RCT Systems

Power and Energy Management Solutions

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The RCT Systems Advantage

"To be the leading developer of energy management, storage, distribution and control technologies to meet the needs of a more electric future."

RCT Systems (*formerly Satcon Applied Technology*) is an innovative small business focused on design, development, prototyping, and transitioning to production products with state of the art technology in:

- Power Conversion Electronics
- Power Management & Distribution Systems
- Hybrid Electric Vehicles
- Electric Machinery
- Advanced Electronic Material Applications

RCT Systems performs development work, engineering consulting services as well as prototype development and manufacturing for both government agencies and private industry. We have used our expertise in custom power devices, system integration, dynamic system modeling, grid electronics, packaging and thermal management to assist our customers in achieving technology breakthroughs. From concept studies to design and prototype development, testing and production, we can support the next generation of your products and systems.

Sustainable Competitive Advantage

- ⇒ Multi-disciplined depth and breadth that enables RCT Systems to be adaptable and responsive to our customers.
- ⇒ Recognized reputation for delivering high quality, power dense products in power conversion and advanced machinery that are unmatched in our industry.
- ⇒ Strong, proven track record of Intellectual Property success that translates into the design and manufacture of innovative, leading edge products.
- ⇒ Reliable production hardware installed in commercial and military platforms.

Commitment

RCT Systems demonstrates a commitment to technical excellence and innovation. We are committed to the design and development of critical power and energy solutions and transitioning them into cost effective, viable products for industry partners and customers.

Our Capabilities

► The RCT Systems Team

⇒ Dedicated, educated & experienced staff of Engineers and Scientists
⇒ 75% of technical staff have advanced degrees, 25% with PhD.
⇒ Represents a wide breadth of disciplines:

- Power Conversion & Electronics
  - DC-DC & Pulse Power Converters, DC-AC Inverters, and systems to support the Navy's Next Generation Integrated Power System (NGIPS) architectures.
- Motor Drive Electronics & Controls
- Power Control & Distribution
- Rotating & Linear Motors & Generators
- Grid Interface and Controls
- Mobile Exportable Power
- Wide Band-Gap (SiC & GaN) Technologies and Applications
- Cutting Edge Control & Packaging Technologies
- Advanced Thermal Management

► R&D & Production

Technology development that transition into products for manufacture

⇒ Fully certified, including ISO: 9001:2008
⇒ Engineering, laboratory and production space
  ⇒ Prototyping facilities include a well equipped Electronics Laboratory
  ⇒ Assembly & Test Areas
  ⇒ Prototype to full Production capable
⇒ Compliant with all Federal, and Local Environmental Regulations.
⇒ Systems Engineering, Design, Simulation, and Testing Capabilities.
⇒ Over 80 Sole Patents, and 70 Joint Patents
⇒ Strong innovation track record 175 SBIRs – 56Phase II's (with DoD, NASA, DoE and NSF)

Our Experience

RCT Systems provides advanced technology solutions for major Aerospace/Defense Contractors, Commercial customers and government agencies that address critical power and energy management needs. Over the years, our major partners have included:

- BAE Systems
- General Atomics
- General Dynamics
- ITT Corporation
- Lockheed Martin
- Northrop Grumman
- Raytheon
- Chrysler, General Motors, and Ford

RCT Systems has provided power solutions to the United States Government with the following agencies among others:

- Department of Defense
  - ⇒ ARMY
  - ⇒ NAVY/USMC
  - ⇒ AIR FORCE
  - ⇒ DARPA
- Department of Energy
- NASA

Some Recent Major Programs with RCT Systems participation:

- Integrated Power Management Systems for shipboard power distribution systems
- Hybrid Electric Vehicle (HEV) Powertrain
- High Temperature Electro-magnetic Actuator (HTEMA)
- Predictive Controller for Power Supply Prognostication
- DDG-51 Ship ESM Prototype
- Pulsed Power Electronics
- WBG (SiC) Semiconductor Power Electronics
- Integrated Starter Generator/Traction Motor for multiple vehicle applications

RCT Systems – *an innovative leader in the field of power control and conversion technology.*

Power Conversion Electronics

RCT Systems has wide-ranging experience in the design and development of high power-density power conversion electronics for military, industrial, automotive and commercial applications. We have produced numerous first-of-a-kind power systems using leading edge technologies, and the company continues to pioneer implementation of new technologies to push the power converter state-of-the-art.

We have built power converters ranging from several kilowatts, all the way up to several megawatts. Many of the systems that have been built are modular, and can be expanded in power level simply by adding more of the basic power electronics building blocks. A good example of this is the US Navy IPS DC-DC Converter systems and DC-AC Inverter systems shown above. These are built around a power conversion building block of approximately 100kW, and can be expanded to provide up to 3MW for shipboard power distribution.

Pulse Power Converter

For example, the **Pulse Power Converter (150 kW Capacitor Charger – 0-10kV in 2 sec)** shown above achieves a power density of 7.5 kW/liter, which is over 3 times the power density achieved by previous converter solutions.

Modular Energy Storage Module (ESM)

We successfully developed and tested an **800kW modular Shipboard Energy Storage System** for the DDG-51 Class. The system shown here was tested at NSWC Philadelphia, and is being used for simulated shipboard laser testing, and will go to sea on the ex-Paul Foster [Self-Defense Test Ship – SDTS] for at sea Laser system testing in 2018. The system includes 4 - 200kW high power density bi-directional (450VAC 3Φ to 1000VDC) inverters.

200kW LRU

Under a major contract US Army (TARDEC) we developed a **220kW SiC Motor Drive** for next generation tactical military HEV's.

220kW SiC Traction Motor Drive

Our designs are focused on meeting the specific needs of the unique and challenging applications of our customers – applications requiring high power density, low noise, special packaging requirements, high temperature environments, to name a few.

We look forward to addressing your special power conversion needs.

HEV Technology

RCT Systems personnel have a long history of EV/HEV component and systems development, dating back to the mid- 1990's and the Chrysler Patriot Race Car, various fuel cell development vehicles, and development of a 120 HP EV powertrain for the 1999 model year Chrysler EPIC Minivan, and also a 250HP Powertrain and battery charging systems for Bluebird Buses. Our current development is a full HEV/PHEV system for the demanding tactical military vehicle market under an Air Force Research Lab contract and a USArmy/USMC Vehicle OEM

The RCT Systems Hybrid Vehicle Power System was developed to meet or exceed all Joint Light Tactical Vehicle (JLTV) objective electric power requirements for on-board as well as export power, providing power for all anticipated weapon/sensor systems, and a future "silent move" capability.

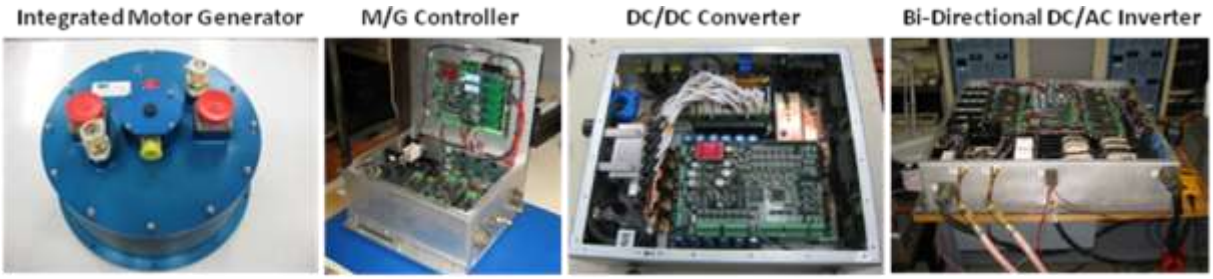
The system includes a scalable 60 KW inline motor generator and controller, that functions both as a generator, and also to provide vehicle starting, propulsion and torque assist/smoothing. Other components in the system include a DC/DC Vehicle Power Converter (VPC) module used to power the vehicle 28VDC systems, and an Off-Board Power Converter (OPC) providing bi-directional, galvanically isolated DC/AC inverter for 120/208VAC 50/60Hz power from the 600V Vehicle DC Bus, as well as a Plug-in Hybrid (PHEV) battery charging capability.

Hybrid Power System Characteristics:

• **Vehicle DC Bus**	**600VDVC nominal, 460 – 750VDC**
• **Motor-Generator**	**60kW, 81HP, 0-4krpm, inline**
• **Motor-Generator Controller**	**63.2kW, Bi-directional**
• **Off Board Power Converter**	**120/208VAC, 30kW, Bi-directional, isolated**
• **Vehicle Power Converter**	**28VDC, 300A, 8.4kW, isolated**
• **Radiator**	**EGW 50/50, 1.5gpm, -40°C to 70°C**
• **Communications Bus**	**CAN Bus Class C, SAE J1939**

Our power conversion experience includes the full range of vehicle power conversion technology, which is directly applicable to the country's future alternative energy needs, including the development of modular motors and drives for hybrid-electric vehicle applications, onboard and off-board power converters, battery charging systems and fuel cell converters.

All RCT Systems components/systems for the HEV market are scalable and can be easily integrated into various designs by OEM's or vehicle integrators, for tactical military vehicles or trucks, as well as for the commercial automotive or trucking industry.



Machinery and Magnetics

RCT Systems provides a full range of trade study, analysis, design, prototype development, testing, and production for electric machinery and magnetics components and systems. If it converts between mechanical and electrical energy RCT Systems can provide the solution.

Selected Projects

- Traction Motors/Starter Generators
  - Electric LeMans racecar traction motor, flywheel, and alternators
  - Electric vehicle powertrain production for transit busses and Chrysler minivan
  - Interior PM (IPM) traction motor
- Industrial Drive Motors
  - High speed compressor PM drive motor for rooftop chillers
- Rim Motors
  - Underwater PM propulsors
- Generators
  - Hybrid Army vehicle induction machine generator
  - HMMWV hybrid PM generator
- Gas turbine engine oilfree bearings
  - Magnetic bearings
  - Hybrid air/magnetic bearings

We have developed machinery and magnetics solutions for traction motors, starter/generators, ultra high speed motors and generators, magnetic suspension systems, linear actuators, and flywheel systems. We have developed motors with powers up to 500HP, and speeds up to 100,000 RPM. This wide range of capabilities enables us to develop solutions for any customer, industrial, military, or automotive with challenging application requirements.

Engineering Services

Today outsourcing of engineering, research and development tasks is an increasingly attractive alternative. RCT Systems performs research that supports contract Research and Development for government agencies and private industry. Our expertise in custom power devices, system integration, dynamic system modeling, packaging and thermal management is used to assist our customers in achieving technology breakthroughs which support their next generation products and systems. Our staff has the complete range of skills necessary for power conversion and electromechanical developments, including Power Electronics; Digital Electronics; Electromagnetics; Mechanical and Thermal Design and Analysis; Software and Controls; and CAD/CAE.

If your research and development needs include Distributed Power Systems, Electric Machines and Drives, Energy Conversion and Storage, Power Electronics and Control Systems, Packaging and Thermal Management, Active Magnetic Systems, or Sensors and Actuators, please consider RCT Systems as a resource.

RCT Systems Summary

RCT Systems (as Satcon Applied Technology) was the technical core and engine that drove the business for our former parent company Satcon Technology Corporation. Satcon was spun out of MIT and Draper Labs in 1985 as a privately held technology development company, focused on advanced technology needs for Defense and Aerospace applications. Satcon sold our group to RCT Holdings a small private company and we became RCT Systems in January 2010. With all of our key technologists and facilities in place, we are continuing our legacy of meeting customer needs for challenging power and energy management systems.

► RCT Systems

- ⇒ **Technology:** Advanced Power Converters, Inverters, Motors, Generators and associated drive systems. Advanced Thermal Management and Packaging
- ⇒ **Products & Services:** Innovative power conversion solutions, and system design & engineering services for defense, aerospace and commercial markets
- ⇒ **Manufacturing:** Broad, Flexible Capability…prototype to full production capable
- ⇒ **Certification:** ISO 9001:2008
- ⇒ **Location:** Linthicum, MD close to BWI Airport
- ⇒ **Team:** Management & Engineering team with strong technology & execution background

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… From Design to Production…