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Electrical Energy Storage Applications and Technologies Conference

October 17-19, 2005

San Francisco, CA

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Bipolar Nickel Metal Hydride High Power and Energy Storage Batteries for Utility Applications

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Key Points

- Bipolar Battery Design
- Applications
- Benefits and Advantages
- High Power Bipolar NiMH Batteries
- High Energy Bipolar NiMH Batteries
- Safety Considerations
- Acknowledgements

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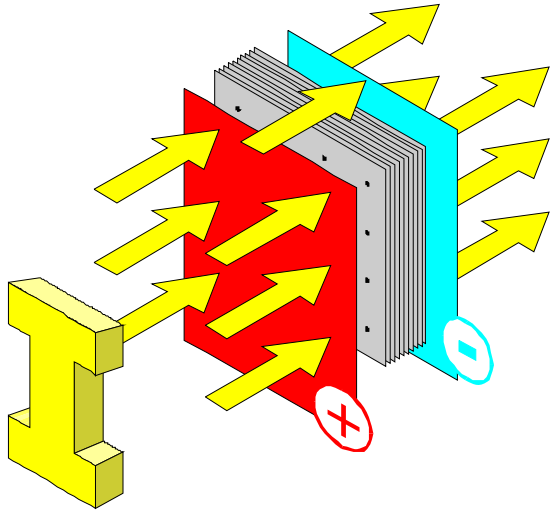
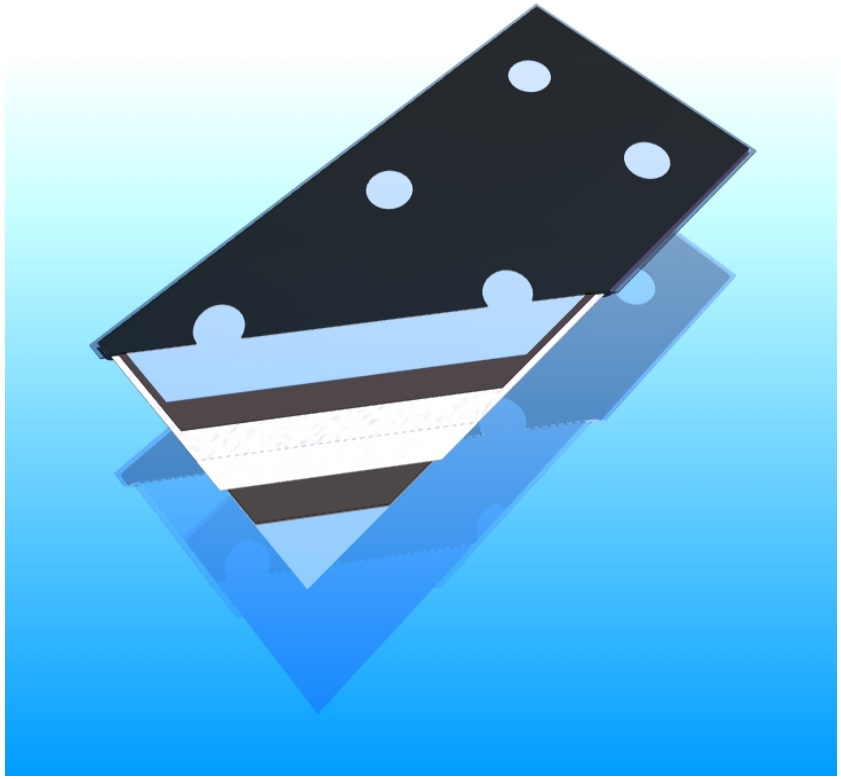
Advantages of EEI Bi-polar Wafer Design



- Each cell individually sealed
- No external cell terminals
- No separate cell-to-cell current collectors
- Adaptable to heat transfer fins placed in stack

- Scaleable to large area, capacity, high voltage
- Compatible with coated or plastic bonded electrodes
- Automated flexible manufacturing
- Improved energy and power density
- Lower cost

The Electro Energy Bipolar Advantage



- EEI's Patented Bipolar battery design allows EEI to build high power and high energy products that meet demanding energy applications not met by existing technologies
  - 25% Lower Manufacturing Cost
  - 50% Higher Power
  - 30% Better Volume
  - Environmentally Friendly
  - Excellent Life

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Energy Storage Applications

- High Rate UPS <20 minutes
- High Energy UPS <120 minutes
- Load Management and Power Quality
- Peak Shaving
- Wind, Solar, and Other Electric Utility Energy Storage
- Automotive Applications

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Benefits to Applications

- Improved Efficiency – Reducing peak generation demands
- Reliable means of distributing energy and power back-up
- Increased energy storage for continuous solar and wind systems
- Power assist for electric generation fuel cells
- Reduced volume and cost batteries for automotive applications

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High Power Bipolar Batteries

- Prior work – single cells and low voltage packs
  - DOE
  - PNGV
  - United Defense, LLP
- Current work – low and higher voltage packs
  - DOE
  - First Energy
- General features of batteries
  - Thin electrodes
  - High power, low energy per unit weight / volume
  - EEI has built systems up to 700 V, 60 kW

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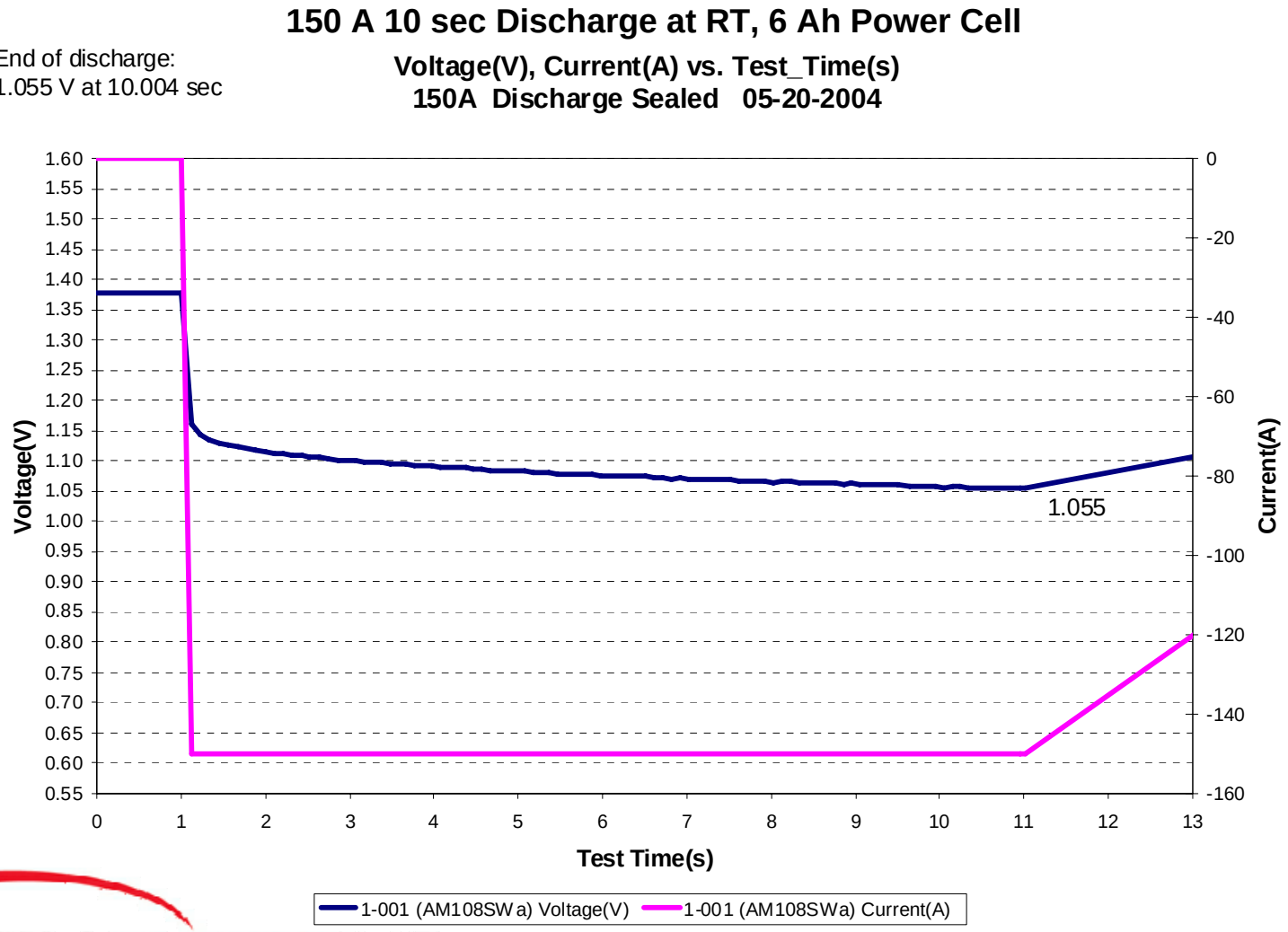
6 Ah, High Power Cell – 150 A Pulse Discharge

End of discharge:
1.055 V at 10.004 sec



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350 V, High Power Battery

6.2” x 14” x 14.5” 6 Ah, 350 V

23 l and 55 kg

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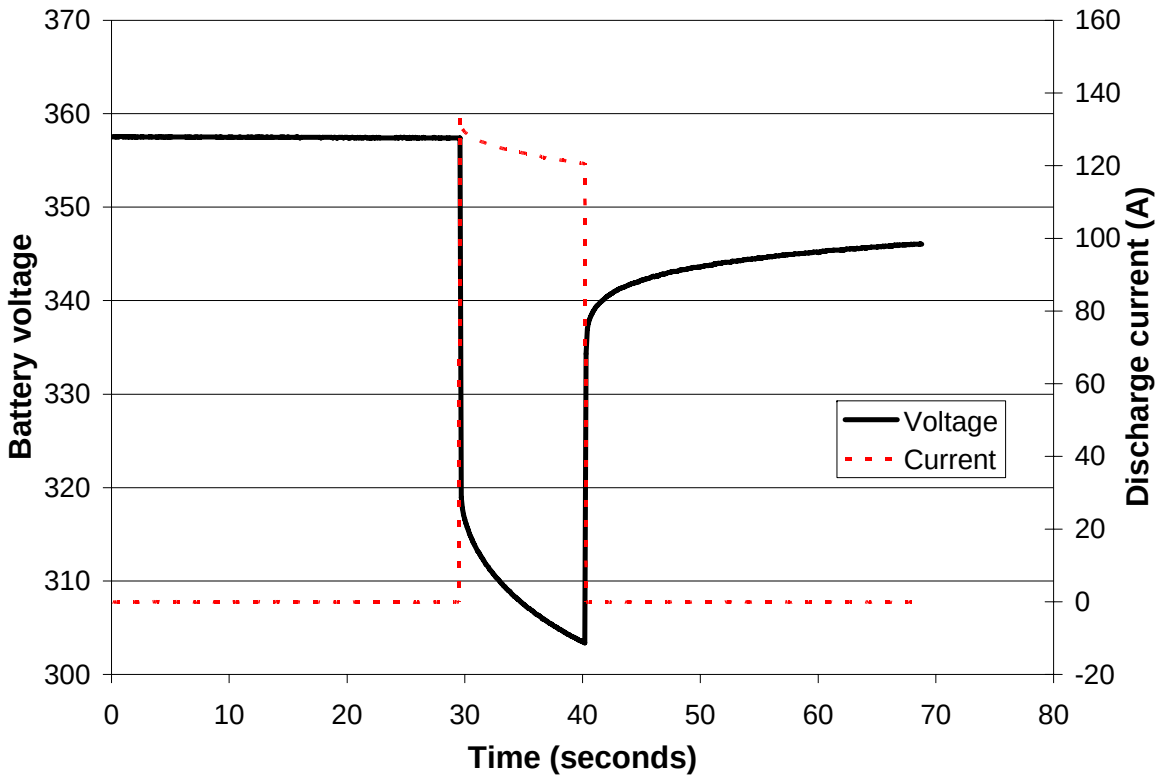
Nominal 38 kW discharge pulse lasting 10 seconds resistive load.



The power density at 100% SOC approximately (305 V) (125 A) / 23 l, or 1.66 kW / l.
The specific power can be calculated as (305 V) (125 A) / 55 kg, or 0.69 kW / kg @ 35C.

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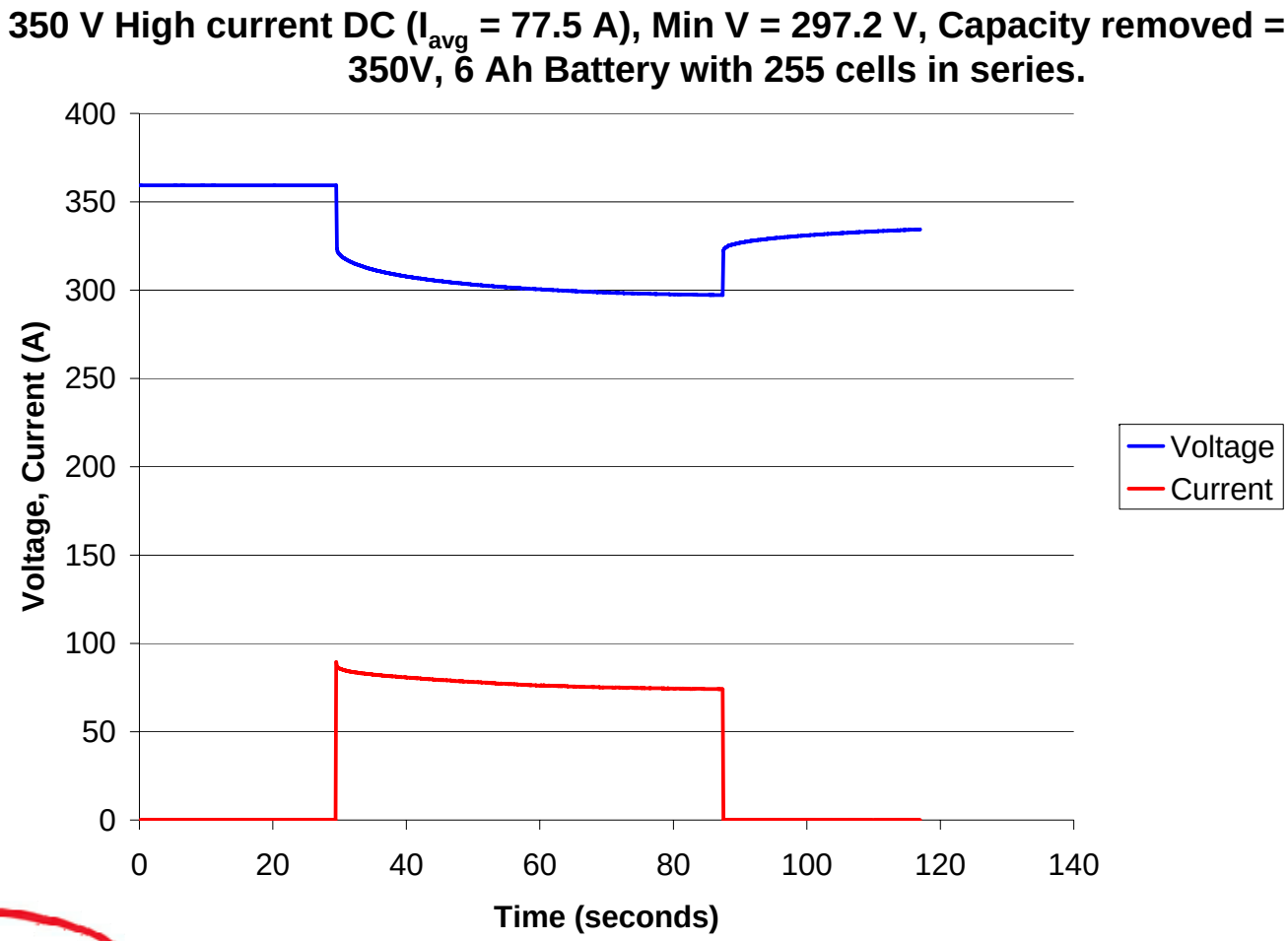
High Voltage, High Power Discharge Profile



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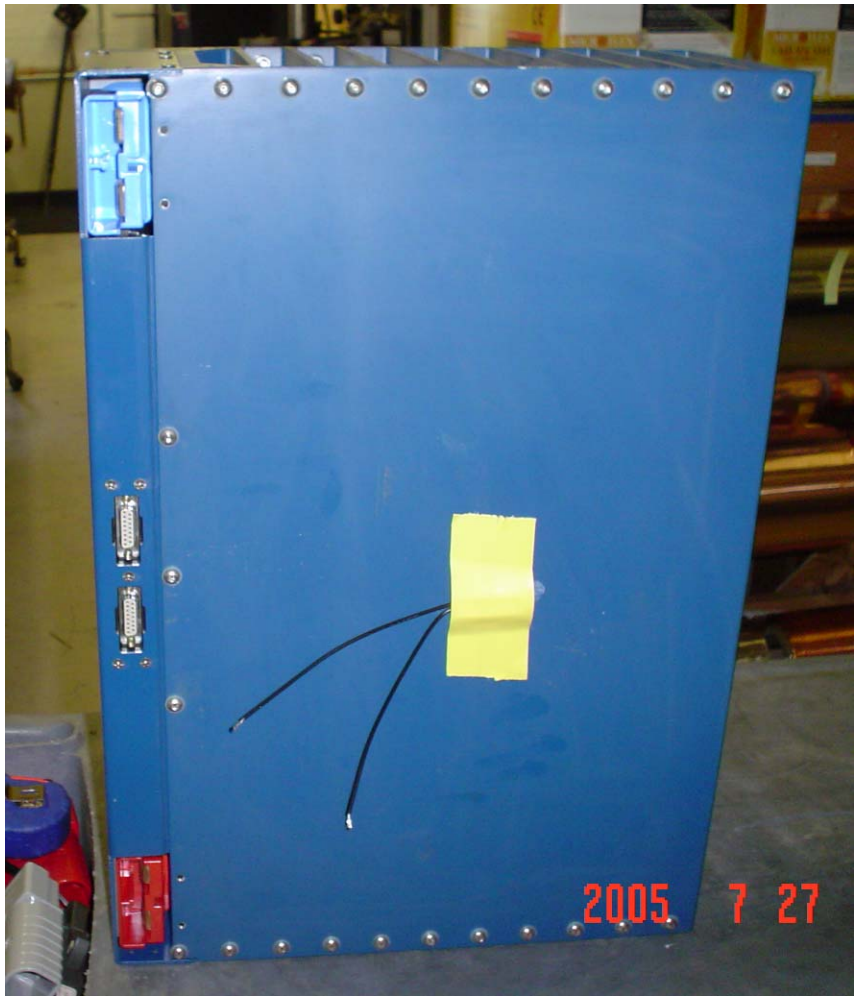
50 V/50 Ah 3 kW Inverter System Battery

15”L x 6.62”W x 21.5”H, 200 lbs



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EEI Nickel Metal Hydride vs. Capacitor

First Energy/EEI are in the process of comparing the Bipolar NiMH to the ESMA capacitor system

- 3 kW Pioneer Inverter
- 100 kVA Liebert Inverter

EEI is using

- 1 eq.blue modules for 3 kW
- 4 smaller modules for 100 kVA

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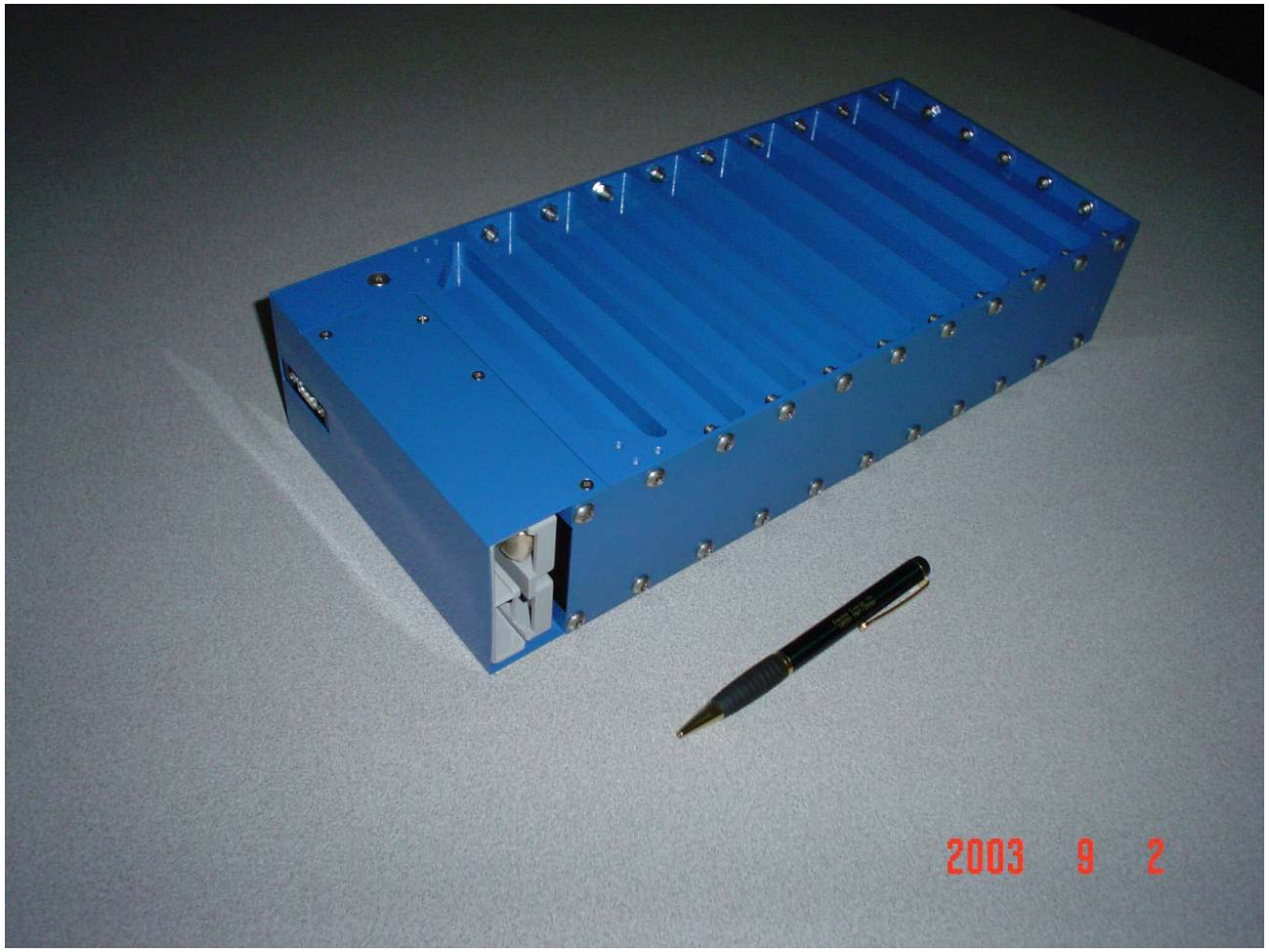
42 V, 6 Ah Automotive Battery



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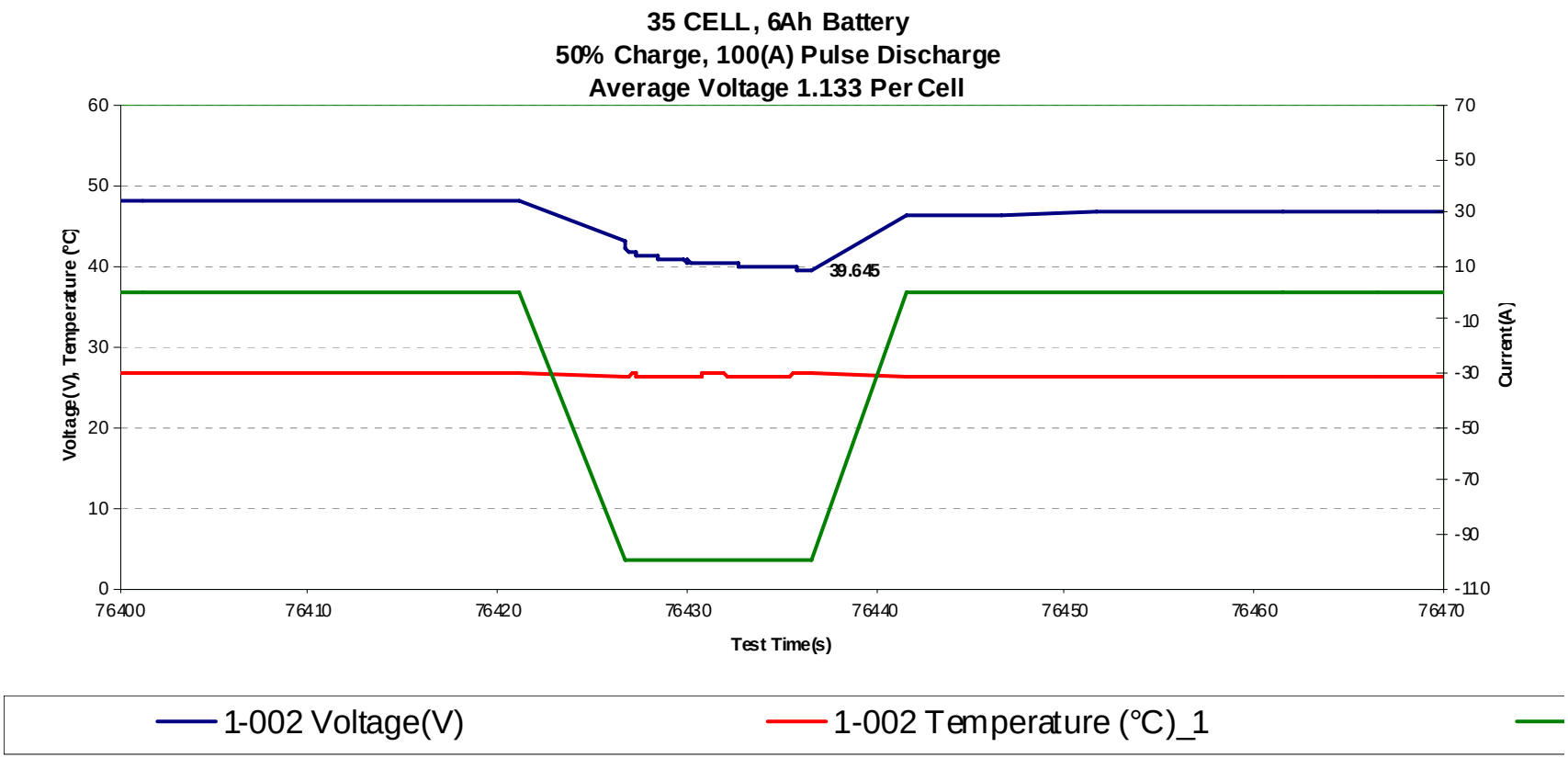
42 V Battery - High Power Discharge Profile

43.75 V, 6 Ah Battery – 100 A Pulse Discharge for 10 Seconds, at 50% SOC, 35 cells in series



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High Energy Bipolar Batteries

- Prior work – single cells and high voltage packs
  - DOE
- Current work – single cells and higher voltage packs
  - DOE
  - EPRI Solutions
  - First Energy
  - Commercial Applications
- General features of batteries
  - Thicker electrodes
  - High energy per unit weight / volume
  - Lower power per unit weight / volume

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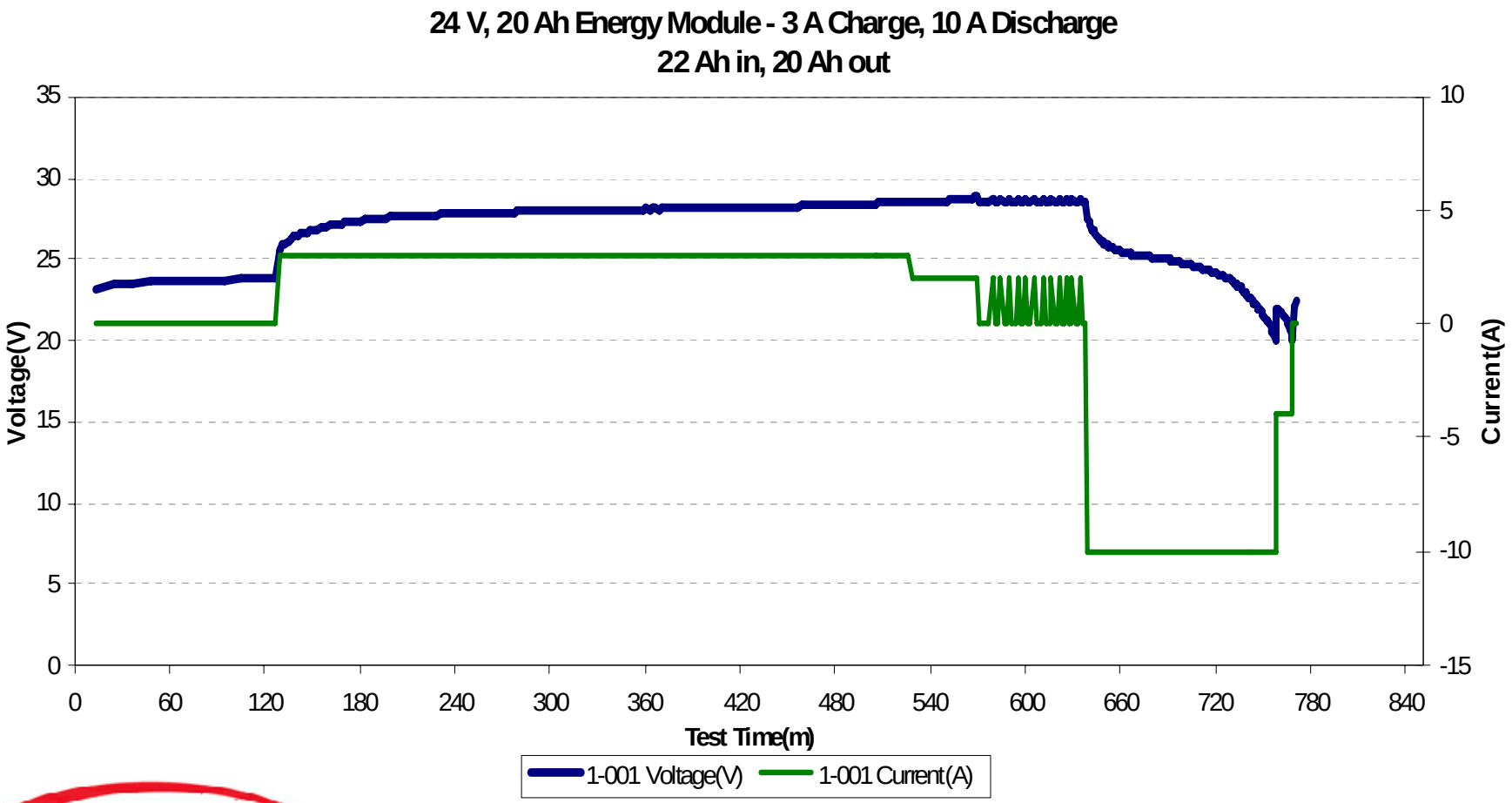
24 V, 20 Ah Energy Module Charge & 2-Hour Discharge



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20 kW UPS Battery System Specifications/Features

- Total System: 35 kWh/20 kW
  - 60-70 Ah, 600 V
  - 76”L x 34”W x 92”H, 3,200 lbs
- 1,920 cells, housed in 16 individual battery modules
  - Four parallel strings of four modules connected in series
  - Two battery cabinets (with air conditioning), and one charger/control cabinet
- Module Design
  - Four 30-Cell Stacks in Series
  - 20 Ah, 150 V
  - 9.07” x 14.24” x 15.47”, 145 lbs

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20 kW/35 kWh/600 V High Energy Battery System

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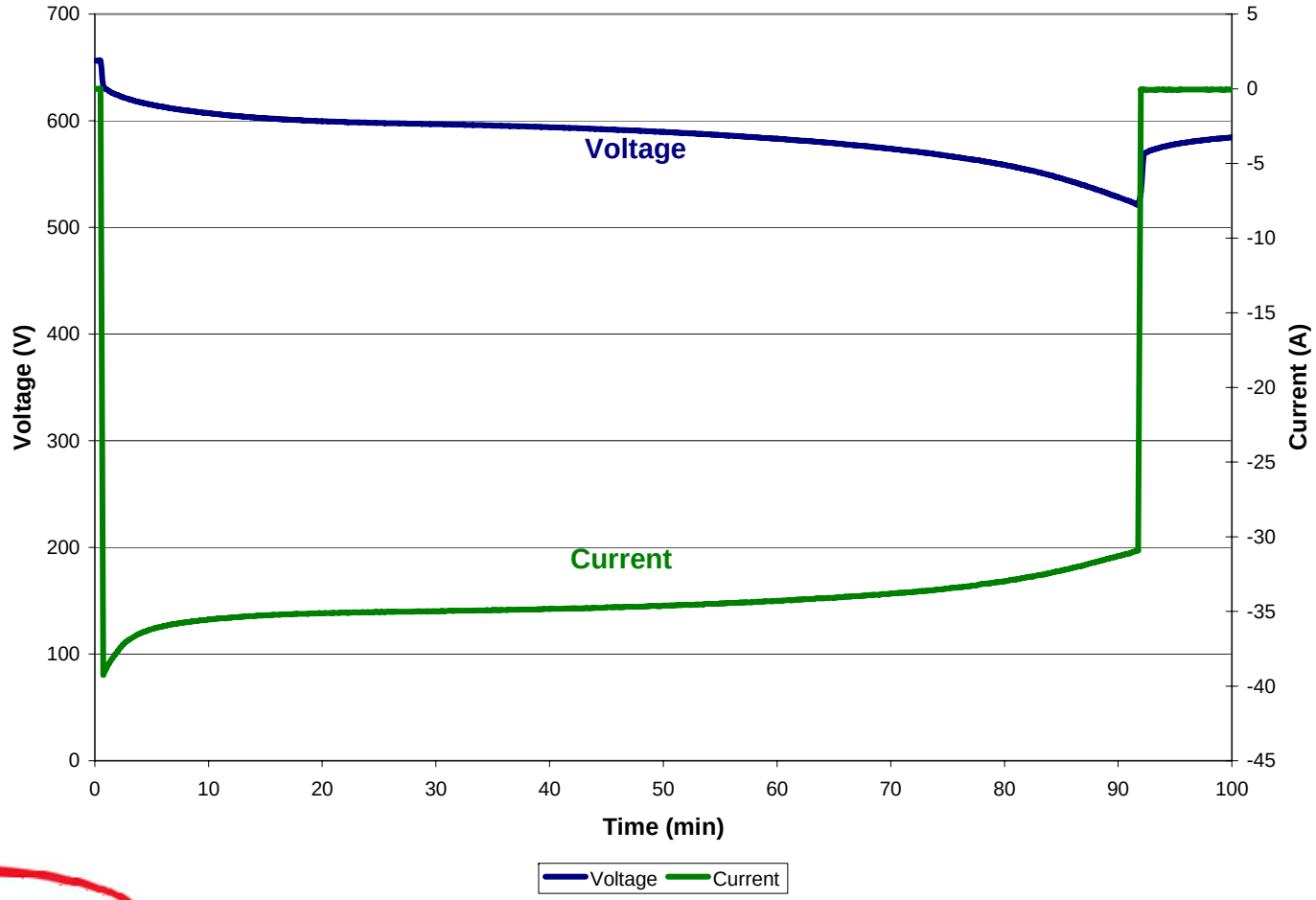
600 V/35 kWh/20 kW System
20 kW Discharge – 33 kWh Out



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220 V, 35 Ah Pluggable Hybrid Electric Vehicle Battery System

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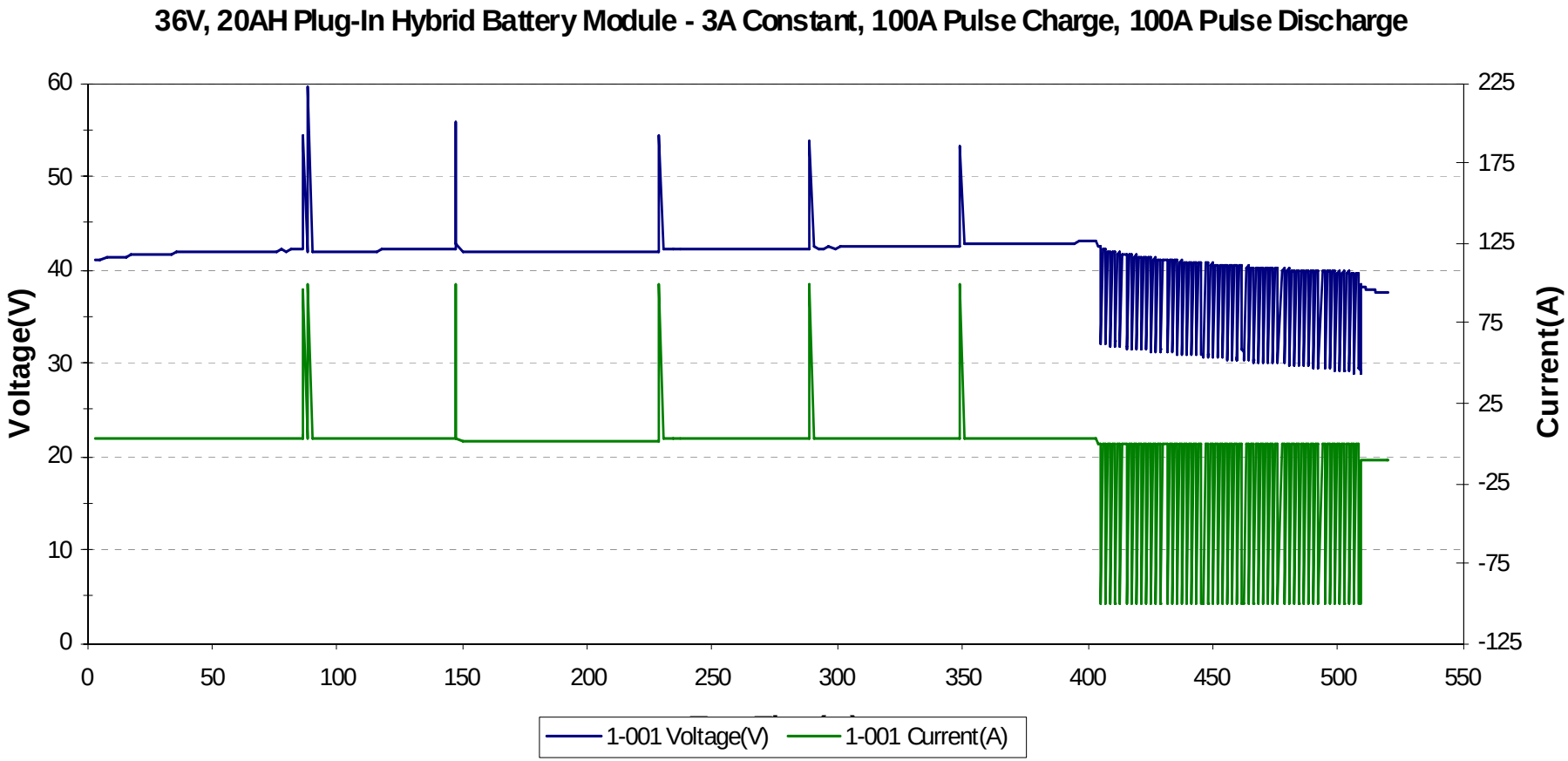
36 V, 20 Ah, Plug-In Hybrid (PHEV) Battery Module - 2 Sec 100 A Pulses



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EEI's Charge/Discharge Control

- EEI controls charge and discharge by monitoring voltage, pressure, and/or temperature.
- Monitoring voltage alone does not account for cell unbalancing, since the total battery voltage is monitored and not each individual cell.
- EEI has developed a means of control that utilizes pressure.
  - Each cell stack is monitored via a switch, which activates once pressure is detected.
  - If any cell in the stack begins to build up pressure, it will expand and set-off the corresponding stack switch.

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