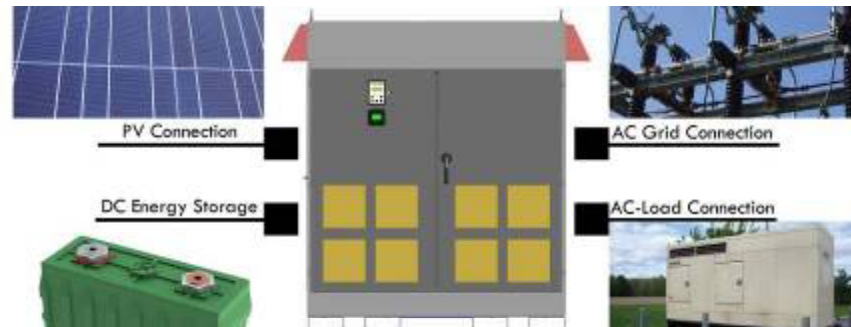
Compatible with:

- Commercial-scale solar arrays
- Commercial-scale wind turbine generators
- Battery banks and energy storage



# DEMAND RESPONSE INVERTER (DRI)

3-Phase, Grid-tied, Controllable 4-Terminal Power Conditioner



## E-QUAD Power Flow Control Technology:

Dynamic control of four bi-directional loads and sources through a central high-frequency link

- PV Connection
- AC Grid Connection
- AC-load Connection
- DC Battery Storage

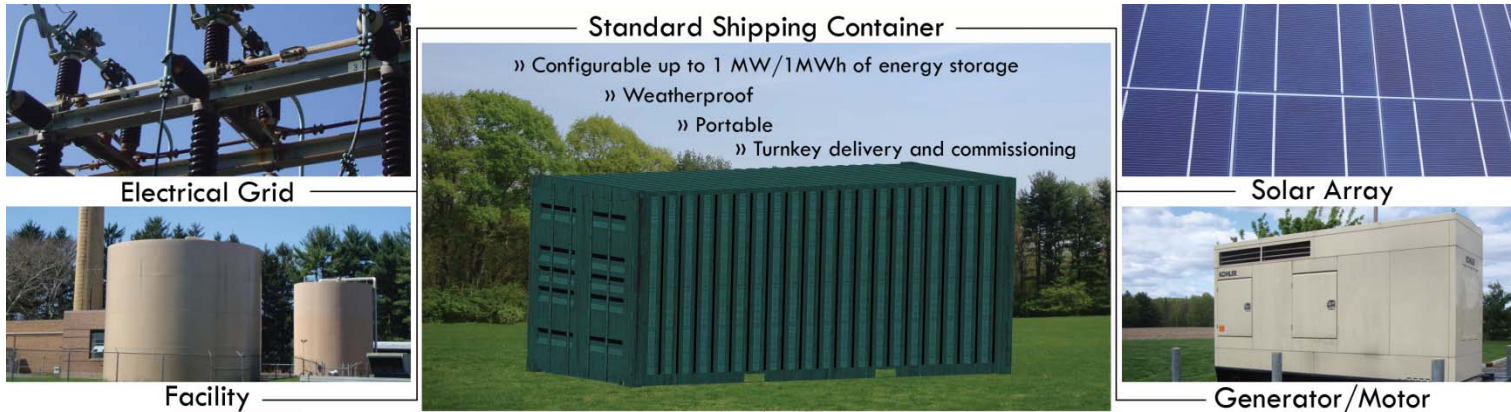
Five Smart Relays automatically shed low-priority loads in the event of power loss, or in response to price signals and grid needs





# ENERGY STORAGE SYSTEM

## Demand Response Inverter (DRI) and Battery Module



**Solar Time-Shifting:** Generate predictable, reliable power from intermittent distributed resources, and use it when it is most valuable

**Demand Response:** Automatically respond to price signals and electric grid needs by shedding loads and increasing power output

**Backup Power:** Hours or days of power backup by combining batteries with off-grid generators (solar, wind, diesel, etc.)

**Microgrid:** Maximize facility security and reliability by disconnecting from the electric grid when needed, while managing multiple loads and generators effectively

**Optimize Generation Sources:** Allow all generators to run at optimum efficiency to significantly reduce fuel use (30-50% reduction)



# SOLAR ENERGY SYSTEMS

## TURNKEY ENERGY STORAGE SYSTEMS

- We design and install turnkey solar systems in the US
- Including advanced systems with Demand Response, Load Control, and Microgrid Capabilities
- Financing options including Power Purchase Agreements (PPAs)
  
- Turnkey Energy Storage Systems
- 20/40/53 ft ISO Containers
- Large-format prismatic lithium-iron-phosphate cells
- Lead-acid or other technologies available



# MARKETS AND APPLICATIONS

## **Distributed Generation**

- Solar Arrays
- Commercial Wind Turbines (100kW-500kW)
- Wave/Tidal Power
- Fuel Cells
- Micro-turbines

## **Utility Energy Storage Systems**

- Solar Time-shifting
- Demand Response
- Load-Leveling
- Distributed Generation Integration (“Smart Grids”)

## **Facility/Agriculture**

- Optimized Power Generation
- Backup Power
- Increased Control



Princeton University E-Quad Solar Array  
Installation





# TECHNICAL CAPABILITIES

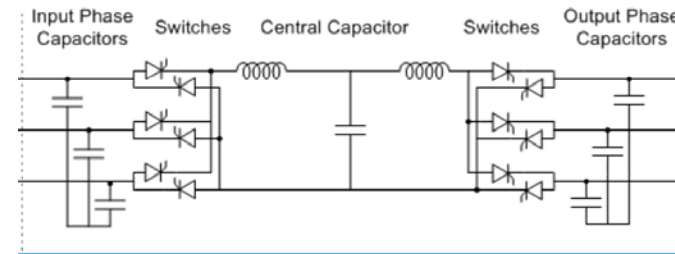
AC-link technology (3 US patents) is a novel 3-phase circuit and control methods.

## Benefits of AC-link:

Low  $dV/dt$

Low harmonic distortion

Soft-switching, high-efficiency, low EMI



AC-link circuit and controls (3 US patents)

High-frequency magnetics (20-50kHz switching, nanocrystalline, Sendust materials)

Silicon Carbide (SiC), high-voltage silicon switch stacks



75kW transformer

Application software (PV, generator, motor, battery) and communications

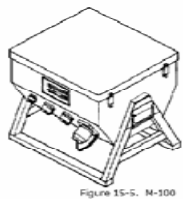
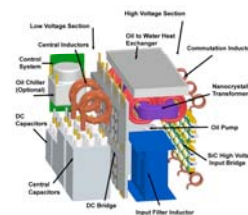


Figure 15-5. M-100

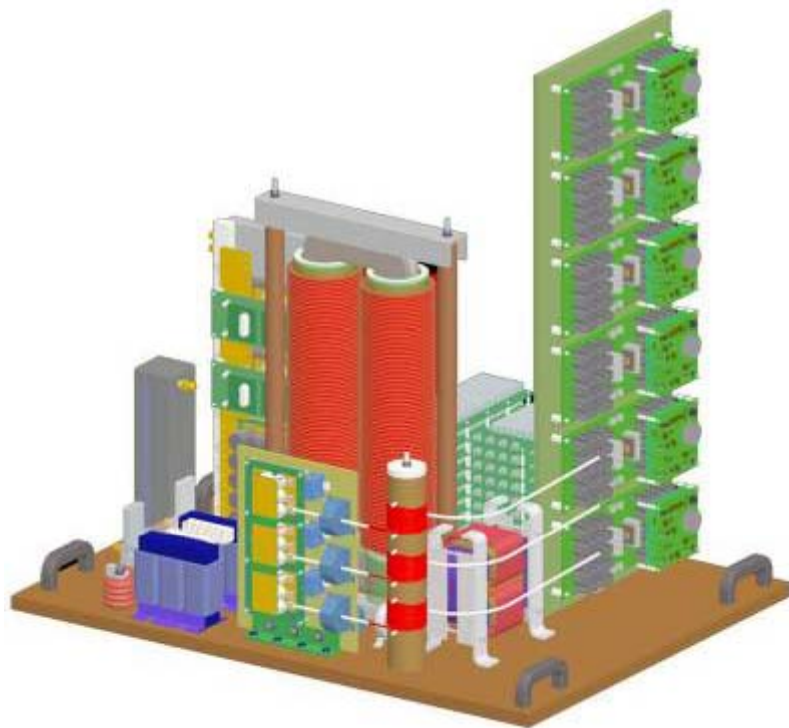
30kW microgrid converter



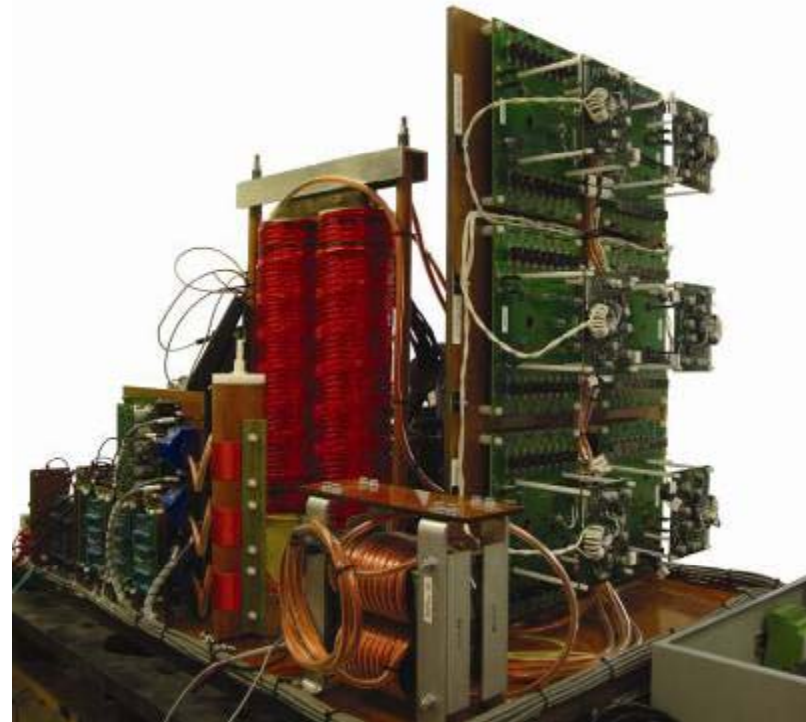
1.5MW shipboard converter

# RESEARCH & DEVELOPMENT

Our team is constantly learning as we undertake new and interesting projects for our customers. Case studies and application notes, available upon request, describe the integration of PPS electronics into a variety of unique and demanding applications.



From concept...



...to reality





# FACILITY

Princeton Power Systems' headquarters is an advanced facility for the development, testing and manufacturing of high-power electronics systems.

Located on the Sarnoff Corporation's 254-acre main campus in Princeton, NJ.

## Highlights:

1600 Vac 200 A main service

Induction motors, PM motors, and resistive loads up to 800kW

Advanced high-power, high-voltage test and measurement equipment

Testing/Research Areas

MW-scale battery banks

Dynamometer testing cell



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PPS has launched an aggressive program to expand its equipment and facilities over the next two years to further develop its state-of-the-art research and manufacturing capabilities

