Protonex

Portable, JP-8 fueled battery charger for remote operation and portable solid oxide fuel cell systems

2007 Joint Service Power Expo
April 26, 2007

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Outline

- Introduction
- Why portable SOFCs?
- SOFCs at Protonex
- Technical approach
- 250 W battery charger
- 75 W battery charger
- Summary

Mesoscopic Devices

POWERED BY Protonex

Mesoscopic Devices, LLC
merged with Protonex in April 2007

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PROTONEX OVERVIEW

- Leading provider of 10 - 1000 watt PEM and SOFC power solutions
  - Portable, remote and mobile power
  - Targeting applications underserved by batteries and small generators
  - World class developer of pumps, blowers and meso-scale reformers
- Developing products for military and commercial applications
  - High performance and low cost
- Facilities in Southborough, MA and Broomfield, CO

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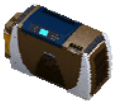
PROTONEX PRODUCTS

- Fully integrated power systems – fuel in, power out
- Supporting multiple fuel types
  - Hydrogen, Chemical Hydrides, Methanol, Propane, JP-8
- Hydrogen PEM fuel cell technology
- SOFC technology



Valta™ 250 Multi-Purpose APU

150W & 500W Power Generators

75W SOFC Power System

ProPack™ C50 Man-Portable Power

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Why portable SOFC generators?

- Relative to other power sources, SOFCs are:
  - Quieter than IC-engine generators
  - Lighter than batteries
  - More efficient than IC-engines
  - Longer maintenance interval than IC-engines
- Relative to other fuel cells, SOFCs offer:
  - High energy density (hydrocarbon fuels)
  - Widely available fuels
  - Simple fuel reforming
  - Wide environmental tolerance range

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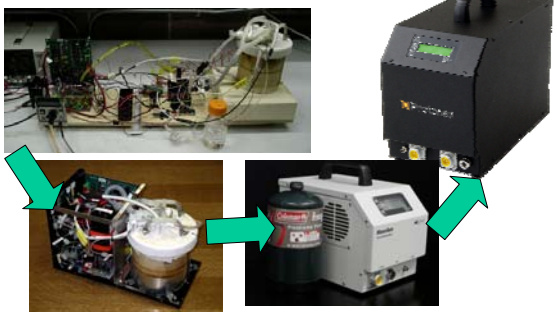
SOFCs at MD/Protonex



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SOFC development approach

- 250 W battery charger
  - ONR program
  - JP-8 (desulfurized)
- 75 W battery charger
  - Commercial system
  - Propane
- Build family of generators

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SOFC technical approach

- Tubular solid oxide fuel cells
- Catalytic Partial Oxidation reforming (CPOX)
  - No water required
  - JP-8, propane
- Battery hybridization
  - Start-up, peaking power
- Optimized components

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Emphasis: integration, commonality

- Tightly integrated hot zone
- Stacks designed for integration
  - Mechanical
  - Fluid flow
  - Thermal
- Subassemblies in cold zone
  - Fuel delivery
  - Air delivery
  - Controls, sensing, power management

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250 W Battery Charger (ONR)

- Squad-level field battery charging
- Single button operation
- 7.1 x 9.6 x 13.1 in (180 x 245 x 332 mm)
- 13.7 lb (6.2 kg) dry
- Desulfurized JP-8 fuel
  - <0.8 gal/day (2.7 L/day) (prediction for current generation)

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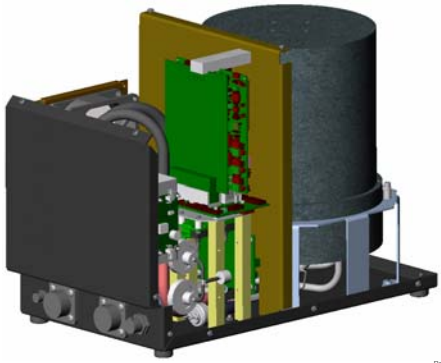

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Liquid fuel, stand alone desulfurizer

- Sulfur removal from liquid fuel
- Reduces sulfur from >3000 ppm to <10 ppm S
- Single sorbent bed, with automatic regeneration
  - <6 hours to clean fuel for a 24 hour test
  - <24 hours cycle (including regeneration)
- Multiple sorbent beds
  - Continuous regeneration
  - Highly compact
  - 5 kW model under development for TACOM

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SOFC generator status (ONR program)

- 2nd generation system in assembly
- Testing to begin May 1
- Additional test articles to be built through Aug. 07
- By September 2007
  - Bench testing at Protonex
  - Demo power generation and battery charging
  - Stand-alone operation
  - Unit to Navy for bench testing with desulfurizer to support testing

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MesoGen™ portable generator

- Propane fired
- Target: 75W nominal, 150W peak
- 12/24 VDC
- 8.5 lb (3.85 kg)
- 10.1 x 6.6 x 7.3 in 257x167x185 mm
- Advanced LSGM cells

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Complete system demonstration

- Cold start on propane
- Multiple start/stop cycles
- Long-term tests of key BOP components (up to 2000 hours)
  - Fuel reformer, blowers, fuel feed system
- Recent cell tests:
  - 1000 start/stop cycles—no tube failures
  - 3% degradation at 500 hours
- 58 W gross power in initial tests

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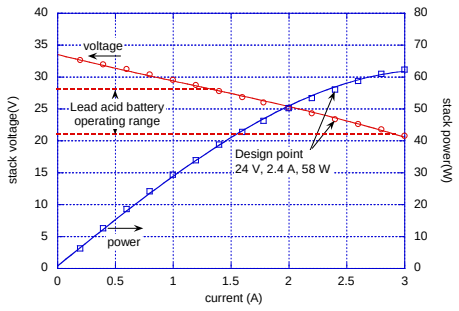

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Summary

- Portable SOFCs offer significant advantages for military applications:
  - High energy density in fuel (>3000 Wh/kg)
  - Ability to use fuels already in theater (propane, JP-8 with processing)
  - Field or on-board desulfurization of JP-8 is practical
  - Protonex is moving aggressively to demonstrate SOFC generators for military applications

Acknowledgements

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