Ultrabattery Test Results for Utility Cycling Applications

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Presented by:

Tom Hund,

Nancy Clark and Wes Baca

Sandia National Laboratories
Albuquerque, NM
(505) 844-8627
tdhund@sandia.gov

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Introduction

- Funded by the Energy Storage Systems Program of the U.S. Department Of Energy (DOE/ESS) through Sandia National Laboratories (SNL).
- The DOE Energy Storage Program provides support to develop and evaluate integrated energy storage systems involving batteries, superconducting magnetic energy storage (SMES), flywheels, electrochemical capacitors and other advanced energy storage devices.
- The Ultrabattery battery was tested using a high-rate-partial-state-of-charge (HRPSoC) cycle profile designed to simulate the ancillary regulation services of a utility and wind farm energy smoothing application.

Introduction

- The Ultrabattery is a hybrid energy storage device which combines an asymmetric electrochemical capacitor in parallel with a lead-acid battery designed to improve cycling and power performance.
- Hybrid electric vehicle (HEV) testing as of January 2008 in a Honda Insight at the Millbrook Proving Ground near London has completed over 100,000 miles of road tests. In addition, laboratory HEV cycle tests have demonstrated comparable HRPSoC cycle performance to NiMH HEV batteries.

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Introduction

- East Penn Manufacturing in the United States has obtained manufacturing rights for large format 1,000 Ah stationary cells. The large cells would allow entry into the mega-watt scale markets including utility, solar, and wind applications.

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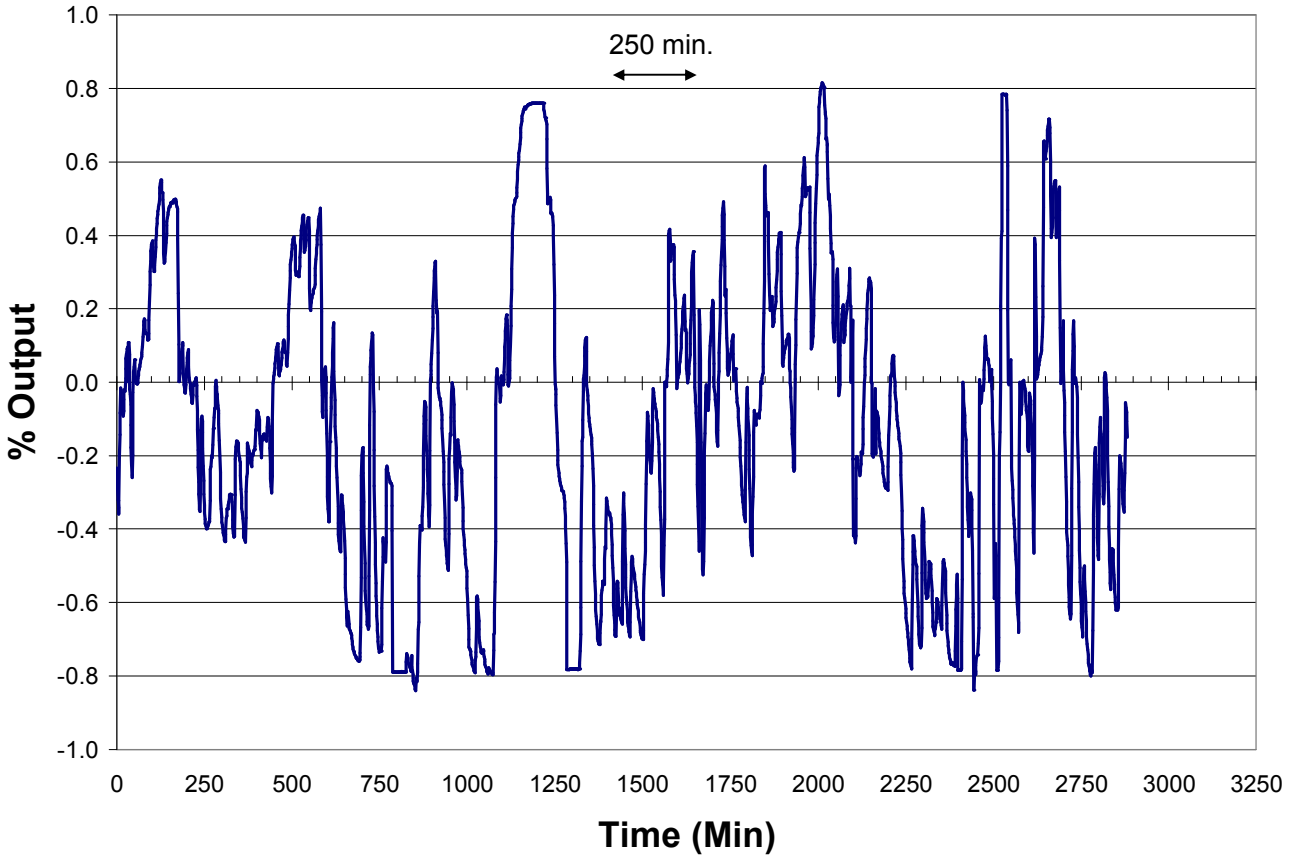
Utility Application

PJM Ancillary Services Power Requirements
Prepared by C. Koontz, WPS.



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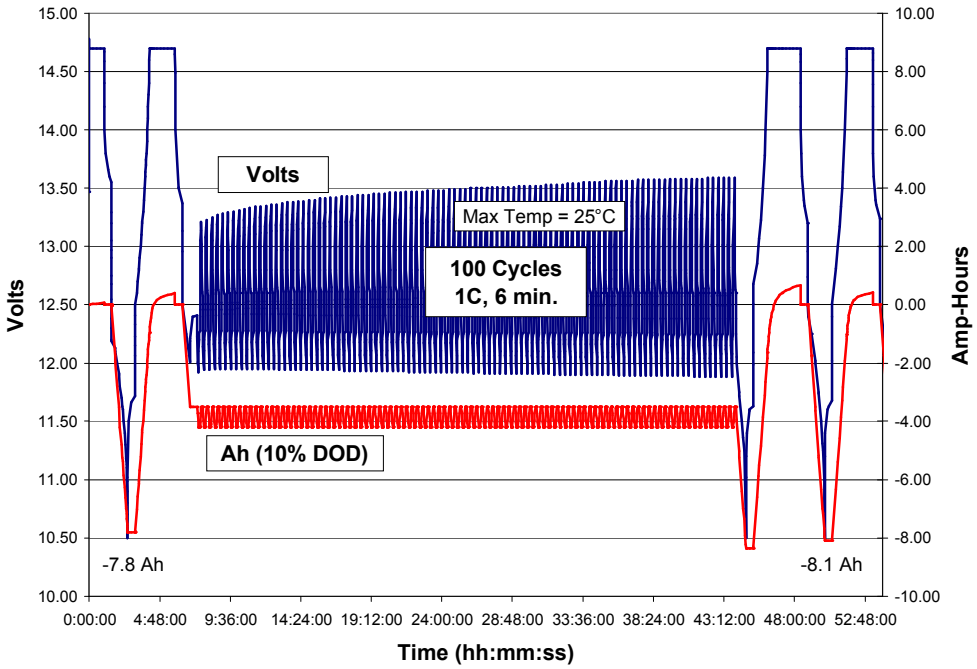
Test Procedure

- **Capacity Test** – Establishes initial and final capacity
- **DC Ohmic Resistance** – Identifies performance degradation before and after cycling
- **Float Current** – Useful for float applications
- **Power Density and Specific Energy Density** – Measures power and energy density
- **Utility HRPSoC Cycle Test** – Measures the ability of the battery to cycle for utility and wind farm energy smoothing applications

HRPSoC Cycle Test Procedure

- Step 1 – 1C Capacity Test
- Step 2 - Utility HRPSoC Cycle Test
  - 1C to 4C rate
  - 50% SOC
  - 10% dch/chr
  - 5 min rest
  - 100 to 1,000 cy/ sequence
- Step 3 – End of cycle sequence capacity test
- Step 4 - Repeat cycle sequence



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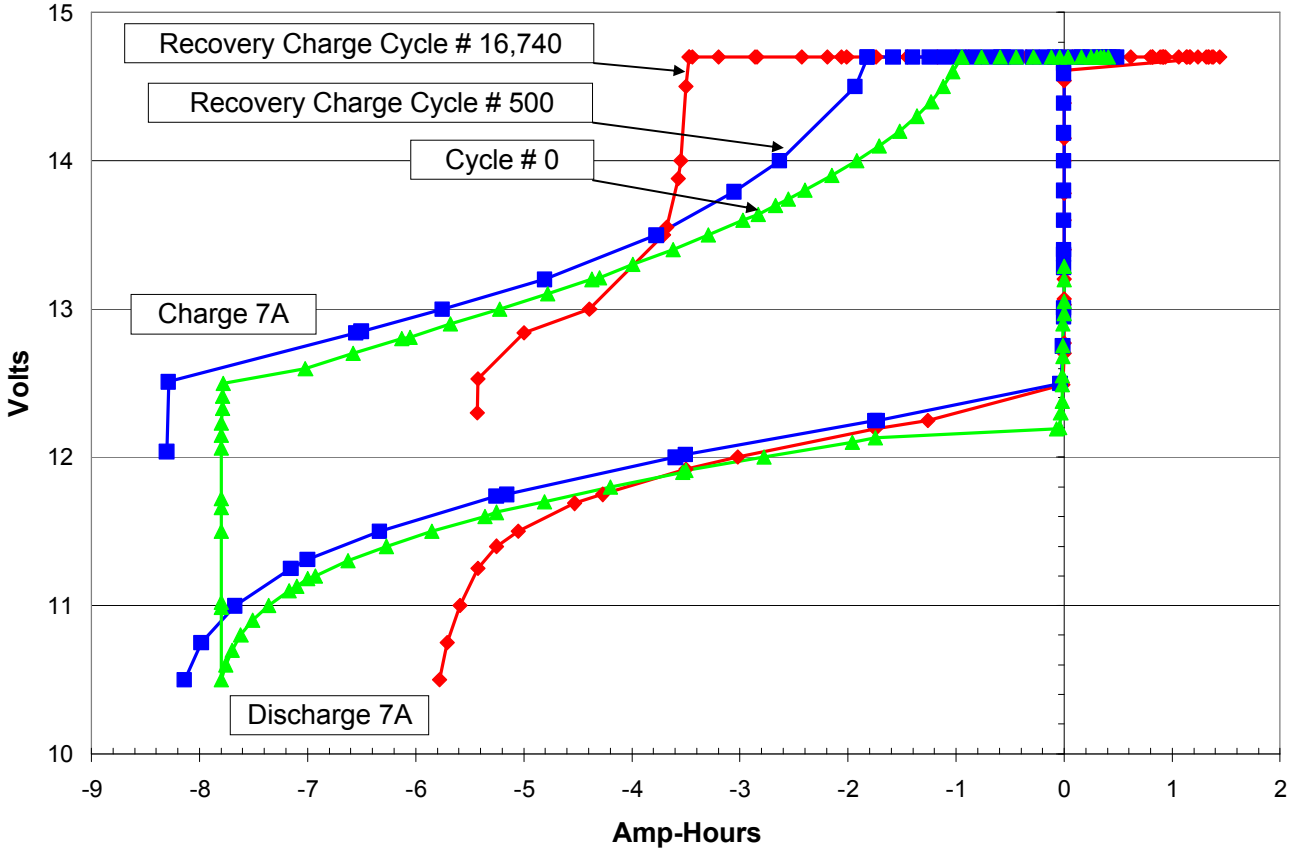
Capacity Results

Ultrabattery Recovery Capacity Curve at 0, 500, and 16,740 HRPSoC Utility Cycles



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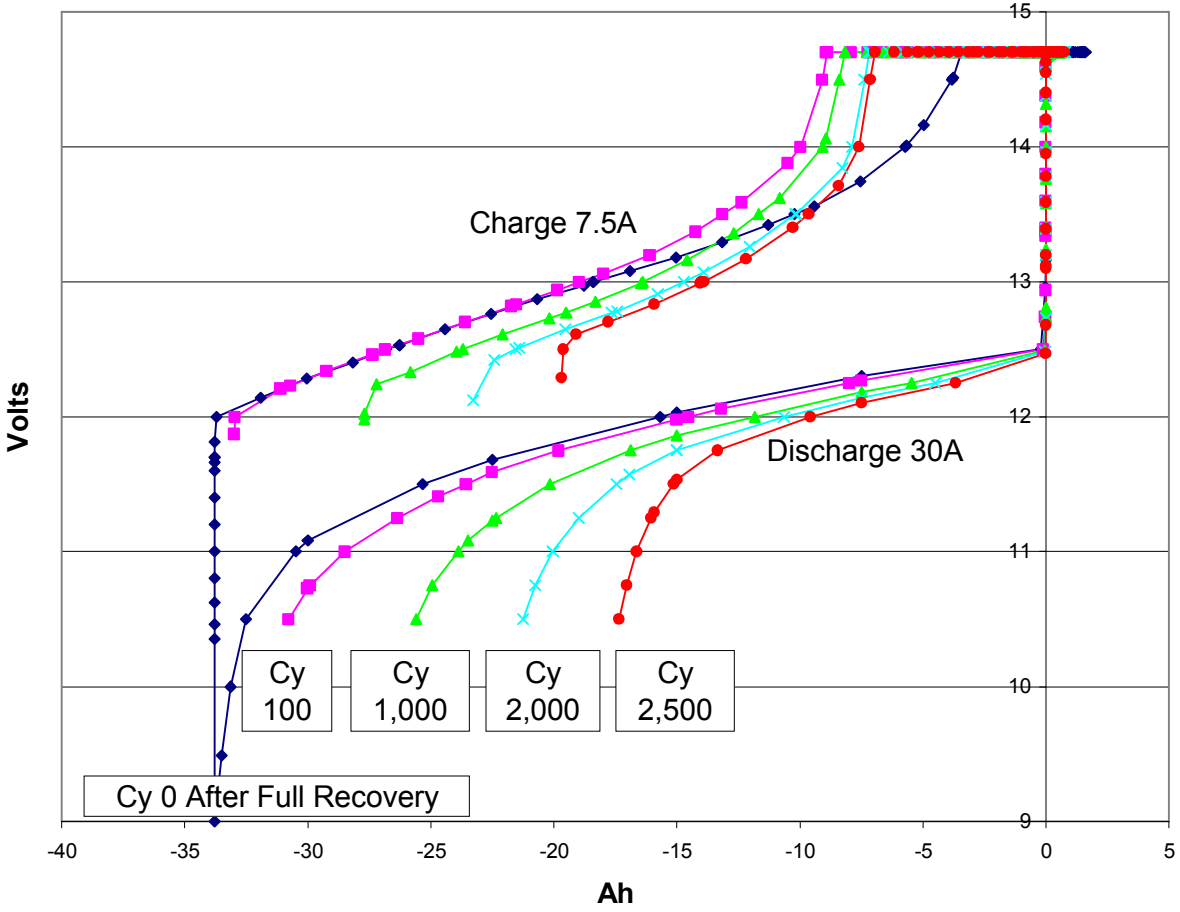
Capacity Results

AGM VRLA Battery Recovery Capacity Curve at 0, 100, 1,000, 2,000 and 2,500 Utility HRPSoC Cycles



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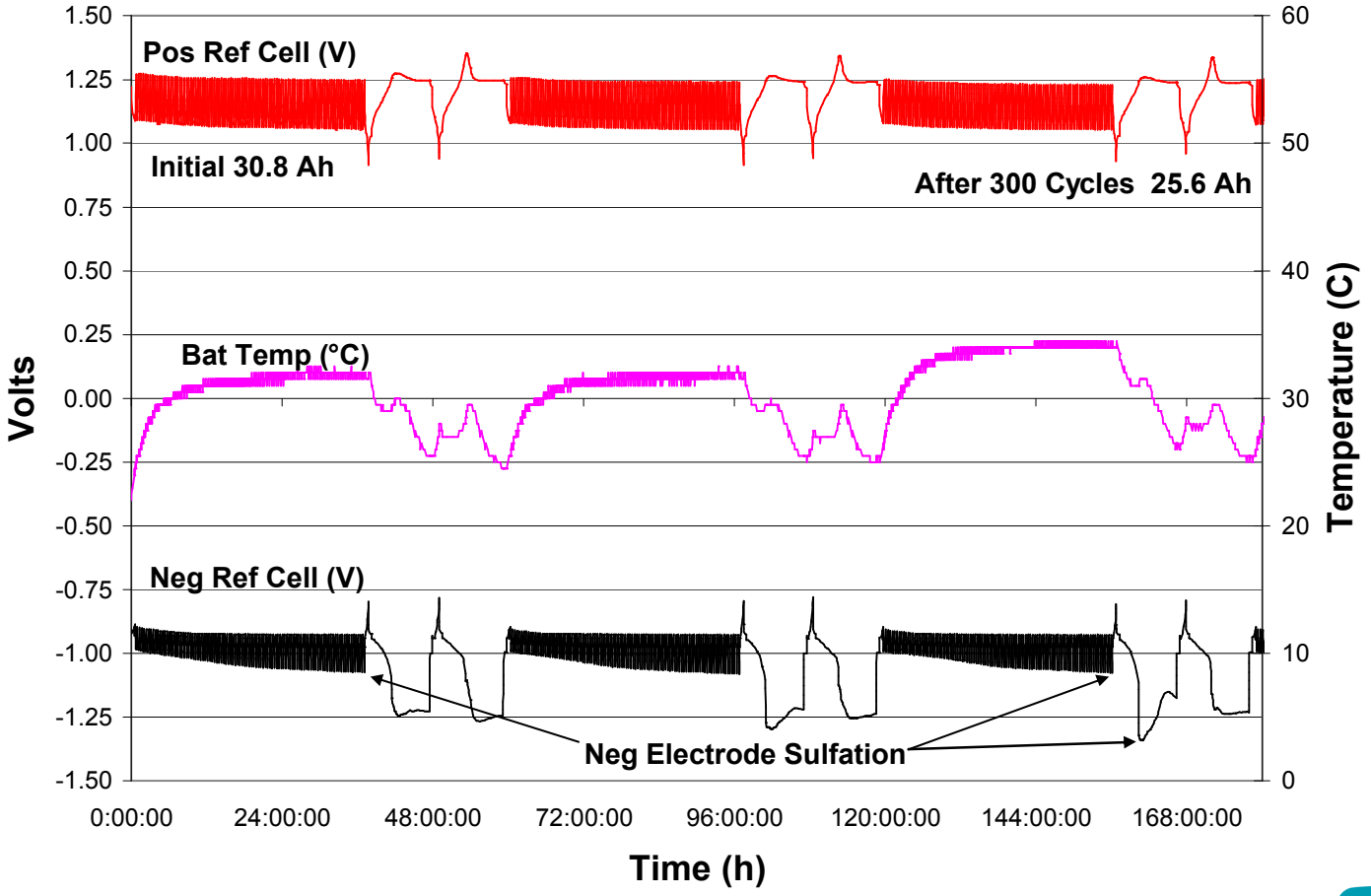
VRLA Negative Plate Sulfation

VRLA Battery Reference Electrode Cell Voltage During HRPSoC Cycles



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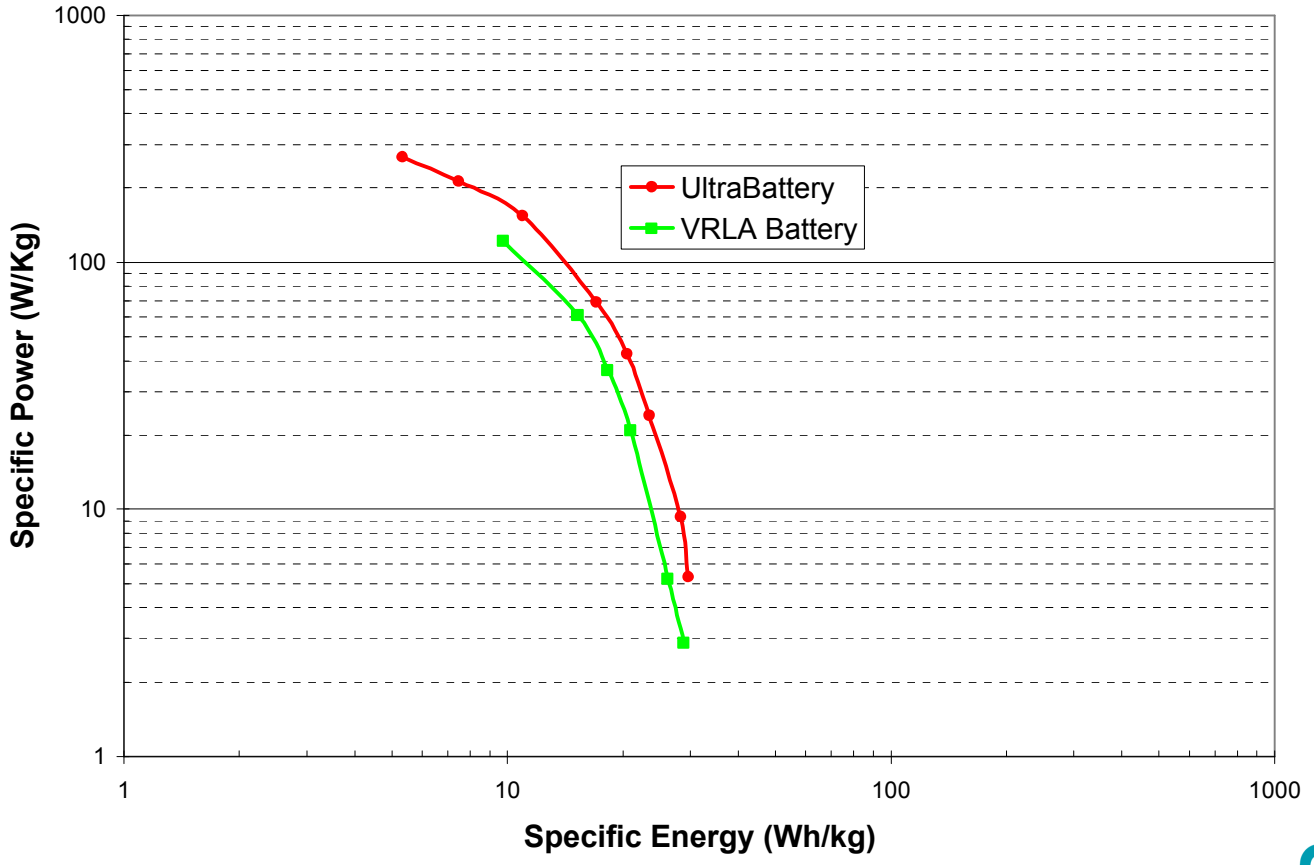
Specific Power and Energy

Ultrabattery And VRLA Battery Specific Energy And Power



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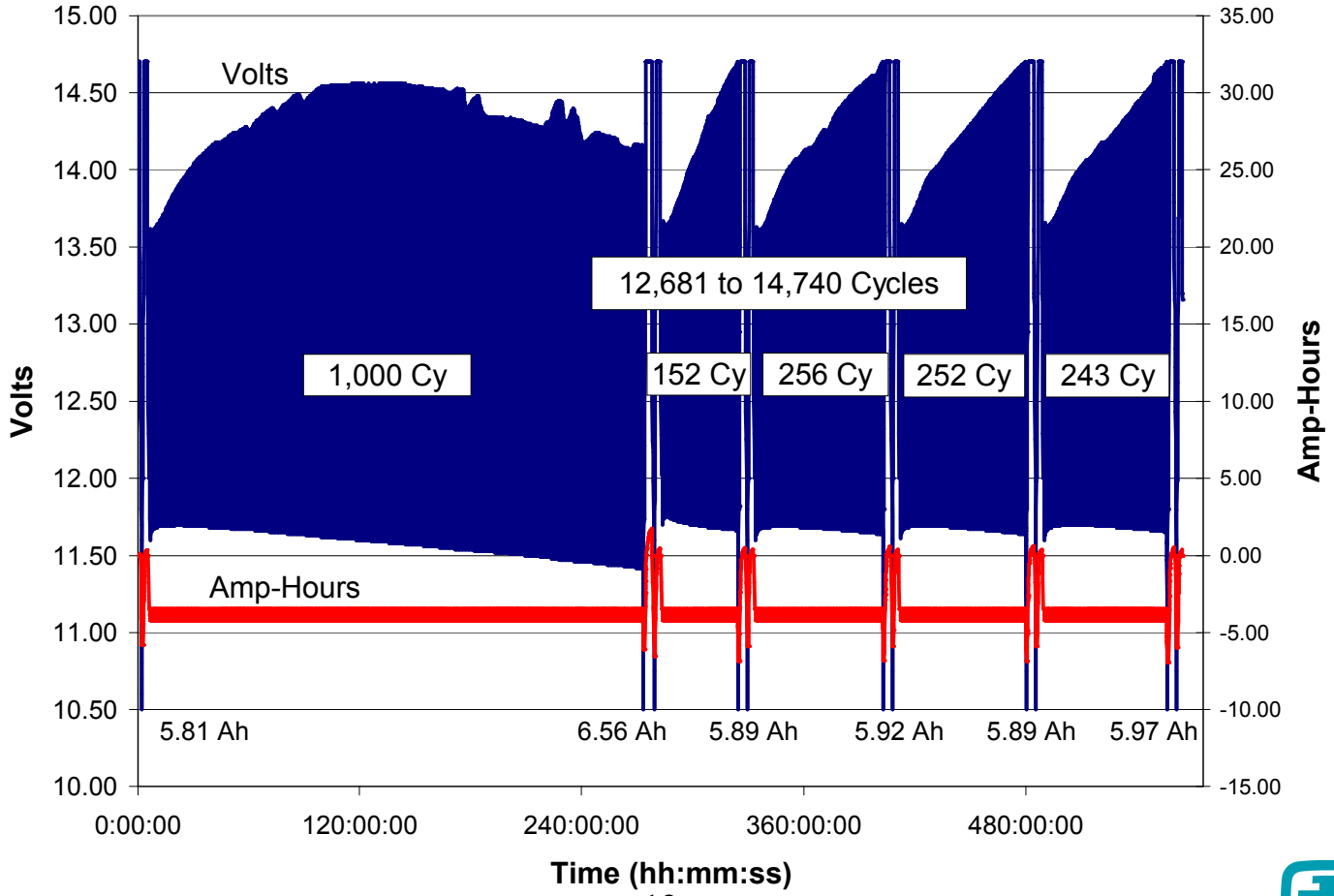
HRPSoC Utility Cycle Results

Ultrabattery HRPSoC Cycling Accelerated Rise In End of Charge Voltage, At $2C_1$ Rate For 3 min.



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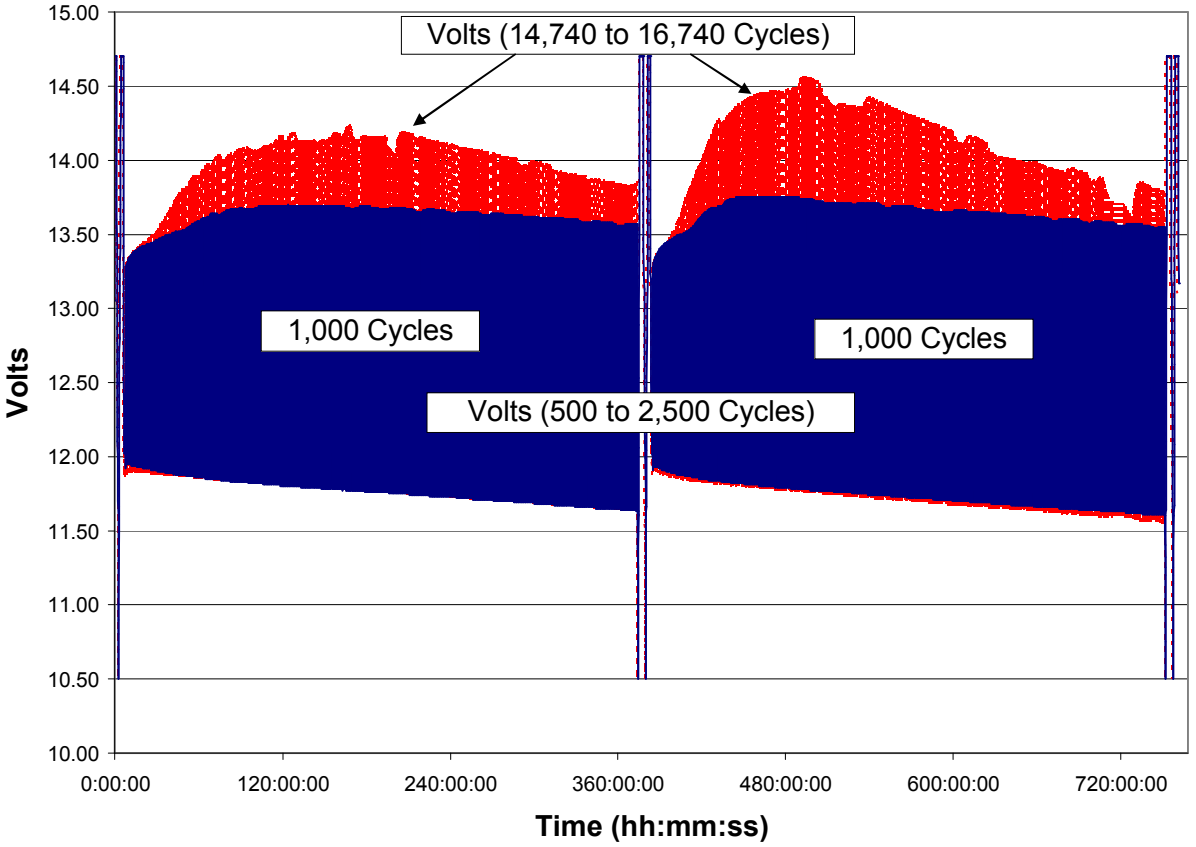
HRPSoC Utility Cycle Results

Ultrabattery HRPSoC Cycling Aging Effect Between 2,500 and 16,740 Cycles, At $1C_1$ Rate For 6 min.



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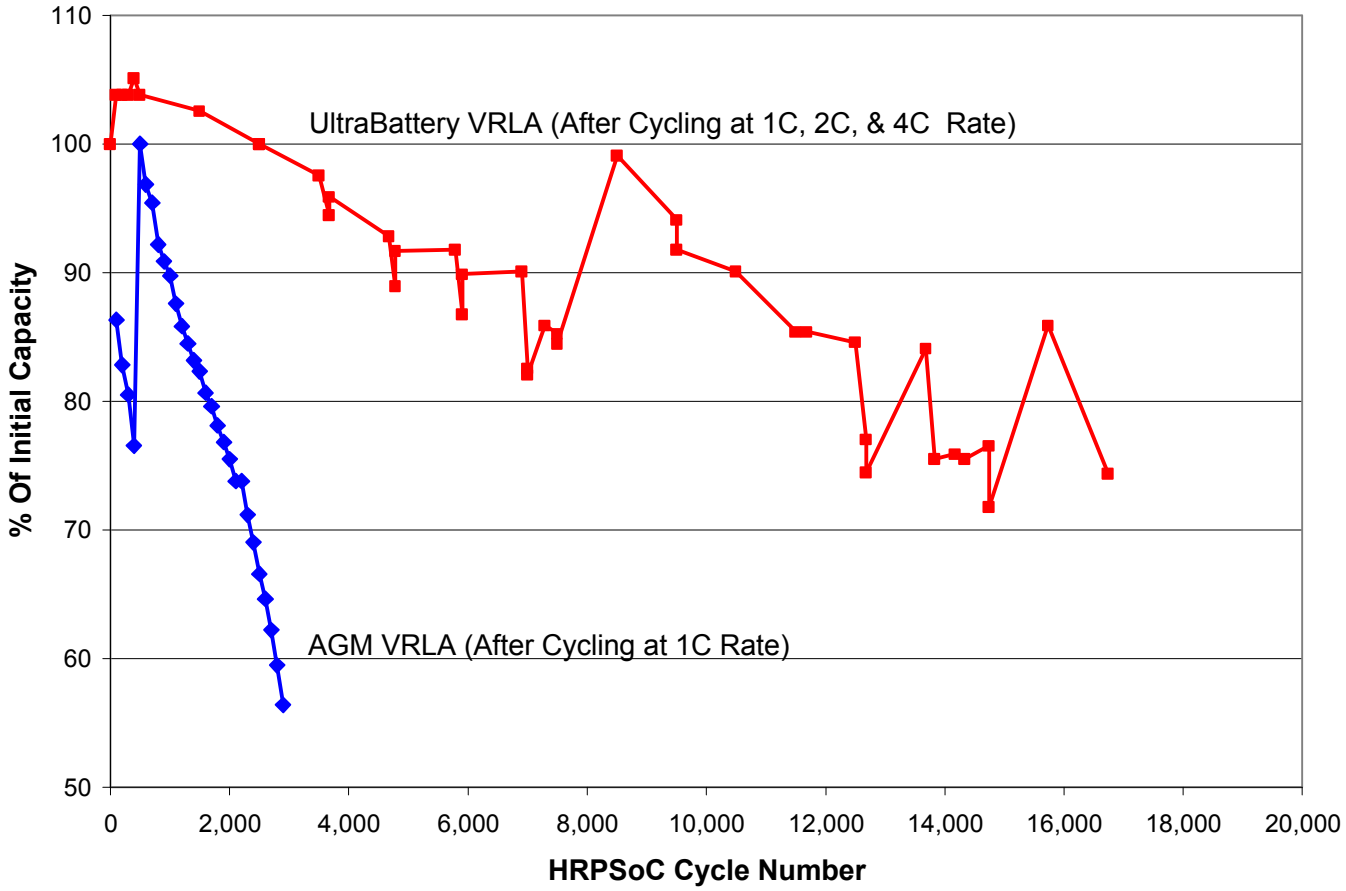
HRPSoC Utility Cycle Results

Ultrabattery And VRLA Battery $1C_1$ Capacity After HRPSoC Cycling.



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Conclusions

- The Ultrabattery $1C_1$ capacity after cycling for over 15,000 HRPSoC cycles was just under 80% of its initial capacity. This is over 13 times greater than the VRLA battery at about 1,100 cycles at 80% SOC.
- The Ultrabattery was also able to HRPSoC cycle well over 10 times the number of cycles before requiring a recovery charge. The VRLA battery was recovery charged every 100 HRPSoC cycles and the Ultrabattery could cycle well beyond 1,000 HRPSoC cycles.
- The Ultrabattery was HRPSoC cycled up to the $4C_1$ rate with minimal temperature rise at an operational temperature of less than 32°C. The VRLA battery was limited to about the $1C_1$ rate at an operating temperature of less than 32°C.

Conclusions

- The Ultrabattery appeared to age between 500 and 14,740 HRPSoC cycles. At 14,740 cycles the end of charge voltage increased more rapidly and had a different overall shape indicating some sort of ageing effect. The VRLA battery end of charge voltage rise was consistent throughout the test sequence.
- The Ultrabattery end of charge voltage also rose more rapidly after the first cycle sequence and all subsequent cycle sequences. The end of charge voltage recovered after the test sequence was terminated and restarted after an extended rest.
- The Ultrabattery $1C_1$ capacity was much more variable after about 7,500 HRPSoC cycles.
- A constant current recovery charge on the Ultrabattery after 16,740 HRPSoC cycles was only able to recover about 9% of the lost capacity from 74 to 83%.

Future Work

- Test 1,000 Ah Ultrabattery for utility, wind farm, and PV hybrid power systems (off grid remote area power systems).
- Full scale demonstration??